# AWS Lambda

## Developer Guide



# AWS Lambda: Developer Guide

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# What is AWS Lambda?

Lambda is a compute service that lets you run code without provisioning or managing servers. Lambda runs your code on a high-availability compute infrastructure and performs all of the administration of the compute resources, including server and operating system maintenance, capacity provisioning and automatic scaling, and logging. With Lambda, you can run code for virtually any type of application or backend service. All you need to do is supply your code in one of the languages that Lambda supports (p. 82).

> **Note**
> In the AWS Lambda Developer Guide, we assume that you have experience with coding, compiling, and deploying programs using one of the supported languages.

You organize your code into Lambda functions (p. 12). Lambda runs your function only when needed and scales automatically, from a few requests per day to thousands per second. You pay only for the compute time that you consume—there is no charge when your code is not running.

You can invoke your Lambda functions using the Lambda API, or Lambda can run your functions in response to events from other AWS services. For example, you can use Lambda to:

- Build data-processing triggers for AWS services such as Amazon Simple Storage Service (Amazon S3) and Amazon DynamoDB.
- Process streaming data stored in Amazon Kinesis.
- Create your own backend that operates at AWS scale, performance, and security.

Lambda is a highly available service. For more information, see the AWS Lambda Service Level Agreement.

**Sections**

- When should I use Lambda? (p. 1)
- Lambda features (p. 2)
- Getting started with Lambda (p. 2)
- Related services (p. 3)
- Accessing Lambda (p. 3)
- Pricing for Lambda (p. 4)

# When should I use Lambda?

Lambda is an ideal compute service for many application scenarios, as long as you can run your application code using the Lambda standard runtime environment (p. 100) and within the resources that Lambda provides.

When using Lambda, you are responsible only for your code. Lambda manages the compute fleet that offers a balance of memory, CPU, network, and other resources to run your code. Because Lambda manages these resources, you cannot log in to compute instances or customize the operating system on provided runtimes (p. 82). Lambda performs operational and administrative activities on your behalf, including managing capacity, monitoring, and logging your Lambda functions.

If you need to manage your own compute resources, AWS has other compute services to meet your needs. For example:

- Amazon Elastic Compute Cloud (Amazon EC2) offers a wide range of EC2 instance types to choose from. It lets you customize operating systems, network and security settings, and the entire software stack. You are responsible for provisioning capacity, monitoring fleet health and performance, and using Availability Zones for fault tolerance.
- AWS Elastic Beanstalk enables you to deploy and scale applications onto Amazon EC2. You retain ownership and full control over the underlying EC2 instances.

# Lambda features

The following key features help you develop Lambda applications that are scalable, secure, and easily extensible:

**Concurrency and scaling controls**

Concurrency and scaling controls (p. 30) such as concurrency limits and provisioned concurrency give you fine-grained control over the scaling and responsiveness of your production applications.

**Functions defined as container images**

Use your preferred container image (p. 143) tooling, workflows, and dependencies to build, test, and deploy your Lambda functions.

**Code signing**

Code signing (p. 211) for Lambda provides trust and integrity controls that let you verify that only unaltered code that approved developers have published is deployed in your Lambda functions.

**Lambda extensions**

You can use Lambda extensions (p. 101) to augment your Lambda functions. For example, use extensions to more easily integrate Lambda with your favorite tools for monitoring, observability, security, and governance.

**Function blueprints**

A function blueprint provides sample code that shows how to use Lambda with other AWS services or third-party applications. Blueprints include sample code and function configuration presets for Node.js and Python runtimes.

**Database access**

A database proxy (p. 201) manages a pool of database connections and relays queries from a function. This enables a function to reach high concurrency levels without exhausting database connections.

**File systems access**

You can configure a function to mount an Amazon Elastic File System (Amazon EFS) file system (p. 206) to a local directory. With Amazon EFS, your function code can access and modify shared resources safely and at high concurrency.

# Getting started with Lambda

To work effectively with Lambda, you need coding experience and expertise in the following domains:

- Linux OS and commands, as well as concepts such as processes, threads, and file permissions.
- Cloud concepts and IP networking concepts (for public and private networks).
- Distributed computing concepts such as HTTP as an IPC, queues, messaging, notifications, and concurrency.

- Familiarity with security services and concepts: AWS Identity and Access Management (IAM) and access control principles, and AWS Key Management Service (AWS KMS) and public key infrastructure.
- Familiarity with key services that interact with Lambda: Amazon API Gateway, Amazon S3, Amazon Simple Queue Service (Amazon SQS), and DynamoDB.
- Configuring EC2 instances with Linux.

If you are a first-time user of Lambda, we recommend that you start with the following topics to help you learn the basics:

1. **Read the Lambda product overview and explore the Lambda getting started page.**
2. **To create and test a Lambda function using the Lambda console, try the console-based getting started exercise (p. 8).** This exercise teaches you about the Lambda programming model and other concepts.
3. **If you are familiar with container image workflows, try the getting started exercise to create a Lambda function defined as a container image (p. 136).**

AWS also provides the following resources for learning about serverless applications and Lambda:

- The AWS Compute Blog includes useful articles about Lambda.
- AWS Serverless provides blogs, videos, and training related to AWS serverless development.
- The AWS Online Tech Talks YouTube channel includes videos about Lambda-related topics. For an overview of serverless applications and Lambda, see the Introduction to AWS Lambda & Serverless Applications video.

# Related services

Lambda integrates with other AWS services (p. 496) to invoke functions based on events that you specify. For example:

- Use API Gateway (p. 502) to provide a secure and scalable gateway for web APIs that route HTTP requests to Lambda functions.
- For services that generate a queue or data stream (such as DynamoDB (p. 559) and Kinesis (p. 613)), Lambda polls the queue or data stream from the service and invokes your function to process the received data.
- Define Amazon S3 (p. 663) events that invoke a Lambda function to process Amazon S3 objects, for example, when an object is created or deleted.
- Use a Lambda function to process Amazon SQS (p. 697) messages or Amazon Simple Notification Service (Amazon SNS) (p. 689) notifications.
- Use AWS Step Functions (p. 783) to connect Lambda functions together into serverless workflows called state machines.

# Accessing Lambda

You can create, invoke, and manage your Lambda functions using any of the following interfaces:

- **AWS Management Console** – Provides a web interface for you to access your functions. For more information, see Lambda console (p. 38).
- **AWS Command Line Interface (AWS CLI)** – Provides commands for a broad set of AWS services, including Lambda, and is supported on Windows, macOS, and Linux. For more information, see Using Lambda with the AWS CLI (p. 45).

- **AWS SDKs** – Provide language-specific APIs and manage many of the connection details, such as signature calculation, request retry handling, and error handling. For more information, see AWS SDKs.
- **AWS CloudFormation** – Enables you to create templates that define your Lambda applications. For more information, see AWS Lambda applications (p. 760). AWS CloudFormation also supports the AWS Cloud Development Kit (AWS CDK).
- **AWS Serverless Application Model (AWS SAM)** – Provides templates and a CLI to configure and manage AWS serverless applications. For more information, see SAM CLI (p. 6).

# Pricing for Lambda

There is no additional charge for creating Lambda functions. There are charges for running a function and for data transfer between Lambda and other AWS services. Some optional Lambda features (such as provisioned concurrency (p. 180)) also incur charges. For more information, see AWS Lambda Pricing.

# Prerequisites

To use AWS Lambda, you need an AWS account. If you plan to configure and use Lambda functions from the command line, set up the AWS CLI. You can set up other development and build tools as required for the environment and language that you are planning to use.

**Sections**


- AWS Account (p. 5)
- AWS CLI (p. 5)
- AWS SAM (p. 5)
- AWS SAM CLI (p. 6)
- Tools for container images (p. 6)
- Code authoring tools (p. 6)


## AWS Account

To use Lambda and other AWS services, you need an AWS account. If you do not have an account, visit aws.amazon.com and choose **Create an AWS Account**. For instructions, see How do I create and activate a new AWS account?

As a best practice, create an AWS Identity and Access Management (IAM) user with administrator permissions, and then use that IAM user for all work that does not require root credentials. Create a password for console access, and create access keys to use command line tools. For instructions, see Creating your first IAM admin user and group in the *IAM User Guide*.

## AWS CLI

If you plan to configure and use Lambda functions from the command line, install the AWS Command Line Interface (AWS CLI). Tutorials in this guide use the AWS CLI, which has commands for all Lambda API operations. Some functionality is not available in the Lambda console and can be accessed only with the AWS CLI or the AWS SDKs.

To set up the AWS CLI, see the following topics in the *AWS Command Line Interface User Guide*.

- Installing, updating, and uninstalling the AWS CLI
- Configuring the AWS CLI

To verify that the AWS CLI is configured correctly, run the `list-functions` command to see a list of your Lambda functions in the current AWS Region.

```
aws lambda list-functions
```

## AWS SAM

The AWS Serverless Application Model (AWS SAM) is an extension for the AWS CloudFormation template language that lets you define serverless applications at a higher level. AWS SAM abstracts away common

tasks such as function role creation, making it easier to write templates. AWS SAM is supported directly by AWS CloudFormation, and includes additional functionality through the AWS CLI and AWS SAM CLI.

For more information about AWS SAM templates, see the AWS SAM specification in the *AWS Serverless Application Model Developer Guide*.

# AWS SAM CLI

The AWS SAM CLI is a separate command line tool that you can use to manage and test AWS SAM applications. In addition to commands for uploading artifacts and launching AWS CloudFormation stacks that are also available in the AWS CLI, the AWS SAM CLI provides commands for validating templates and running applications locally in a Docker container. You can use the AWS SAM CLI to build functions deployed as .zip file archives or container images.

To set up the AWS SAM CLI, see Installing the AWS SAM CLI in the *AWS Serverless Application Model Developer Guide*.

# Tools for container images

To create and test functions deployed as container images, you can use native container tools such as the Docker CLI.

To set up the Docker CLI, see Get Docker on the Docker Docs website. For an introduction to using Docker with AWS, see Getting started with Amazon ECR using the AWS CLI in the *Amazon Elastic Container Registry User Guide*.

# Code authoring tools

You can author your Lambda function code in the languages that Lambda supports. For a list of supported languages, see Lambda runtimes (p. 82). There are tools for authoring code, such as the Lambda console, Eclipse integrated development environment (IDE), and Visual Studio IDE. But the available tools and options depend on:

- The language that you use to write your Lambda function code.
- The libraries that you use in your code. The Lambda runtimes provide some of the libraries, and you must upload any additional libraries that you use.

The following table lists the languages that Lambda supports, and the tools and options that you can use with them.

| Language | Tools and options for authoring code |
| --- | --- |
| Node.js | • Lambda console<br>• Visual Studio, with IDE plugin (see AWS Lambda Support in Visual Studio on the AWS Developer Blog)<br>• Your own authoring environment |
| Java | • Eclipse, with the AWS Toolkit for Eclipse<br>• IntelliJ, with the AWS Toolkit for JetBrains<br>• Your own authoring environment |

| Language | Tools and options for authoring code |
| --- | --- |
| C# | • Visual Studio, with IDE plugin (see AWS Toolkit for Visual Studio)<br>• .NET Core (see Download .NET on the Microsoft website)<br>• Your own authoring environment |
| Python | • Lambda console<br>• PyCharm, with the AWS Toolkit for JetBrains<br>• Your own authoring environment |
| Ruby | • Lambda console<br>• Your own authoring environment |
| Go | • Your own authoring environment |
| PowerShell | • Your own authoring environment<br>• PowerShell Core 6.0 (see Installing various versions of PowerShell on the Microsoft Docs website)<br>• .NET Core 3.1 SDK (see Download .NET on the Microsoft website)<br>• AWSLambdaPSCore module (see AWSLambdaPSCore on the PowerShell Gallery website) |

# Getting started with Lambda

To get started with Lambda, use the Lambda console to create a function. In a few minutes, you can create a function, invoke it, and then view logs, metrics, and trace data.

> **Note**
> To use Lambda and other AWS services, you need an AWS account. If you don't have an account, visit aws.amazon.com and choose **Create an AWS Account**. For instructions, see How do I create and activate a new AWS account?
> As a best practice, create an AWS Identity and Access Management (IAM) user with administrator permissions, and then use that IAM user for all work that does not require root credentials. Create a password for console access, and create access keys to use command line tools. For instructions, see Creating your first IAM admin user and group in the *IAM User Guide*.

You can author functions in the Lambda console, or with an IDE toolkit, command line tools, or the AWS SDKs. The Lambda console provides a code editor (p. 38) for non-compiled languages that lets you modify and test code quickly. The AWS Command Line Interface (AWS CLI) (p. 45) gives you direct access to the Lambda API for advanced configuration and automation use cases.

You deploy your function code to Lambda using a deployment package. Lambda supports two types of deployment packages:

- A .zip file archive (p. 132) that contains your function code and its dependencies. For a tutorial, see Create a Lambda function with the console (p. 8).
- A container image (p. 143) that is compatible with the Open Container Initiative (OCI) specification.

# Create a Lambda function with the console

In this getting started exercise, you create a Lambda function using the console. The function uses the default code that Lambda creates. The Lambda console provides a code editor (p. 38) for non-compiled languages that lets you modify and test code quickly. For compiled languages, you must create a .zip archive deployment package (p. 35) to upload your Lambda function code.

## Create the function

You create a Node.js Lambda function using the Lambda console. Lambda automatically creates default code for the function.

### To create a Lambda function with the console

1. Open the Functions page of the Lambda console.
2. Choose **Create function**.
3. Under **Basic information**, do the following:
   a. For **Function name**, enter `my-function`.
   b. For **Runtime**, confirm that **Node.js 14.x** is selected. Note that Lambda provides runtimes for .NET (PowerShell, C#), Go, Java, Node.js, Python, and Ruby.
4. Choose **Create function**.

Lambda creates a Node.js function and an execution role (p. 52) that grants the function permission to upload logs. The Lambda function assumes the execution role when you invoke your function, and uses the execution role to create credentials for the AWS SDK and to read data from event sources.

# Invoke the Lambda function

Invoke your Lambda function using the sample event data provided in the console.

### To invoke a function

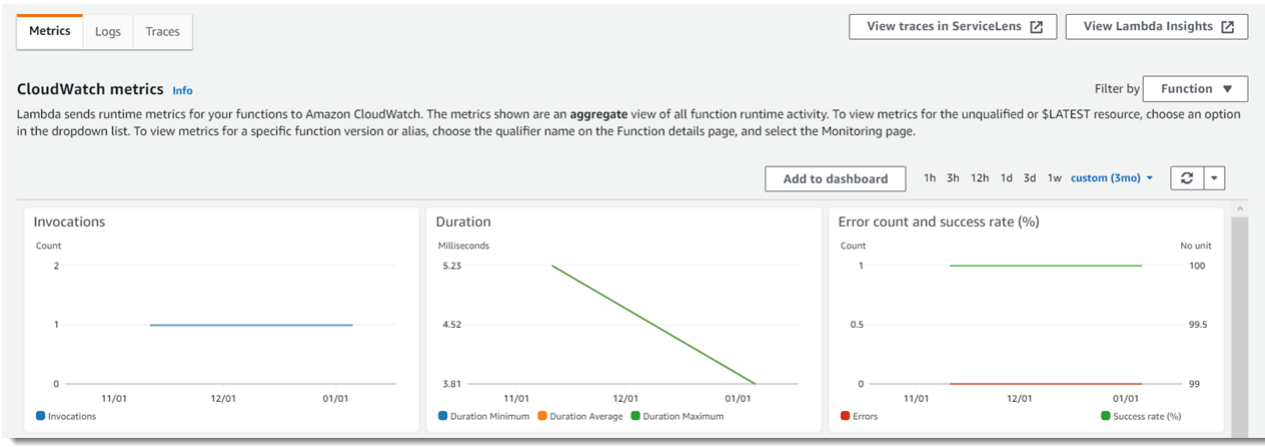
1. After selecting your function, choose the **Test** tab.
2. In the **Test event** section, choose **New event**. In **Template**, leave the default **hello-world** option. Enter a **Name** for this test and note the following sample event template:

```
{
    "key1": "value1",
    "key2": "value2",
    "key3": "value3"
}
```

3. Choose **Save changes**, and then choose **Test**. Each user can create up to 10 test events per function. Those test events are not available to other users.

   Lambda runs your function on your behalf. The function handler receives and then processes the sample event.
4. Upon successful completion, view the results in the console.

   - The **Execution result** shows the execution status as **succeeded**. To view the function execution results, expand **Details**. Note that the **logs** link opens the **Log groups** page in the CloudWatch console.
   - The **Summary** section shows the key information reported in the **Log output** section (the *REPORT* line in the execution log).
   - The **Log output** section shows the log that Lambda generates for each invocation. The function writes these logs to CloudWatch. The Lambda console shows these logs for your convenience. Choose **Click here** to add logs to the CloudWatch log group and open the **Log groups** page in the CloudWatch console.
5. Run the function (choose **Test**) a few more times to gather some metrics that you can view in the next step.
6. Choose the **Monitor** tab. This page shows graphs for the metrics that Lambda sends to CloudWatch.




For more information on these graphs, see Monitoring functions on the Lambda console (p. 719).

# Clean up

If you are done working with the example function, delete it. You can also delete the log group that stores the function's logs, and the execution role that the console created.

### To delete a Lambda function

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Actions**, **Delete**.
4. In the **Delete function** dialog box, choose **Delete**.

### To delete the log group

1. Open the Log groups page of the CloudWatch console.
2. Select the function's log group (`/aws/lambda/my-function`).
3. Choose **Actions**, **Delete log group(s)**.
4. In the **Delete log group(s)** dialog box, choose **Delete**.

### To delete the execution role

1. Open the Roles page of the AWS Identity and Access Management (IAM) console.
2. Select the function's role (`my-function-role-31exxmpl`).
3. Choose **Delete role**.
4. In the **Delete role** dialog box, choose **Yes, delete**.

You can automate the creation and cleanup of functions, log groups, and roles with AWS CloudFormation and the AWS Command Line Interface (AWS CLI). For fully functional sample applications, see Lambda sample applications (p. 800).

# AWS Lambda foundations

The Lambda function is the foundational principle of Lambda. You can configure your functions using the Lambda console, Lambda API, AWS CloudFormation or AWS SAM. You create code for the function and upload the code using a deployment package. Lambda invokes the function when an event occurs. Lambda runs multiple instances of your function in parallel, governed by concurrency and scaling limits.

**Topics**


- Lambda concepts (p. 12)
- Lambda features (p. 16)
- Lambda programming model (p. 22)
- Lambda instruction set architectures (p. 23)
- VPC networking for Lambda (p. 26)
- Lambda function scaling (p. 30)
- Lambda deployment packages (p. 35)
- Lambda console (p. 38)
- Using Lambda with the AWS CLI (p. 45)

# Lambda concepts

Lambda runs instances of your function to process events. You can invoke your function directly using the Lambda API, or you can configure an AWS service or resource to invoke your function.

**Concepts**


- Function (p. 12)
- Trigger (p. 12)
- Event (p. 12)
- Execution environment (p. 13)
- Instruction set architecture (p. 13)
- Deployment package (p. 13)
- Runtime (p. 13)
- Layer (p. 14)
- Extension (p. 14)
- Concurrency (p. 14)
- Qualifier (p. 14)
- Destination (p. 15)


## Function

A *function* is a resource that you can invoke to run your code in Lambda. A function has code to process the events (p. 12) that you pass into the function or that other AWS services send to the function.

For more information, see Configuring AWS Lambda functions (p. 155).

## Trigger

A *trigger* is a resource or configuration that invokes a Lambda function. Triggers include AWS services that you can configure to invoke a function and event source mappings (p. 236). An event source mapping is a resource in Lambda that reads items from a stream or queue and invokes a function. For more information, see Invoking Lambda functions (p. 224) and Using AWS Lambda with other services (p. 496).

## Event

An *event* is a JSON-formatted document that contains data for a Lambda function to process. The runtime converts the event to an object and passes it to your function code. When you invoke a function, you determine the structure and contents of the event.

**Example custom event – weather data**

```
{
  "TemperatureK": 281,
  "WindKmh": -3,
  "HumidityPct": 0.55,
  "PressureHPa": 1020
}
```

When an AWS service invokes your function, the service defines the shape of the event.

**Example service event – Amazon SNS notification**

```
{
  "Records": [
    {
      "Sns": {
        "Timestamp": "2019-01-02T12:45:07.000Z",
        "Signature": "tcc6faL2yUC6dgZdmrwh1Y4cGa/ebXEkAi6RibDsvpi+tE/1+82j...65r==",
        "MessageId": "95df01b4-ee98-5cb9-9903-4c221d41eb5e",
        "Message": "Hello from SNS!",
        ...
```

For more information about events from AWS services, see Using AWS Lambda with other services (p. 496).

# Execution environment

An *execution environment* provides a secure and isolated runtime environment for your Lambda function. An execution environment manages the processes and resources that are required to run the function. The execution environment provides lifecycle support for the function and for any extensions (p. 14) associated with your function.

For more information, see AWS Lambda execution environment (p. 100).

# Instruction set architecture

The *instruction set architecture* determines the type of computer processor that Lambda uses to run the function. Lambda provides a choice of instruction set architectures:

- arm64 – 64-bit ARM architecture, for the AWS Graviton2 processor.
- x86_64 – 64-bit x86 architecture, for x86-based processors.

For more information, see Lambda instruction set architectures (p. 23).

# Deployment package

You deploy your Lambda function code using a *deployment package*. Lambda supports two types of deployment packages:

- A .zip file archive that contains your function code and its dependencies. Lambda provides the operating system and runtime for your function.
- A container image that is compatible with the Open Container Initiative (OCI) specification. You add your function code and dependencies to the image. You must also include the operating system and a Lambda runtime.

For more information, see Lambda deployment packages (p. 35).

# Runtime

The *runtime* provides a language-specific environment that runs in an execution environment. The runtime relays invocation events, context information, and responses between Lambda and the function. You can use runtimes that Lambda provides, or build your own. If you package your code as a .zip file archive, you must configure your function to use a runtime that matches your programming language. For a container image, you include the runtime when you build the image.

For more information, see Lambda runtimes (p. 82).

# Layer

A Lambda *layer* is a .zip file archive that can contain additional code or other content. A layer can contain libraries, a custom runtime (p. 90), data, or configuration files.

Layers provide a convenient way to package libraries and other dependencies that you can use with your Lambda functions. Using layers reduces the size of uploaded deployment archives and makes it faster to deploy your code. Layers also promote code sharing and separation of responsibilities so that you can iterate faster on writing business logic.

You can include up to five layers per function. Layers count towards the standard Lambda deployment size quotas (p. 796). When you include a layer in a function, the contents are extracted to the `/opt` directory in the execution environment.

By default, the layers that you create are private to your AWS account. You can choose to share a layer with other accounts or to make the layer public. If your functions consume a layer that a different account published, your functions can continue to use the layer version after it has been deleted, or after your permission to access the layer is revoked. However, you cannot create a new function or update functions using a deleted layer version.

Functions deployed as a container image do not use layers. Instead, you package your preferred runtime, libraries, and other dependencies into the container image when you build the image.

For more information, see Creating and sharing Lambda layers (p. 156).

# Extension

Lambda *extensions* enable you to augment your functions. For example, you can use extensions to integrate your functions with your preferred monitoring, observability, security, and governance tools. You can choose from a broad set of tools that AWS Lambda Partners provides, or you can create your own Lambda extensions (p. 101).

An internal extension runs in the runtime process and shares the same lifecycle as the runtime. An external extension runs as a separate process in the execution environment. The external extension is initialized before the function is invoked, runs in parallel with the function's runtime, and continues to run after the function invocation is complete.

For more information, see Using Lambda extensions (p. 254).

# Concurrency

*Concurrency* is the number of requests that your function is serving at any given time. When your function is invoked, Lambda provisions an instance of it to process the event. When the function code finishes running, it can handle another request. If the function is invoked again while a request is still being processed, another instance is provisioned, increasing the function's concurrency.

Concurrency is subject to quotas (p. 796) at the AWS Region level. You can configure individual functions to limit their concurrency, or to enable them to reach a specific level of concurrency. For more information, see Managing Lambda reserved concurrency (p. 180).

# Qualifier

When you invoke or view a function, you can include a *qualifier* to specify a version or alias. A *version* is an immutable snapshot of a function's code and configuration that has a numerical qualifier. For

example, `my-function:1`. An *alias* is a pointer to a version that you can update to map to a different version, or split traffic between two versions. For example, `my-function:BLUE`. You can use versions and aliases together to provide a stable interface for clients to invoke your function.

For more information, see Lambda function versions (p. 173).

# Destination

A *destination* is an AWS resource where Lambda can send events from an asynchronous invocation. You can configure a destination for events that fail processing. Some services also support a destination for events that are successfully processed.

For more information, see Configuring destinations for asynchronous invocation (p. 230).

# Lambda features

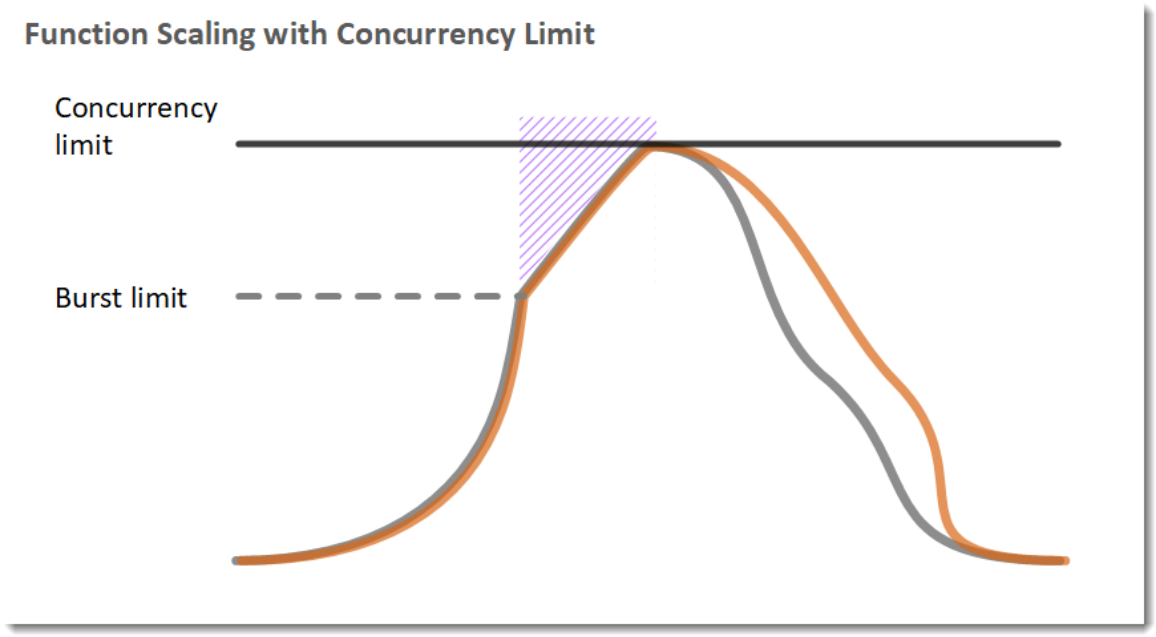
Lambda provides a management console and API for managing and invoking functions. It provides runtimes that support a standard set of features so that you can easily switch between languages and frameworks, depending on your needs. In addition to functions, you can also create versions, aliases, layers, and custom runtimes.

**Features**


- Scaling (p. 16)
- Concurrency controls (p. 17)
- Function URLs (p. 18)
- Asynchronous invocation (p. 18)
- Event source mappings (p. 19)
- Destinations (p. 19)
- Function blueprints (p. 20)
- Testing and deployment tools (p. 20)
- Application templates (p. 21)


## Scaling

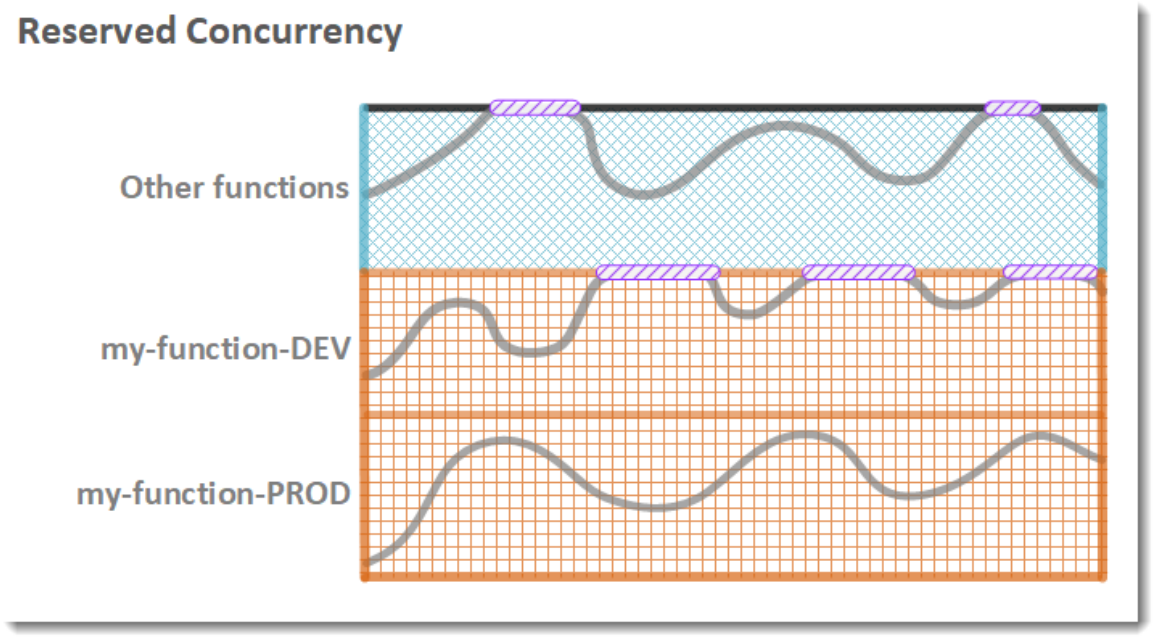
Lambda manages the infrastructure that runs your code, and scales automatically in response to incoming requests. When your function is invoked more quickly than a single instance of your function can process events, Lambda scales up by running additional instances. When traffic subsides, inactive instances are frozen or stopped. You pay only for the time that your function is initializing or processing events.



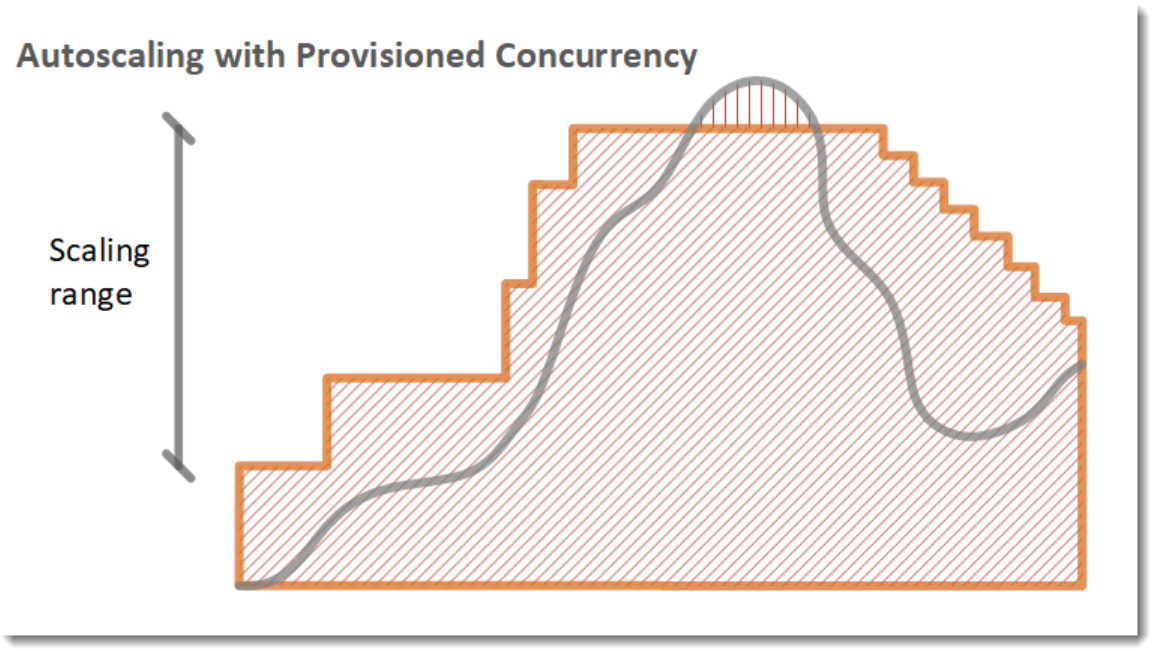

For more information, see Lambda function scaling (p. 30).

# Concurrency controls

Use concurrency settings to ensure that your production applications are highly available and highly responsive. To prevent a function from using too much concurrency, and to reserve a portion of your account's available concurrency for a function, use *reserved concurrency*. Reserved concurrency splits the pool of available concurrency into subsets. A function with reserved concurrency only uses concurrency from its dedicated pool.




To enable functions to scale without fluctuations in latency, use *provisioned concurrency*. For functions that take a long time to initialize, or that require extremely low latency for all invocations, provisioned concurrency enables you to pre-initialize instances of your function and keep them running at all times. Lambda integrates with Application Auto Scaling to support autoscaling for provisioned concurrency based on utilization.




For more information, see Managing Lambda reserved concurrency (p. 180).

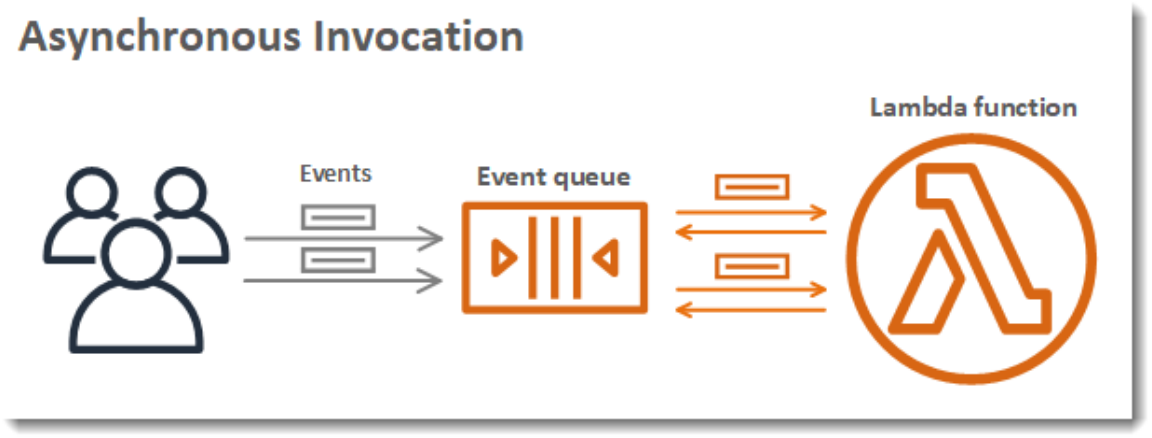
# Function URLs

Lambda offers built-in HTTP(S) endpoint support through *function URLs*. With function URLs, you can assign a dedicated HTTP endpoint to your Lambda function. When your function URL is configured, you can use it to invoke your function through a web browser, curl, Postman, or any HTTP client.

You can add a function URL to an existing function, or create a new function with a function URL. For more information, see Invoking Lambda function URLs (p. 269).

# Asynchronous invocation

When you invoke a function, you can choose to invoke it synchronously or asynchronously. With synchronous invocation (p. 225), you wait for the function to process the event and return a response. With asynchronous invocation, Lambda queues the event for processing and returns a response immediately.

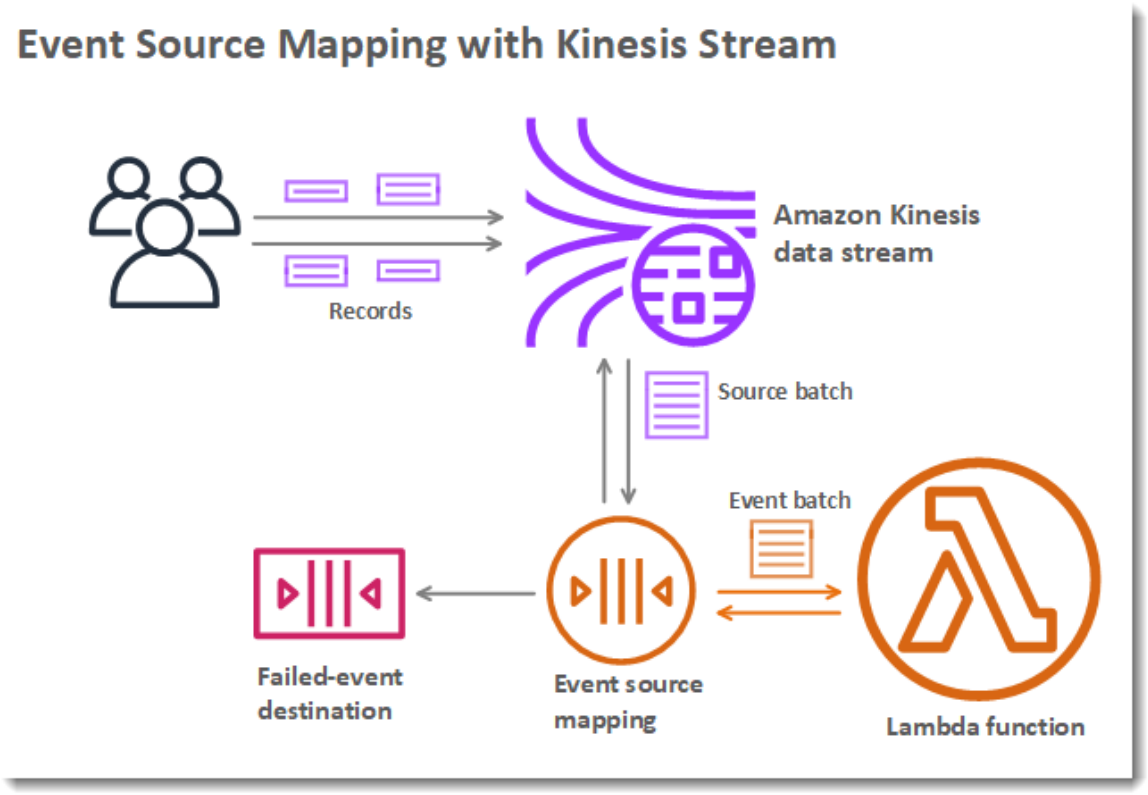


For asynchronous invocations, Lambda handles retries if the function returns an error or is throttled. To customize this behavior, you can configure error handling settings on a function, version, or alias. You can also configure Lambda to send events that failed processing to a dead-letter queue, or to send a record of any invocation to a destination (p. 19).

For more information, see Asynchronous invocation (p. 228).

# Event source mappings

To process items from a stream or queue, you can create an *event source mapping*. An event source mapping is a resource in Lambda that reads items from an Amazon Simple Queue Service (Amazon SQS) queue, an Amazon Kinesis stream, or an Amazon DynamoDB stream, and sends the items to your function in batches. Each event that your function processes can contain hundreds or thousands of items.

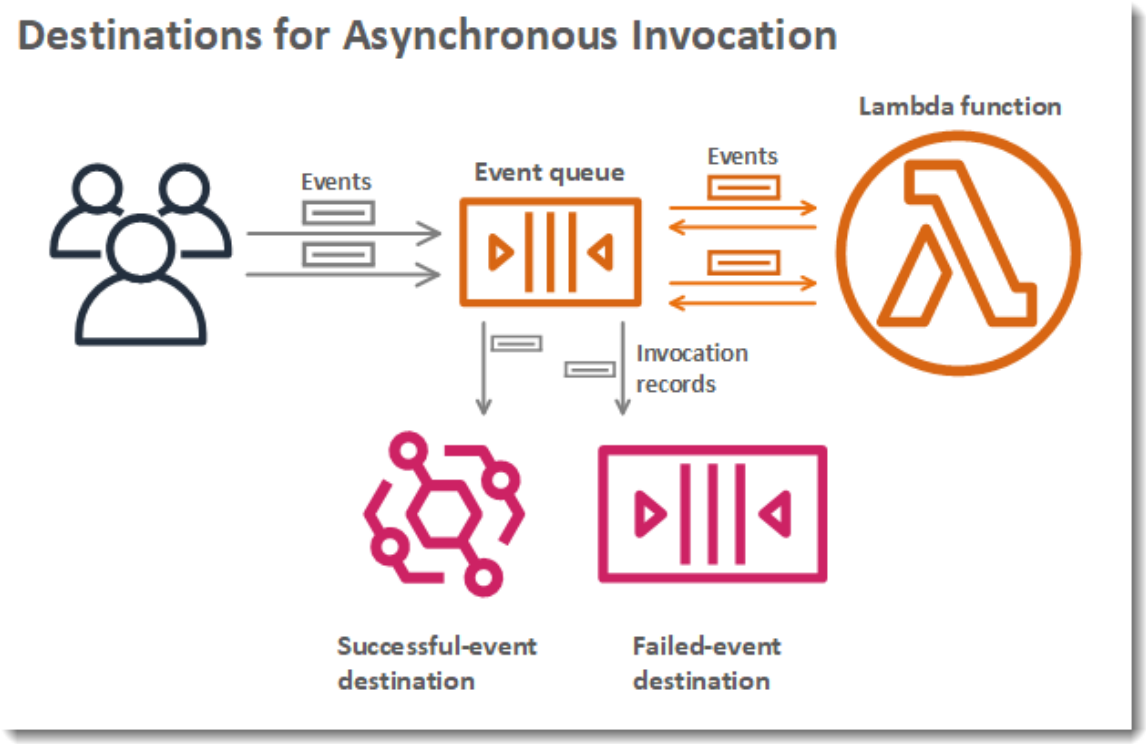



Event source mappings maintain a local queue of unprocessed items and handle retries if the function returns an error or is throttled. You can configure an event source mapping to customize batching behavior and error handling, or to send a record of items that fail processing to a destination.

For more information, see Lambda event source mappings (p. 236).

# Destinations

A destination is an AWS resource that receives invocation records for a function. For asynchronous invocation (p. 18), you can configure Lambda to send invocation records to a queue, topic, function, or event bus. You can configure separate destinations for successful invocations and events that failed processing. The invocation record contains details about the event, the function's response, and the reason that the record was sent.




For event source mappings (p. 19) that read from streams, you can configure Lambda to send a record of batches that failed processing to a queue or topic. A failure record for an event source mapping contains metadata about the batch, and it points to the items in the stream.

For more information, see Configuring destinations for asynchronous invocation (p. 230) and the error handling sections of Using AWS Lambda with Amazon DynamoDB (p. 559) and Using AWS Lambda with Amazon Kinesis (p. 613).

# Function blueprints

When you create a function in the Lambda console, you can choose to start from scratch, use a blueprint, use a container image (p. 35), or deploy an application from the AWS Serverless Application Repository. A blueprint provides sample code that shows how to use Lambda with an AWS service or a popular third-party application. Blueprints include sample code and function configuration presets for Node.js and Python runtimes.

Blueprints are provided for use under the Amazon Software License. They are available only in the Lambda console.

# Testing and deployment tools

Lambda supports deploying code as is or as container images (p. 35). You can use a rich tools ecosystem for authoring, building, and deploying your Lambda functions using AWS and popular community tools like the Docker command line interface (CLI).

To set up the Docker CLI, see Get Docker on the Docker Docs website. For an introduction to using Docker with AWS, see Getting started with Amazon ECR using the AWS CLI in the *Amazon Elastic Container Registry User Guide*.

The AWS CLI (p. 5) and SAM CLI (p. 6) are command line tools for managing Lambda application stacks. In addition to commands for managing application stacks with the AWS CloudFormation API, the AWS

CLI supports higher-level commands that simplify tasks like uploading deployment packages and updating templates. The AWS SAM CLI provides additional functionality, including validating templates, testing locally, and integrating with CI/CD systems.

- Installing the AWS SAM CLI
- Testing and debugging serverless applications with AWS SAM
- Deploying serverless applications using CI/CD systems with AWS SAM

# Application templates

You can use the Lambda console to create an application with a continuous delivery pipeline. Application templates in the Lambda console include code for one or more functions, an application template that defines functions and supporting AWS resources, and an infrastructure template that defines an AWS CodePipeline pipeline. The pipeline has build and deploy stages that run every time you push changes to the included Git repository.

Application templates are provided for use under the MIT No Attribution license. They are available only in the Lambda console.

For more information, see Creating an application with continuous delivery in the Lambda console (p. 764).

# Lambda programming model

Lambda provides a programming model that is common to all of the runtimes. The programming model defines the interface between your code and the Lambda system. You tell Lambda the entry point to your function by defining a *handler* in the function configuration. The runtime passes in objects to the handler that contain the invocation *event* and the *context*, such as the function name and request ID.

When the handler finishes processing the first event, the runtime sends it another. The function's class stays in memory, so clients and variables that are declared outside of the handler method in *initialization code* can be reused. To save processing time on subsequent events, create reusable resources like AWS SDK clients during initialization. Once initialized, each instance of your function can process thousands of requests.

When AWS X-Ray tracing (p. 715) is enabled, the runtime records separate subsegments for initialization and execution.

Your function also has access to local storage in the `/tmp` directory. Instances of your function that are serving requests remain active for a few hours before being recycled.

The runtime captures logging output from your function and sends it to Amazon CloudWatch Logs. In addition to logging your function's output, the runtime also logs entries when function invocation starts and ends. This includes a report log with the request ID, billed duration, initialization duration, and other details. If your function throws an error, the runtime returns that error to the invoker.

> **Note**
> Logging is subject to CloudWatch Logs quotas. Log data can be lost due to throttling or, in some cases, when an instance of your function is stopped.

For a hands-on introduction to the programming model in your preferred programming language, see the following chapters.

- Building Lambda functions with Node.js (p. 282)
- Building Lambda functions with Python (p. 324)
- Building Lambda functions with Ruby (p. 354)
- Building Lambda functions with Java (p. 379)
- Building Lambda functions with Go (p. 420)
- Building Lambda functions with C# (p. 449)
- Building Lambda functions with PowerShell (p. 481)

Lambda scales your function by running additional instances of it as demand increases, and by stopping instances as demand decreases. Unless noted otherwise, incoming requests might be processed out of order or concurrently. Store your application's state in other services, and don't rely on instances of your function being long lived. Use local storage and class-level objects to increase performance, but keep to a minimum the size of your deployment package and the amount of data that you transfer onto the execution environment.

# Lambda instruction set architectures

The *instruction set architecture* of a Lambda function determines the type of computer processor that Lambda uses to run the function. Lambda provides a choice of instruction set architectures:

- arm64 – 64-bit ARM architecture, for the AWS Graviton2 processor. The arm64 architecture is available in most AWS Regions.
- x86_64 – 64-bit x86 architecture, for x86-based processors.

**Topics**


- Advantages of using arm64 architecture (p. 23)
- Function migration to arm64 architecture (p. 23)
- Function code compatibility with arm64 architecture (p. 23)
- Suggested migration steps (p. 24)
- Configuring the instruction set architecture (p. 24)


## Advantages of using arm64 architecture

Lambda functions that use arm64 architecture (AWS Graviton2 processor) can achieve significantly better price and performance than the equivalent function running on x86_64 architecture. Consider using arm64 for compute-intensive applications such as high-performance computing, video encoding, and simulation workloads.

The Graviton2 CPU uses the Neoverse N1 core and supports Armv8.2 (including CRC and crypto extensions) plus several other architectural extensions.

Graviton2 reduces memory read time by providing a larger L2 cache per vCPU, which improves the latency performance of web and mobile backends, microservices, and data processing systems. Graviton2 also provides improved encryption performance and supports instruction sets that improve the latency of CPU-based machine learning inference.

For more information about AWS Graviton2, see AWS Graviton Processor.

## Function migration to arm64 architecture

When you select a Lambda function to migrate to arm64 architecture, to ensure a smooth migration, make sure that your function meets the following requirements:

- The function currently uses a Lambda Amazon Linux 2 runtime.
- The deployment package contains only open-source components and source code that you control, so that you can make any necessary updates for the migration.
- If the function code includes third-party dependencies, each library or package provides an arm64 version.

## Function code compatibility with arm64 architecture

Your Lambda function code must be compatible with the instruction set architecture of the function. Before you migrate a function to arm64 architecture, note the following points about the current function code:

- If you added your function code using the embedded code editor, your code probably runs on either architecture without modification.

- If you uploaded your function code, you must upload new code that is compatible with your target architecture.
- If your function uses layers, you must check each layer (p. 222) to ensure that it is compatible with the new architecture. If a layer is not compatible, edit the function to replace the current layer version with a compatible layer version.
- If your function uses Lambda extensions, you must check each extension to ensure that it is compatible with the new architecture.
- If your function uses a container image deployment package type, you must create a new container image that is compatible with the architecture of the function.

## Suggested migration steps

To migrate a Lambda function to the arm64 architecture, we recommend following these steps:

1. Build the list of dependencies for your application or workload. Common dependencies include:
   - All the libraries and packages that the function uses.
   - The tools that you use to build, deploy, and test the function, such as compilers, test suites, continuous integration and continuous delivery (CI/CD) pipelines, provisioning tools, and scripts.
   - The Lambda extensions and third-party tools that you use to monitor the function in production.
2. For each of the dependencies, check the version, and then check whether arm64 versions are available.
3. Build an environment to migrate your application.
4. Bootstrap the application.
5. Test and debug the application.
6. Test the performance of the arm64 function. Compare the performance with the x86_64 version.
7. Update your infrastructure pipeline to support arm64 Lambda functions.
8. Stage your deployment to production.

   For example, use alias routing configuration (p. 176) to split traffic between the x86 and arm64 versions of the function, and compare the performance and latency.

For more information about how to create a code environment for arm64 architecture, including language-specific information for Java, Go, .NET, and Python, see the Getting started with AWS Graviton GitHub repository.

# Configuring the instruction set architecture

You can configure the instruction set architecture for new Lambda functions using the Lambda console, AWS SDKs, AWS Command Line Interface (AWS CLI), or AWS CloudFormation. You can deploy the function code to Lambda with either a .zip archive file or a container image deployment package.

Lambda provides the following runtimes for the arm64 architecture. These runtimes all use the Amazon Linux 2 operating system.

- Node.js 12, Node.js 14, Node.js 16
- Python 3.8, Python 3.9
- Java 8 (AL2), Java 11
- .NET Core 3.1
- Ruby 2.7
- Custom Runtime on Amazon Linux 2

**Note**
Runtimes that use the Amazon Linux operating system, such as Go 1.x, do not support the arm64 architecture. To use arm64 architecture, you can run Go with the provided.al2 runtime. For example, see Build a Go function for the provided.al2 runtime (p. 429) or Create a Go image from the provided.al2 base image (p. 432).

For an example of how to create a function with arm64 architecture, see AWS Lambda Functions Powered by AWS Graviton2 Processor.

# VPC networking for Lambda

Amazon Virtual Private Cloud (Amazon VPC) is a virtual network in the AWS cloud, dedicated to your AWS account. You can use Amazon VPC to create a private network for resources such as databases, cache instances, or internal services. For more information about Amazon VPC, see What is Amazon VPC?

A Lambda function always runs inside a VPC owned by the Lambda service. Lambda applies network access and security rules to this VPC and Lambda maintains and monitors the VPC automatically. If your Lambda function needs to access the resources in your account VPC, configure the function to access the VPC (p. 191). Lambda provides managed resources named Hyperplane ENIs, which your Lambda function uses to connect from the Lambda VPC to an ENI (Elastic network interface) in your account VPC.

There's no additional charge for using a VPC or a Hyperplane ENI. There are charges for some VPC components, such as NAT gateways. For more information, see Amazon VPC Pricing.

**Topics**


- VPC network elements (p. 26)
- Connecting Lambda functions to your VPC (p. 27)
- Lambda Hyperplane ENIs (p. 27)
- Connections (p. 28)
- Security (p. 28)
- Observability (p. 29)


## VPC network elements

Amazon VPC networks includes the following network elements:

- Elastic network interface – elastic network interface is a logical networking component in a VPC that represents a virtual network card.
- Subnet – A range of IP addresses in your VPC. You can add AWS resources to a specified subnet. Use a public subnet for resources that must connect to the internet, and a private subnet for resources that don't connect to the internet.
- Security group – use security groups to control access to the AWS resources in each subnet.
- Access control list (ACL) – use a network ACL to provide additional security in a subnet. The default subnet ACL allows all inbound and outbound traffic.
- Route table – contains a set of routes that AWS uses to direct the network traffic for your VPC. You can explicitly associate a subnet with a particular route table. By default, the subnet is associated with the main route table.
- Route – each route in a route table specifies a range of IP addresses and the destination where Lambda sends the traffic for that range. The route also specifies a target, which is the gateway, network interface, or connection through which to send the traffic.
- NAT gateway – An AWS Network Address Translation (NAT) service that controls access from a private VPC private subnet to the Internet.
- VPC endpoints – You can use an Amazon VPC endpoint to create private connectivity to services hosted in AWS, without requiring access over the internet or through a NAT device, VPN connection, or AWS Direct Connect connection. For more information, see AWS PrivateLink and VPC endpoints.

For more information about Amazon VPC networking definitions, see How Amazon VPC works in the Amazon VPC Developer Guide and the Amazon VPC FAQs.

# Connecting Lambda functions to your VPC

A Lambda function always runs inside a VPC owned by the Lambda service. By default, a Lambda function isn't connected to VPCs in your account. When you connect a function to a VPC in your account, the function can't access the internet unless your VPC provides access.

Lambda accesses resources in your VPC using a Hyperplane ENI. Hyperplane ENIs provide NAT capabilities from the Lambda VPC to your account VPC using VPC-to-VPC NAT (V2N). V2N provides connectivity from the Lambda VPC to your account VPC, but not in the other direction.

When you create a Lambda function (or update its VPC settings), Lambda allocates a Hyperplane ENI for each subnet in your function's VPC configuration. Multiple Lambda functions can share a network interface, if the functions share the same subnet and security group.

To connect to another AWS service, you can use VPC endpoints for private communications between your VPC and supported AWS services. An alternative approach is to use a NAT gateway to route outbound traffic to another AWS service.

To give your function access to the internet, route outbound traffic to a NAT gateway in a public subnet. The NAT gateway has a public IP address and can connect to the internet through the VPC's internet gateway.

For information about how to configure Lambda VPC networking, see Lambda networking (p. 191).

# Lambda Hyperplane ENIs

The Hyperplane ENI is a managed network resource that the Lambda service creates and manages. Multiple execution environments in the Lambda VPC can use a Hyperplane ENI to securely access resources inside of VPCs in your account. Hyperplane ENIs provide NAT capabilities from the Lambda VPC to your account VPC. For more information about Hyperplane ENIs, see Improved VPC networking for AWS Lambda functions in the AWS compute blog.

Each unique security group and subnet combination in your account requires a different network interface. Functions in the account that share the same security group and subnet combination use the same network interfaces.

Because the functions in your account share the ENI resources, the ENI lifecycle is more complex than other Lambda resources. The following sections describe the ENI lifecycle.

**ENI lifecycle**

- Creating ENIs (p. 27)
- Managing ENIs (p. 28)
- Deleting ENIs (p. 28)

## Creating ENIs

Lambda may create Hyperplane ENI resources for a newly created VPC-enabled function or for a VPC configuration change to an existing function. The function remains in pending state while Lambda creates the required resources. When the Hyperplane ENI is ready, the function transitions to active state and the ENI becomes available for use. Lambda can require several minutes to create a Hyperplane ENI.

For a newly created VPC-enabled function, any invocations or other API actions that operate on the function fail until the function state transitions to active.

For a VPC configuration change to an existing function, any function invocations continue to use the Hyperplane ENI associated with the old subnet and security group configuration until the function state transitions to active.

If a Lambda function remains idle for consecutive weeks, Lambda reclaims the unused Hyperplane ENIs and sets the function state to idle. The next invocation causes Lambda to reactivate the idle function. The invocation fails, and the function enters pending state until Lambda completes the creation or allocation of a Hyperplane ENI.

For more information about function states, see Lambda function states (p. 248).

## Managing ENIs

Lambda uses permissions in your function's execution role to create and manage network interfaces. Lambda creates a Hyperplane ENI when you define a unique subnet plus security group combination for a VPC-enabled function in an account. Lambda reuses the Hyperplane ENI for other VPC-enabled functions in your account that use the same subnet and security group combination.

There is no quota on the number of Lambda functions that can use the same Hyperplane ENI. However, each Hyperplane ENI supports up to 65,000 connections/ports. If the number of connections exceeds 65,000, Lambda creates a new Hyperplane ENI to provide additional connections.

When you update your function configuration to access a different VPC, Lambda terminates connectivity to the Hyperplane ENI in the previous VPC. The process to update the connectivity to a new VPC can take several minutes. During this time, invocations to the function continue to use the previous VPC. After the update is complete, new invocations start using the Hyperplane ENI in the new VPC. At this point, the Lambda function is no longer connected to the previous VPC.

## Deleting ENIs

When you update a function to remove its VPC configuration, Lambda requires up to 20 minutes to delete the attached Hyperplane ENI. Lambda only deletes the ENI if no other function (or published function version) is using that Hyperplane ENI.

Lambda relies on permissions in the function execution role (p. 52) to delete the Hyperplane ENI. If you delete the execution role before Lambda deletes the Hyperplane ENI, Lambda won't be able to delete the Hyperplane ENI. You can manually perform the deletion.

Lambda doesn't delete network interfaces that are in use by functions or function versions in your account. You can use the Lambda ENI Finder to identify the functions or function versions that are using a Hyperplane ENI. For any functions or function versions that you no longer need, you can remove the VPC configuration so that Lambda deletes the Hyperplane ENI.

# Connections

Lambda supports two types of connections: TCP (Transmission Control Protocol) and UDP (User Datagram Protocol).

When you create a VPC, Lambda automatically creates a set of DHCP options and associates them with the VPC. You can configure your own DHCP options set for your VPC. For more details, refer to Amazon VPC DHCP options.

Amazon provides a DNS server (the Amazon Route 53 resolver) for your VPC. For more information, see DNS support for your VPC.

# Security

AWS provides *security groups* and *network ACLs* to increase security in your VPC. Security groups control inbound and outbound traffic for your instances, and network ACLs control inbound and outbound traffic for your subnets. Security groups provide enough access control for most subnets. You can use network ACLs if you want an additional layer of security for your VPC. For more information, see Internetwork

traffic privacy in Amazon VPC. Every subnet that you create is automatically associated with the VPC's default network ACL. You can change the association, and you can change the contents of the default network ACL.

For general security best practices, see VPC security best practices. For details on how you can use IAM to manage access to the Lambda API and resources, see AWS Lambda permissions (p. 51).

You can use Lambda-specific condition keys for VPC settings to provide additional permission controls for your Lambda functions. For more information about VPC condition keys, see Using IAM condition keys for VPC settings (p. 194).

# Observability

You can use VPC Flow Logs to capture information about the IP traffic going to and from network interfaces in your VPC. You can publish Flow log data to Amazon CloudWatch Logs or Amazon S3. After you've created a flow log, you can retrieve and view its data in the chosen destination.

Note: when you attach a function to a VPC, the CloudWatch log messages do not use the VPC routes. Lambda sends them using the regular routing for logs.

# Lambda function scaling

The first time you invoke your function, AWS Lambda creates an instance of the function and runs its handler method to process the event. When the function returns a response, it stays active and waits to process additional events. If you invoke the function again while the first event is being processed, Lambda initializes another instance, and the function processes the two events concurrently. As more events come in, Lambda routes them to available instances and creates new instances as needed. When the number of requests decreases, Lambda stops unused instances to free up scaling capacity for other functions.

The default regional concurrency quota starts at 1,000 instances. For more information, or to request an increase on this quota, see Lambda quotas (p. 796). To allocate capacity on a per-function basis, you can configure functions with reserved concurrency (p. 180).

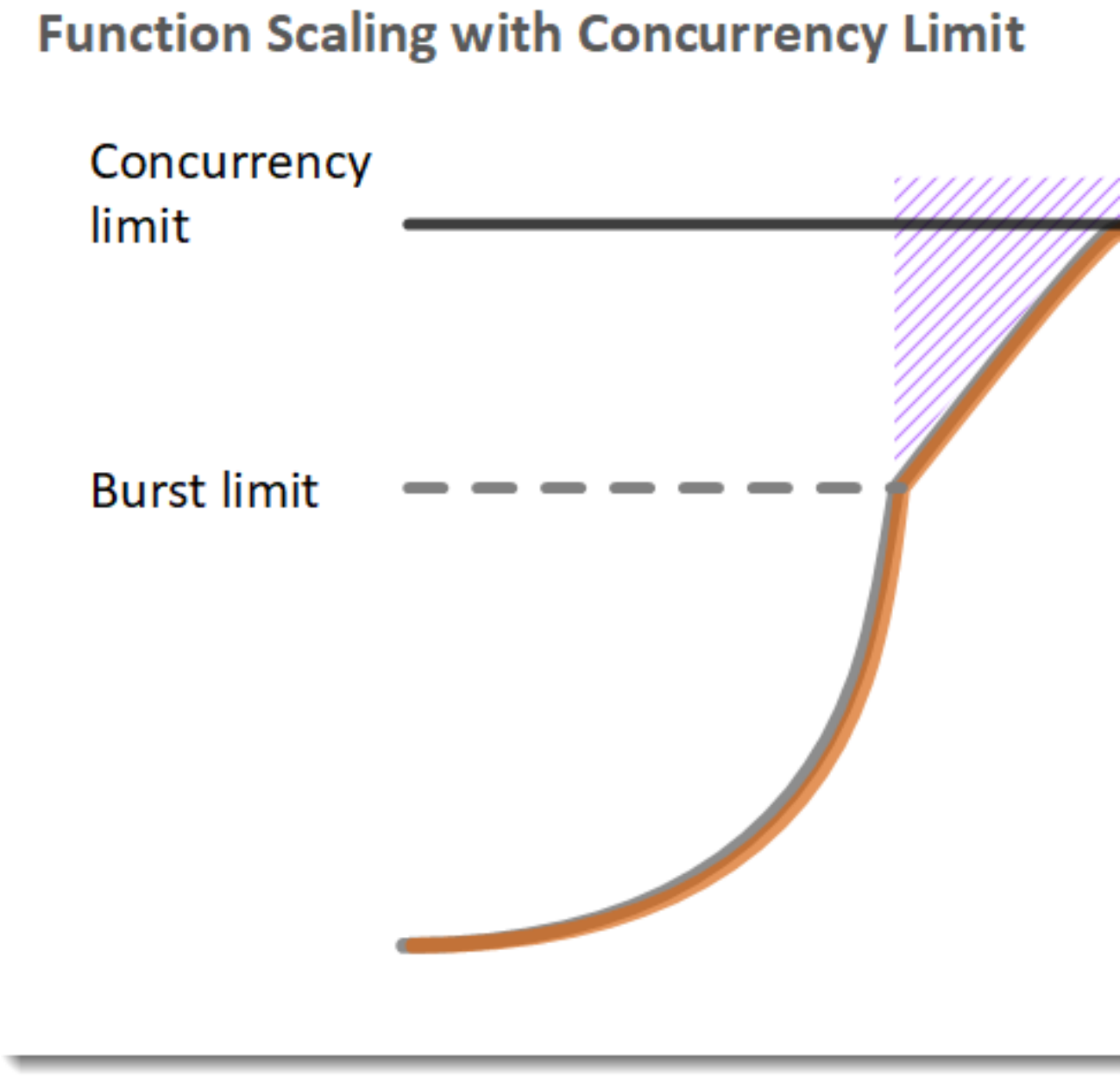
Your functions' *concurrency* is the number of instances that serve requests at a given time. For an initial burst of traffic, your functions' cumulative concurrency in a Region can reach an initial level of between 500 and 3000, which varies per Region. Note that the burst concurrency quota is not per-function; it applies to all your functions in the Region.

**Burst concurrency quotas**

- **3000** – US West (Oregon), US East (N. Virginia), Europe (Ireland)
- **1000** – Asia Pacific (Tokyo), Europe (Frankfurt), US East (Ohio)
- **500** – Other Regions

After the initial burst, your functions' concurrency can scale by an additional 500 instances each minute. This continues until there are enough instances to serve all requests, or until a concurrency limit is reached. When requests come in faster than your function can scale, or when your function is at maximum concurrency, additional requests fail with a throttling error (429 status code).

The following example shows a function processing a spike in traffic. As invocations increase exponentially, the function scales up. It initializes a new instance for any request that can't be routed to an available instance. When the burst concurrency limit is reached, the function starts to scale linearly. If this isn't enough concurrency to serve all requests, additional requests are throttled and should be retried.

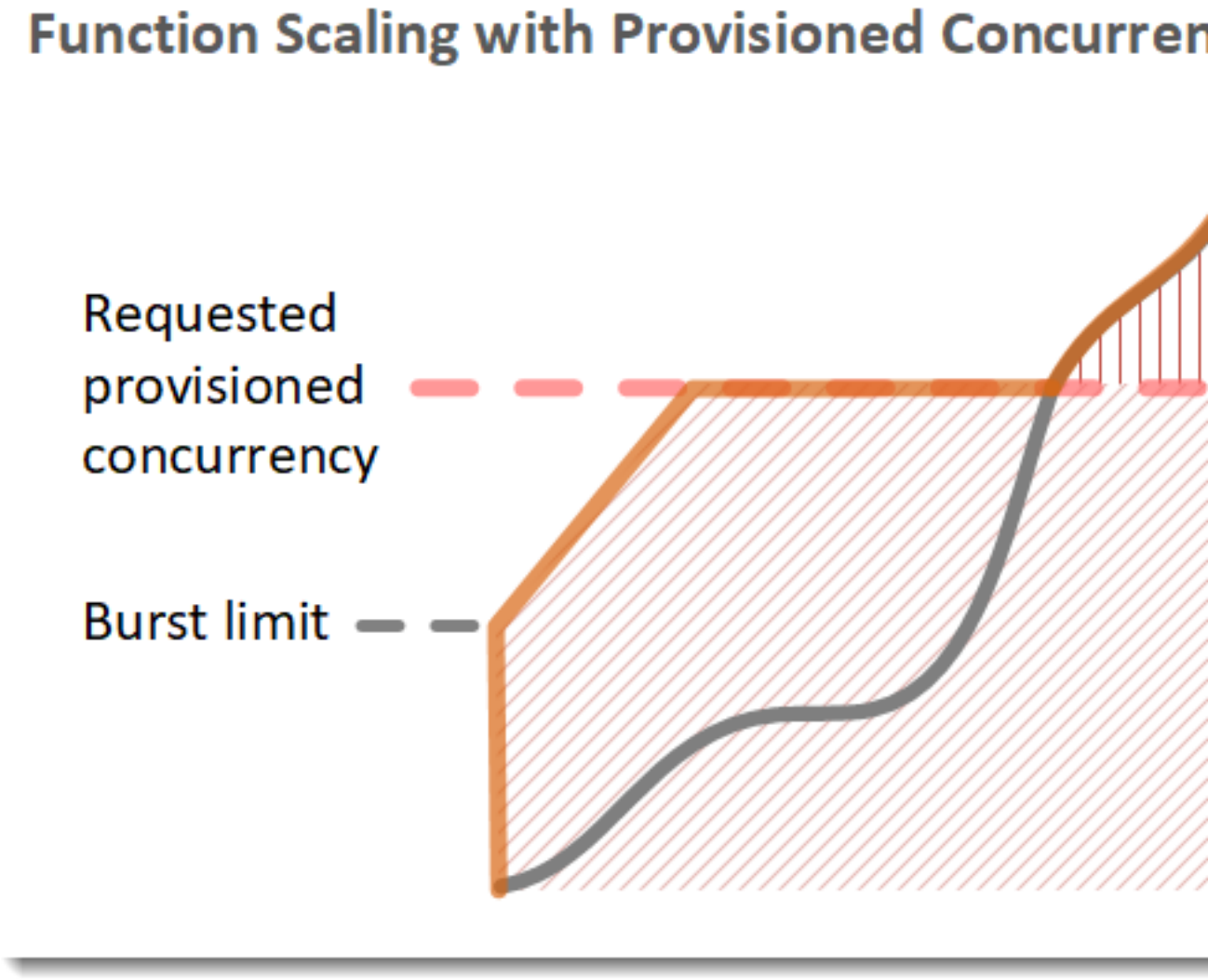



**Legend**

- Function instances
- Open requests
- Throttling possible

The function continues to scale until the account's concurrency limit for the function's Region is reached. The function catches up to demand, requests subside, and unused instances of the function are stopped after being idle for some time. Unused instances are frozen while they're waiting for requests and don't incur any charges.

When your function scales up, the first request served by each instance is impacted by the time it takes to load and initialize your code. If your initialization code (p. 22) takes a long time, the impact on average and percentile latency can be significant. To enable your function to scale without fluctuations in latency, use provisioned concurrency (p. 183). The following example shows a function with provisioned concurrency processing a spike in traffic.




**Legend**

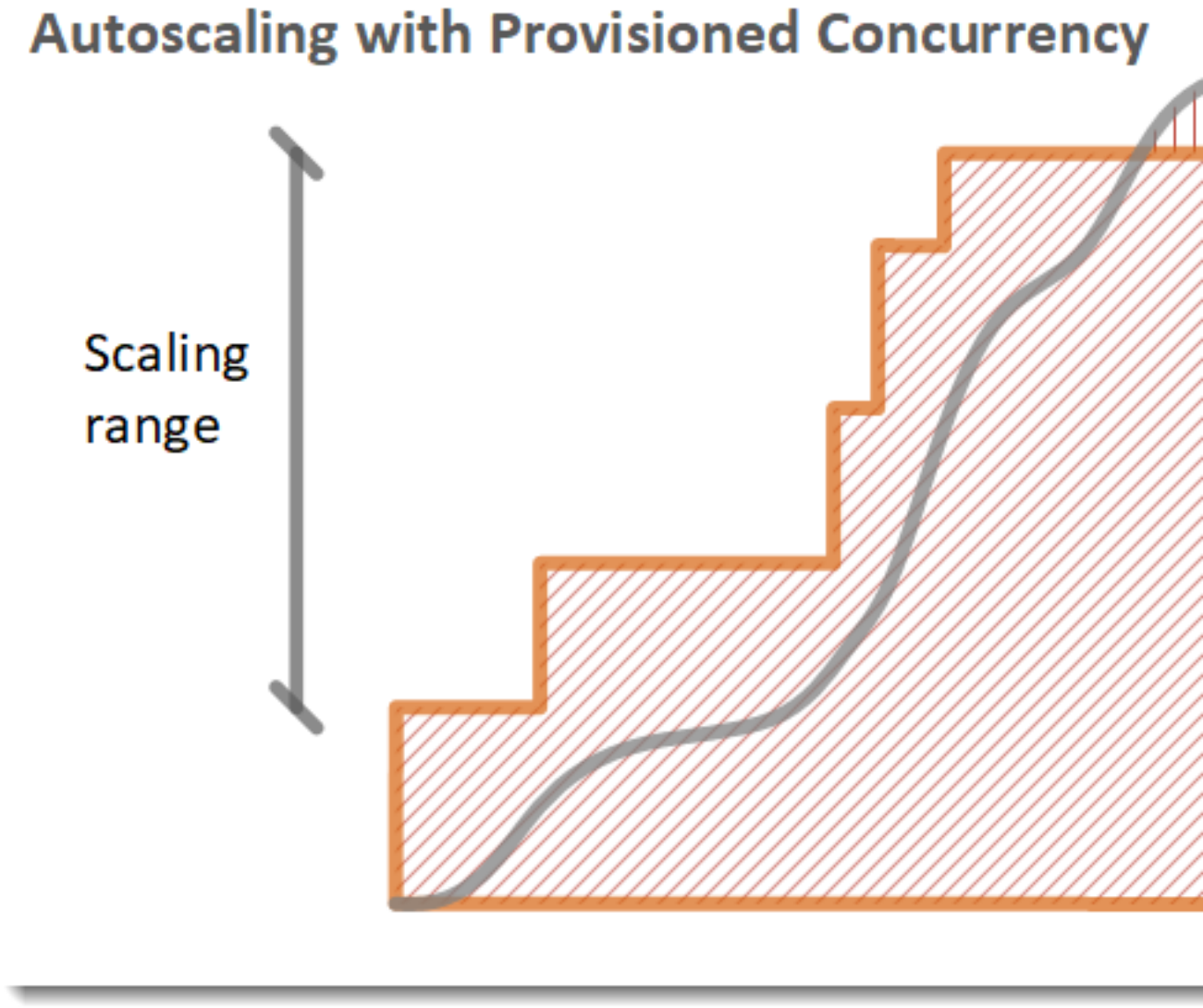
- Function instances
- Open requests
- Provisioned concurrency
- Standard concurrency

When you configure a number for provisioned concurrency, Lambda initializes that number of execution environments. Your function is ready to serve a burst of incoming requests with very low latency. Note that configuring provisioned concurrency (p. 183) incurs charges to your AWS account.

When all provisioned concurrency is in use, the function scales up normally to handle any additional requests.

Application Auto Scaling takes this a step further by providing autoscaling for provisioned concurrency. With Application Auto Scaling, you can create a target tracking scaling policy that adjusts provisioned concurrency levels automatically, based on the utilization metric that Lambda emits. Use the Application Auto Scaling API (p. 182) to register an alias as a scalable target and create a scaling policy.

In the following example, a function scales between a minimum and maximum amount of provisioned concurrency based on utilization. When the number of open requests increases, Application Auto Scaling increases provisioned concurrency in large steps until it reaches the configured maximum. The function continues to scale on standard concurrency until utilization starts to drop. When utilization is consistently low, Application Auto Scaling decreases provisioned concurrency in smaller periodic steps.




**Legend**

- Function instances

- Open requests
- Provisioned concurrency
- Standard concurrency

When you invoke your function asynchronously, by using an event source mapping or another AWS service, scaling behavior varies. For example, event source mappings that read from a stream are limited by the number of shards in the stream. Scaling capacity that is unused by an event source is available for use by other clients and event sources. For more information, see the following topics.

- Asynchronous invocation (p. 228)
- Lambda event source mappings (p. 236)
- Error handling and automatic retries in AWS Lambda (p. 250)
- Using AWS Lambda with other services (p. 496)

You can monitor concurrency levels in your account by using the following metrics:

### Concurrency metrics

- `ConcurrentExecutions`
- `UnreservedConcurrentExecutions`
- `ProvisionedConcurrentExecutions`
- `ProvisionedConcurrencyInvocations`
- `ProvisionedConcurrencySpilloverInvocations`
- `ProvisionedConcurrencyUtilization`

For more information, see Working with Lambda function metrics (p. 727).

# Lambda deployment packages

Your AWS Lambda function's code consists of scripts or compiled programs and their dependencies. You use a *deployment package* to deploy your function code to Lambda. Lambda supports two types of deployment packages: container images and .zip file archives.

**Topics**


- Container images (p. 35)
- .zip file archives (p. 35)
- Layers (p. 36)
- Using other AWS services to build a deployment package (p. 36)


## Container images

A container image includes the base operating system, the runtime, Lambda extensions, your application code and its dependencies. You can also add static data, such as machine learning models, into the image.

Lambda provides a set of open-source base images that you can use to build your container image. To create and test container images, you can use the AWS Serverless Application Model (AWS SAM) command line interface (CLI) or native container tools such as the Docker CLI.

You upload your container images to Amazon Elastic Container Registry (Amazon ECR), a managed AWS container image registry service. To deploy the image to your function, you specify the Amazon ECR image URL using the Lambda console, the Lambda API, command line tools, or the AWS SDKs.

For more information about Lambda container images, see Creating Lambda container images (p. 143).

> **Note**
> Container images aren't supported for Lambda functions in the Middle East (UAE) Region.

## .zip file archives

A .zip file archive includes your application code and its dependencies. When you author functions using the Lambda console or a toolkit, Lambda automatically creates a .zip file archive of your code.

When you create functions with the Lambda API, command line tools, or the AWS SDKs, you must create a deployment package. You also must create a deployment package if your function uses a compiled language, or to add dependencies to your function. To deploy your function's code, you upload the deployment package from Amazon Simple Storage Service (Amazon S3) or your local machine.

You can upload a .zip file as your deployment package using the Lambda console, AWS Command Line Interface (AWS CLI), or to an Amazon Simple Storage Service (Amazon S3) bucket.

### Using the Lambda console

The following steps demonstrate how to upload a .zip file as your deployment package using the Lambda console.

**To upload a .zip file on the Lambda console**

1. Open the Functions page on the Lambda console.
2. Select a function.
3. In the **Code Source** pane, choose **Upload from** and then **.zip file**.

4. Choose **Upload** to select your local .zip file.
5. Choose **Save**.

## Using the AWS CLI

You can upload a .zip file as your deployment package using the AWS Command Line Interface (AWS CLI). For language-specific instructions, see the following topics.

Node.js

Deploy Node.js Lambda functions with .zip file archives (p. 288)

Python

Deploy Python Lambda functions with .zip file archives (p. 330)

Ruby

Deploy Ruby Lambda functions with .zip file archives (p. 358)

Java

Deploy Java Lambda functions with .zip or JAR file archives (p. 386)

Go

Deploy Go Lambda functions with .zip file archives (p. 427)

C#

Deploy C# Lambda functions with .zip file archives (p. 458)

PowerShell

Deploy PowerShell Lambda functions with .zip file archives (p. 483)

## Using Amazon S3

You can upload a .zip file as your deployment package using Amazon Simple Storage Service (Amazon S3). For more information, see the section called “Using other AWS services”.

# Layers

If you deploy your function code using a .zip file archive, you can use Lambda layers as a distribution mechanism for libraries, custom runtimes, and other function dependencies. Layers enable you to manage your in-development function code independently from the unchanging code and resources that it uses. You can configure your function to use layers that you create, layers that AWS provides, or layers from other AWS customers.

You do not use layers with container images. Instead, you package your preferred runtime, libraries, and other dependencies into the container image when you build the image.

For more information about layers, see Creating and sharing Lambda layers (p. 156).

# Using other AWS services to build a deployment package

The following section describes other AWS services you can use to package dependencies for your Lambda function.

## Deployment packages with C or C++ libraries

If your deployment package contains native libraries, you can build the deployment package with AWS Serverless Application Model (AWS SAM). You can use the AWS SAM CLI `sam build` command with the `--use-container` to create your deployment package. This option builds a deployment package inside a Docker image that is compatible with the Lambda execution environment.

For more information, see sam build in the *AWS Serverless Application Model Developer Guide*.

## Deployment packages over 50 MB

If your deployment package is larger than 50 MB, upload your function code and dependencies to an Amazon S3 bucket.

You can create a deployment package and upload the .zip file to your Amazon S3 bucket in the AWS Region where you want to create a Lambda function. When you create your Lambda function, specify the S3 bucket name and object key name on the Lambda console, or using the AWS CLI.

To create a bucket using the Amazon S3 console, see How do I create an S3 Bucket? in the *Amazon Simple Storage Service Console User Guide*.

# Lambda console

You can use the Lambda console to configure applications, functions, code signing configurations, and layers.

**Topics**


- Applications (p. 38)
- Functions (p. 38)
- Code signing (p. 38)
- Layers (p. 38)
- Edit code using the console editor (p. 38)


## Applications

The Applications (p. 760) page shows you a list of applications that have been deployed using AWS CloudFormation, or other tools including the AWS Serverless Application Model. Filter to find applications based on keywords.

## Functions

The functions page shows you a list of functions defined for your account in this region. The initial console flow to create a function depends on whether the function uses a container image (p. 136) or .zip file archive (p. 132) for the deployment package. Many of the optional configuration tasks (p. 162) are common to both types of function.

The console provides a code editor (p. 38) for your convenience.

## Code signing

You can attach a code signing (p. 211) configuration to a function. With code signing, you can ensure that the code has been signed by an approved source and has not been altered since signing, and that the code signature has not expired or been revoked.

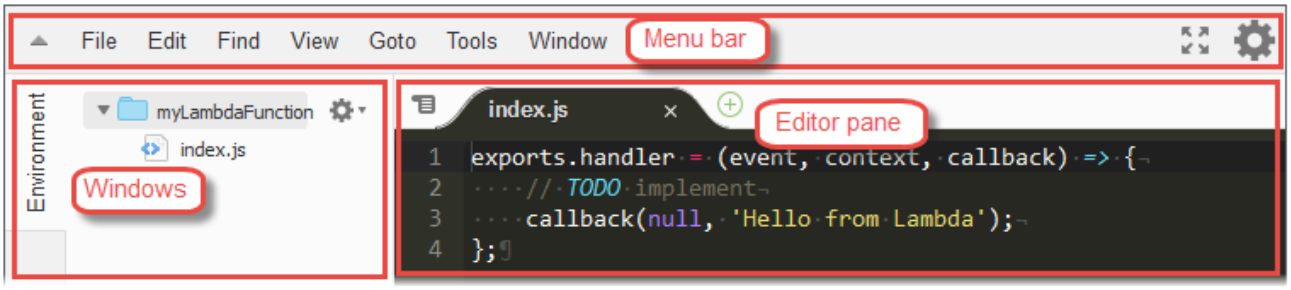
## Layers

Create layers (p. 156) to separate your .zip archive function code from its dependencies. A layer is a ZIP archive that contains libraries, a custom runtime, or other dependencies. With layers, you can use libraries in your function without needing to include them in your deployment package.

## Edit code using the console editor

You can use the code editor in the AWS Lambda console to write, test, and view the execution results of your Lambda function code. The code editor supports languages that do not require compiling, such as Node.js and Python. The code editor suppports only .zip archive deployment packages, and the size of the deployment package must be less than 3 MB.

The code editor includes the *menu bar*, *windows*, and the *editor pane*.



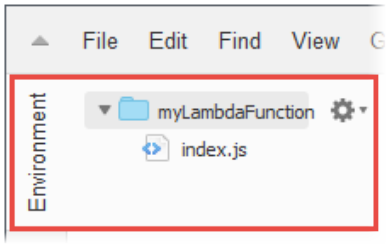

For a list of what the commands do, see the Menu commands reference in the *AWS Cloud9 User Guide*. Note that some of the commands listed in that reference are not available in the code editor.

**Topics**

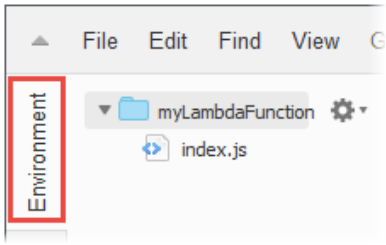

- Working with files and folders (p. 39)
- Working with code (p. 41)
- Working in fullscreen mode (p. 44)
- Working with preferences (p. 44)

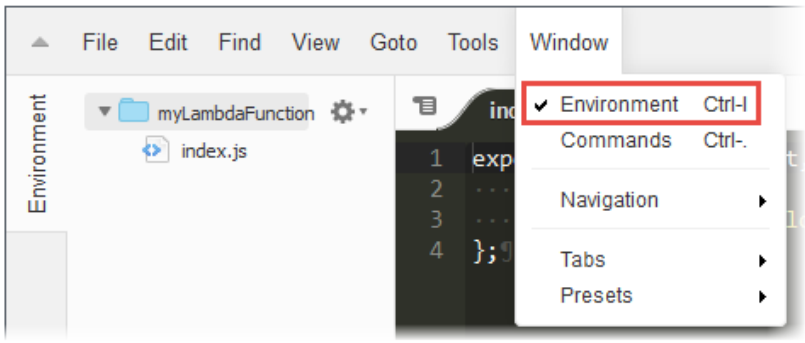

## Working with files and folders

You can use the **Environment** window in the code editor to create, open, and manage files for your function.




**To show or hide the Environment window**, choose the **Environment** button. If the **Environment** button is not visible, choose **Window, Environment** on the menu bar.



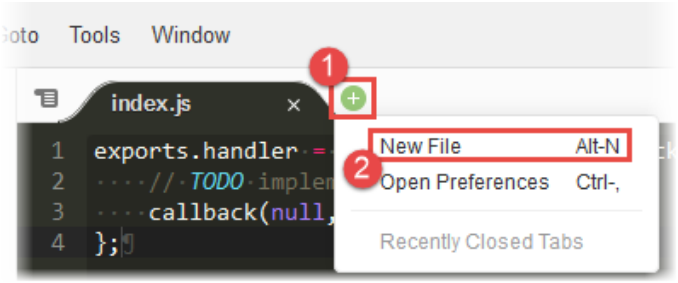



**To open a single file and show its contents in the editor pane**, double-click the file in the **Environment** window.

**To open multiple files and show their contents in the editor pane**, choose the files in the **Environment** window. Right-click the selection, and then choose **Open**.

**To create a new file**, do one of the following:

- In the **Environment** window, right-click the folder where you want the new file to go, and then choose **New File**. Type the file's name and extension, and then press **Enter**.
- Choose **File, New File** on the menu bar. When you're ready to save the file, choose **File, Save** or **File, Save As** on the menu bar. Then use the **Save As** dialog box that displays to name the file and choose where to save it.
- In the tab buttons bar in the editor pane, choose the **+** button, and then choose **New File**. When you're ready to save the file, choose **File, Save** or **File, Save As** on the menu bar. Then use the **Save As** dialog box that displays to name the file and choose where to save it.




**To create a new folder**, right-click the folder in the **Environment** window where you want the new folder to go, and then choose **New Folder**. Type the folder's name, and then press **Enter**.

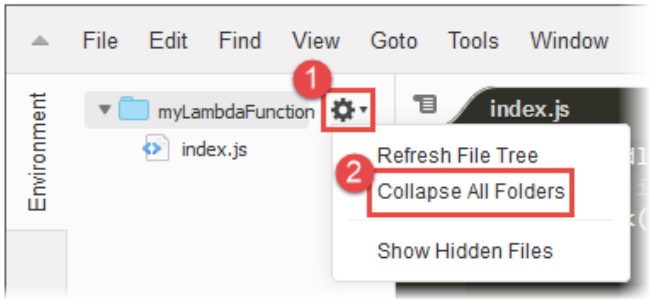
**To save a file**, with the file open and its contents visible in the editor pane, choose **File, Save** on the menu bar.

**To rename a file or folder**, right-click the file or folder in the **Environment** window. Type the replacement name, and then press **Enter**.

**To delete files or folders**, choose the files or folders in the **Environment** window. Right-click the selection, and then choose **Delete**. Then confirm the deletion by choosing **Yes** (for a single selection) or **Yes to All**.

**To cut, copy, paste, or duplicate files or folders**, choose the files or folders in the **Environment** window. Right-click the selection, and then choose **Cut**, **Copy**, **Paste**, or **Duplicate**, respectively.

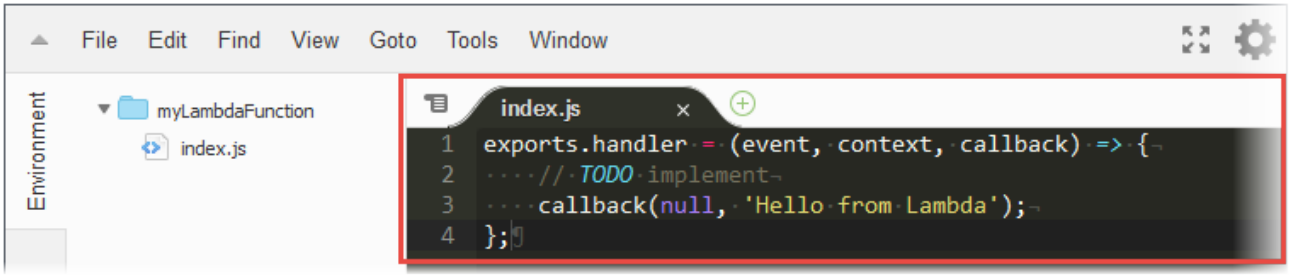
**To collapse folders**, choose the gear icon in the **Environment** window, and then choose **Collapse All Folders**.




**To show or hide hidden files**, choose the gear icon in the **Environment** window, and then choose **Show Hidden Files**.

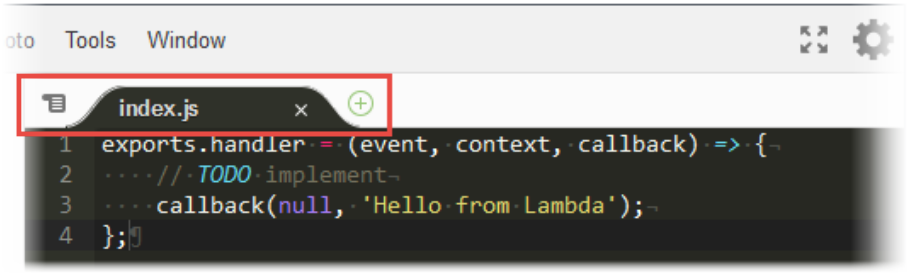
## Working with code

Use the editor pane in the code editor to view and write code.



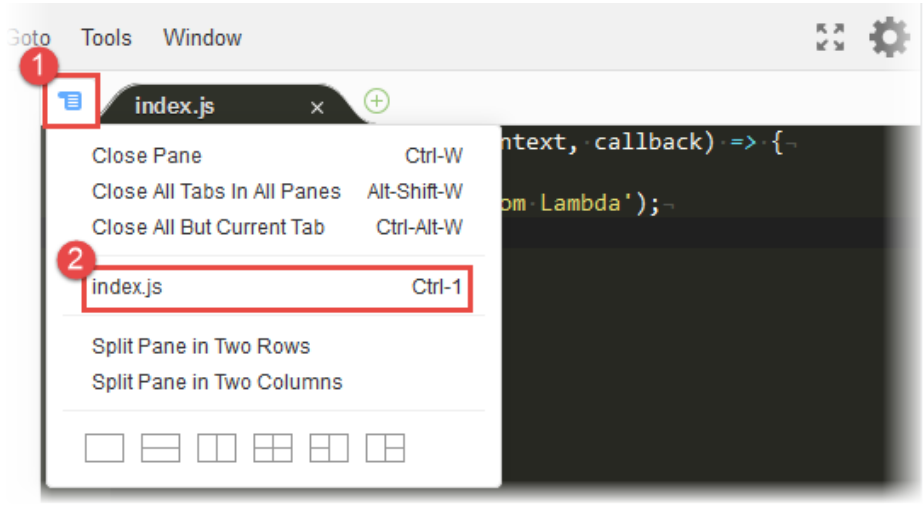

### Working with tab buttons

Use the *tab buttons bar* to select, view, and create files.




**To display an open file's contents**, do one of the following:

- Choose the file's tab.
- Choose the drop-down menu button in the tab buttons bar, and then choose the file's name.




**To close an open file**, do one of the following:

- Choose the **X** icon in the file's tab.
- Choose the file's tab. Then choose the drop-down menu button in the tab buttons bar, and choose **Close Pane**.

**To close multiple open files**, choose the drop-down menu in the tab buttons bar, and then choose **Close All Tabs in All Panes** or **Close All But Current Tab** as needed.

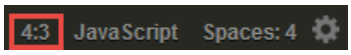
**To create a new file**, choose the **+** button in the tab buttons bar, and then choose **New File**. When you're ready to save the file, choose **File, Save** or **File, Save As** on the menu bar. Then use the **Save As** dialog box that displays to name the file and choose where to save it.

## Working with the status bar

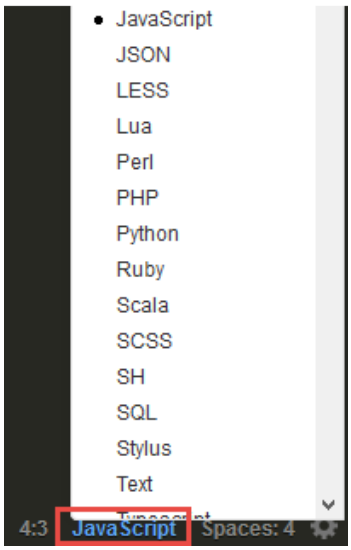
Use the status bar to move quickly to a line in the active file and to change how code is displayed.



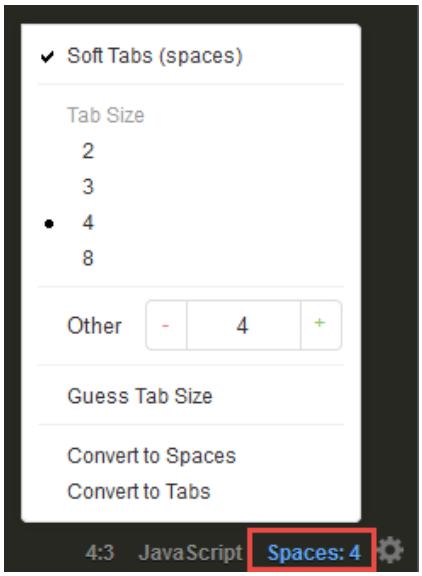

**To move quickly to a line in the active file**, choose the line selector, type the line number to go to, and then press **Enter**.



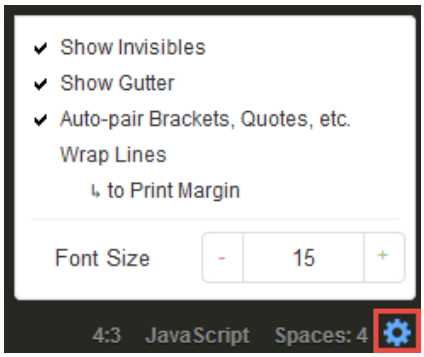

**To change the code color scheme in the active file**, choose the code color scheme selector, and then choose the new code color scheme.




**To change in the active file whether soft tabs or spaces are used, the tab size, or whether to convert to spaces or tabs**, choose the spaces and tabs selector, and then choose the new settings.



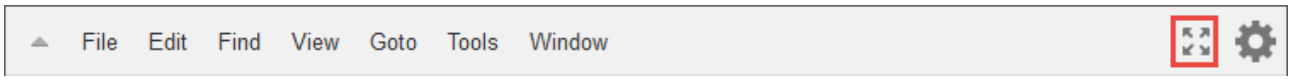

**To change for all files whether to show or hide invisible characters or the gutter, auto-pair brackets or quotes, wrap lines, or the font size**, choose the gear icon, and then choose the new settings.




## Working in fullscreen mode

You can expand the code editor to get more room to work with your code.

To expand the code editor to the edges of the web browser window, choose the **Toggle fullscreen** button in the menu bar.



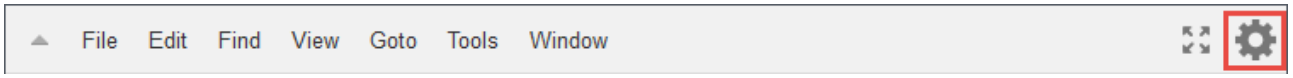

To shrink the code editor to its original size, choose the **Toggle fullscreen** button again.

In fullscreen mode, additional options are displayed on the menu bar: **Save** and **Test**. Choosing **Save** saves the function code. Choosing **Test** or **Configure Events** enables you to create or edit the function's test events.

## Working with preferences

You can change various code editor settings such as which coding hints and warnings are displayed, code folding behaviors, code autocompletion behaviors, and much more.

To change code editor settings, choose the **Preferences** gear icon in the menu bar.




For a list of what the settings do, see the following references in the *AWS Cloud9 User Guide*.

- Project setting changes you can make
- User setting changes you can make

Note that some of the settings listed in those references are not available in the code editor.

# Using Lambda with the AWS CLI

You can use the AWS Command Line Interface to manage functions and other AWS Lambda resources. The AWS CLI uses the AWS SDK for Python (Boto) to interact with the Lambda API. You can use it to learn about the API, and apply that knowledge in building applications that use Lambda with the AWS SDK.

In this tutorial, you manage and invoke Lambda functions with the AWS CLI. For more information, see What is the AWS CLI? in the *AWS Command Line Interface User Guide*.

## Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in the section called “Create a Lambda function with the console” (p. 8).

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

This tutorial uses the AWS Command Line Interface (AWS CLI) to call service API operations. To install the AWS CLI, see Installing the AWS CLI in the AWS Command Line Interface User Guide.

## Create the execution role

Create the execution role (p. 52) that gives your function permission to access AWS resources. To create an execution role with the AWS CLI, use the `create-role` command.

In the following example, you specify the trust policy inline. Requirements for escaping quotes in the JSON string vary depending on your shell.

```
aws iam create-role --role-name lambda-ex --assume-role-policy-document '{"Version":
 "2012-10-17","Statement": [{ "Effect": "Allow", "Principal": {"Service":
 "lambda.amazonaws.com"}, "Action": "sts:AssumeRole"}]}'
```

You can also define the trust policy for the role using a JSON file. In the following example, `trust-policy.json` is a file in the current directory. This trust policy allows Lambda to use the role's permissions by giving the service principal `lambda.amazonaws.com` permission to call the AWS Security Token Service (AWS STS) `AssumeRole` action.

**Example trust-policy.json**

```
{
  "Version": "2012-10-17",
```

```
  "Statement": [
    {
      "Effect": "Allow",
      "Principal": {
        "Service": "lambda.amazonaws.com"
      },
      "Action": "sts:AssumeRole"
    }
  ]
}
```

```
aws iam create-role --role-name lambda-ex --assume-role-policy-document file://trust-
policy.json
```

You should see the following output:

```
{
    "Role": {
        "Path": "/",
        "RoleName": "lambda-ex",
        "RoleId": "AROAQFOXMPL6TZ6ITKWND",
        "Arn": "arn:aws:iam::123456789012:role/lambda-ex",
        "CreateDate": "2020-01-17T23:19:12Z",
        "AssumeRolePolicyDocument": {
            "Version": "2012-10-17",
            "Statement": [
                {
                    "Effect": "Allow",
                    "Principal": {
                        "Service": "lambda.amazonaws.com"
                    },
                    "Action": "sts:AssumeRole"
                }
            ]
        }
    }
}
```

To add permissions to the role, use the **attach-policy-to-role** command. Start by adding the `AWSLambdaBasicExecutionRole` managed policy.

```
aws iam attach-role-policy --role-name lambda-ex --policy-arn arn:aws:iam::aws:policy/
service-role/AWSLambdaBasicExecutionRole
```

The **AWSLambdaBasicExecutionRole** policy has the permissions that the function needs to write logs to CloudWatch Logs.

# Create the function

The following example logs the values of environment variables and the event object.

**Example index.js**

```
exports.handler = async function(event, context) {
  console.log("ENVIRONMENT VARIABLES\n" + JSON.stringify(process.env, null, 2))
  console.log("EVENT\n" + JSON.stringify(event, null, 2))
  return context.logStreamName
}
```

### To create the function

1. Copy the sample code into a file named `index.js`.
2. Create a deployment package.

```
zip function.zip index.js
```

3. Create a Lambda function with the `create-function` command. Replace the highlighted text in the role ARN with your account ID.

```
aws lambda create-function --function-name my-function \
--zip-file fileb://function.zip --handler index.handler --runtime nodejs16.x \
--role arn:aws:iam::123456789012:role/lambda-ex
```

You should see the following output:

```
{
    "FunctionName": "my-function",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "Runtime": "nodejs16.x",
    "Role": "arn:aws:iam::123456789012:role/lambda-ex",
    "Handler": "index.handler",
    "CodeSha256": "FpFMvUhayLkOoVBpNuNiIVML/tuGv2iJQ7t0yWVTU8c=",
    "Version": "$LATEST",
    "TracingConfig": {
        "Mode": "PassThrough"
    },
    "RevisionId": "88ebe1e1-bfdf-4dc3-84de-3017268fa1ff",
    ...
}
```

To get logs for an invocation from the command line, use the `--log-type` option. The response includes a `LogResult` field that contains up to 4 KB of base64-encoded logs from the invocation.

```
aws lambda invoke --function-name my-function out --log-type Tail
```

You should see the following output:

```
{
    "StatusCode": 200,
    "LogResult":
 "U1RBUlQgUmVxdWVzdElkOiA4N2QwNDRiOC1mMTU0LTExZTgtOGNkYS0yOTc0YzVlNGZiMjEgVmVyc2lvb...",
    "ExecutedVersion": "$LATEST"
}
```

You can use the `base64` utility to decode the logs.

```
aws lambda invoke --function-name my-function out --log-type Tail \
--query 'LogResult' --output text |  base64 -d
```

You should see the following output:

```
START RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8 Version: $LATEST
  "AWS_SESSION_TOKEN": "AgoJb3JpZ2luX2VjELj...", "_X_AMZN_TRACE_ID": "Root=1-5d02e5ca-
f5792818b6fe8368e5b51d50;Parent=191db58857df8395;Sampled=0"",ask/lib:/opt/lib",
END RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8
```

```
REPORT RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8  Duration: 79.67 ms      Billed
 Duration: 80 ms         Memory Size: 128 MB     Max Memory Used: 73 MB
```

The `base64` utility is available on Linux, macOS, and Ubuntu on Windows. For macOS, the command is `base64 -D`.

To get full log events from the command line, you can include the log stream name in the output of your function, as shown in the preceding example. The following example script invokes a function named `my-function` and downloads the last five log events.

### Example get-logs.sh Script

This example requires that `my-function` returns a log stream ID.

```
#!/bin/bash
aws lambda invoke --function-name my-function --cli-binary-format raw-in-base64-out --
payload '{"key": "value"}' out
sed -i'' -e 's/"//g' out
sleep 15
aws logs get-log-events --log-group-name /aws/lambda/my-function --log-stream-name $(cat
 out) --limit 5
```

The script uses `sed` to remove quotes from the output file, and sleeps for 15 seconds to allow time for the logs to be available. The output includes the response from Lambda and the output from the `get-log-events` command.

```
./get-logs.sh
```

You should see the following output:

```
{
    "StatusCode": 200,
    "ExecutedVersion": "$LATEST"
}
{
    "events": [
        {
            "timestamp": 1559763003171,
            "message": "START RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf Version:
 $LATEST\n",
            "ingestionTime": 1559763003309
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tENVIRONMENT VARIABLES\r{\r  \"AWS_LAMBDA_FUNCTION_VERSION\": \"$LATEST\",\r ...",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tEVENT\r{\r  \"key\": \"value\"\r}\n",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "END RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\n",
            "ingestionTime": 1559763018353
        },
        {
```

```
            "timestamp": 1559763003218,
            "message": "REPORT RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\tDuration:
 26.73 ms\tBilled Duration: 27 ms \tMemory Size: 128 MB\tMax Memory Used: 75 MB\t\n",
            "ingestionTime": 1559763018353
        }
    ],
    "nextForwardToken": "f/34783877304859518393868359594929986069206639495374241795",
    "nextBackwardToken": "b/34783877303811383369537420289090800615709599058929582080"
}
```

# Update the function

After you create a function, you can configure additional capabilities for the function, such as triggers, network access, and file system access. You can also adjust resources associated with the function, such as memory and concurrency. These configurations apply to functions defined as .zip file archives and to functions defined as container images.

Use the update-function-configuration command to configure functions. The following example sets the function memory to 256 MB.

**Example update-function-configuration command**

```
aws lambda update-function-configuration \
--function-name my-function \
--memory-size 256
```

# List the Lambda functions in your account

Run the following AWS CLI `list-functions` command to retrieve a list of functions that you have created.

```
aws lambda list-functions --max-items 10
```

You should see the following output:

```
{
    "Functions": [
        {
            "FunctionName": "cli",
            "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
            "Runtime": "nodejs16.x",
            "Role": "arn:aws:iam::123456789012:role/lambda-ex",
            "Handler": "index.handler",
            ...
        },
        {
            "FunctionName": "random-error",
            "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:random-error",
            "Runtime": "nodejs16.x",
            "Role": "arn:aws:iam::123456789012:role/lambda-role",
            "Handler": "index.handler",
            ...
        },
        ...
      ],
      "NextToken": "eyJNYXJrZXIiOiBudWxsLCAiYm90b190cnVuY2F0ZV9hbW91bnQiOiAxMH0="
}
```

In response, Lambda returns a list of up to 10 functions. If there are more functions you can retrieve, `NextToken` provides a marker you can use in the next `list-functions` request. The following `list-functions` AWS CLI command is an example that shows the `--starting-token` parameter.

```
aws lambda list-functions --max-items 10 --starting-
token eyJNYXJrZXIiOiBudWxsLCAiYm90b190cnVuY2F0ZV9hbW91bnQiOiAxMH0=
```

# Retrieve a Lambda function

The Lambda CLI `get-function` command returns Lambda function metadata and a presigned URL that you can use to download the function's deployment package.

```
aws lambda get-function --function-name my-function
```

You should see the following output:

```
{
    "Configuration": {
        "FunctionName": "my-function",
        "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
        "Runtime": "nodejs16.x",
        "Role": "arn:aws:iam::123456789012:role/lambda-ex",
        "CodeSha256": "FpFMvUhayLkOoVBpNuNiIVML/tuGv2iJQ7t0yWVTU8c=",
        "Version": "$LATEST",
        "TracingConfig": {
            "Mode": "PassThrough"
        },
        "RevisionId": "88ebe1e1-bfdf-4dc3-84de-3017268fa1ff",
        ...
    },
    "Code": {
        "RepositoryType": "S3",
        "Location": "https://awslambda-us-east-2-tasks.s3.us-east-2.amazonaws.com/
snapshots/123456789012/my-function-4203078a-b7c9-4f35-..."
    }
}
```

For more information, see GetFunction (p. 958).

# Clean up

Run the following `delete-function` command to delete the `my-function` function.

```
aws lambda delete-function --function-name my-function
```

Delete the IAM role you created in the IAM console. For information about deleting a role, see Deleting roles or instance profiles in the *IAM User Guide*.

# Lambda permissions

You can use AWS Identity and Access Management (IAM) to manage access to the Lambda API and resources such as functions and layers. For users and applications in your account that use Lambda, you can create IAM policies that apply to IAM users, groups, or roles.

Every Lambda function has an IAM role called an execution role (p. 52). In this role, you can attach a policy that defines the permissions that your function needs to access other AWS services and resources. At a minimum, your function needs access to Amazon CloudWatch Logs for log streaming. If your function calls other service APIs with the AWS SDK, you must include the necessary permissions in the execution role's policy. Lambda also uses the execution role to get permission to read from event sources when you use an event source mapping (p. 236) to invoke your function.

To give other accounts and AWS services permission to use your Lambda resources, use a resource-based policy (p. 68). Lambda resources include functions, versions, aliases, and layer versions. When a user tries to access a Lambda resource, Lambda considers both the user's identity-based policies (p. 59) and the resource's resource-based policy. When an AWS service such as Amazon Simple Storage Service (Amazon S3) calls your Lambda function, Lambda considers only the resource-based policy.

To manage permissions for users and applications in your account, we recommend using an AWS managed policy (p. 59). You can use these managed policies as-is, or as a starting point for writing your own more restrictive policies. Policies can restrict user permissions by the resource that an action affects, and by additional optional conditions. For more information, see Resources and conditions for Lambda actions (p. 74).

If your Lambda functions contain calls to other AWS resources, you might also want to restrict which functions can access those resources. To do this, include the `lambda:SourceFunctionArn` condition key in a resource-based policy for the target resource. For more information, see Working with Lambda execution environment credentials (p. 56).

For more information about IAM, see the *IAM User Guide*.

For more information about applying security principles to Lambda applications, see Security in the *AWS Lambda Operator Guide*.

**Topics**


- Lambda execution role (p. 52)
- Identity-based IAM policies for Lambda (p. 59)
- Attribute-based access control for Lambda (p. 64)
- Using resource-based policies for Lambda (p. 68)
- Resources and conditions for Lambda actions (p. 74)
- Using permissions boundaries for AWS Lambda applications (p. 80)

# Lambda execution role

A Lambda function's execution role is an AWS Identity and Access Management (IAM) role that grants the function permission to access AWS services and resources. For example, you might create an execution role that has permission to send logs to Amazon CloudWatch and upload trace data to AWS X-Ray.

You provide an execution role when you create a function. **When you invoke your function, Lambda automatically provides your function with temporary credentials by assuming this role.** You don't have to call `sts:AssumeRole` in your function code.

### To view a function's execution role

1. Open the Functions page of the Lambda console.
2. Choose the name of a function.
3. Choose **Configuration**, and then choose **Permissions**.
4. Under **Resource summary**, review the services and resources that the function can access.
5. Choose a service from the dropdown list to see permissions related to that service.

You can add or remove permissions from a function's execution role at any time, or configure your function to use a different role. Add permissions for any services that your function calls with the AWS SDK, and for services that Lambda uses to enable optional features.

When you add permissions to your function, update its code or configuration as well. This forces running instances of your function, which have outdated credentials, to stop and be replaced.

**Topics**


- Creating an execution role in the IAM console (p. 52)
- Grant least privilege access to your Lambda execution role (p. 53)
- Managing roles with the IAM API (p. 53)
- Session duration for temporary security credentials (p. 54)
- AWS managed policies for Lambda features (p. 54)
- Working with Lambda execution environment credentials (p. 56)


# Creating an execution role in the IAM console

By default, Lambda creates an execution role with minimal permissions when you create a function in the Lambda console (p. 8). You can also create an execution role in the IAM console.

### To create an execution role in the IAM console

1. Open the Roles page in the IAM console.
2. Choose **Create role**.
3. Under **Use case**, choose **Lambda**.
4. Choose **Next**.
5. Select the AWS managed policies **AWSLambdaBasicExecutionRole** and **AWSXRayDaemonWriteAccess**.
6. Choose **Next**.
7. Enter a **Role name** and then choose **Create role**.

For detailed instructions, see Creating a role for an AWS service (console) in the *IAM User Guide*.

# Grant least privilege access to your Lambda execution role

When you first create an IAM role for your Lambda function during the development phase, you might sometimes grant permissions beyond what is required. Before publishing your function in the production environment, as a best practice, adjust the policy to include only the required permissions. For more information, see Apply least-privilege permissions in the *IAM User Guide*.

Use IAM Access Analyzer to help identify the required permissions for the IAM execution role policy. IAM Access Analyzer reviews your AWS CloudTrail logs over the date range that you specify and generates a policy template with only the permissions that the function used during that time. You can use the template to create a managed policy with fine-grained permissions, and then attach it to the IAM role. That way, you grant only the permissions that the role needs to interact with AWS resources for your specific use case.

For more information, see Generate policies based on access activity in the *IAM User Guide*.

# Managing roles with the IAM API

To create an execution role with the AWS Command Line Interface (AWS CLI), use the **create-role** command. When using this command, you can specify the trust policy inline. A role's trust policy gives the specified principals permission to assume the role. In the following example, you grant the Lambda service principal permission to assume your role. Note that requirements for escaping quotes in the JSON string may vary depending on your shell.

```
aws iam create-role --role-name lambda-ex --assume-role-policy-document '{"Version":
 "2012-10-17","Statement": [{ "Effect": "Allow", "Principal": {"Service":
 "lambda.amazonaws.com"}, "Action": "sts:AssumeRole"}]}'
```

You can also define the trust policy for the role using a separate JSON file. In the following example, `trust-policy.json` is a file in the current directory.

**Example trust-policy.json**

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Principal": {
        "Service": "lambda.amazonaws.com"
      },
      "Action": "sts:AssumeRole"
    }
  ]
}
```

```
aws iam create-role --role-name lambda-ex --assume-role-policy-document file://trust-
policy.json
```

You should see the following output:

```
{
    "Role": {
        "Path": "/",
        "RoleName": "lambda-ex",
        "RoleId": "AROAQFOXMPL6TZ6ITKWND",
```

```
        "Arn": "arn:aws:iam::123456789012:role/lambda-ex",
        "CreateDate": "2020-01-17T23:19:12Z",
        "AssumeRolePolicyDocument": {
            "Version": "2012-10-17",
            "Statement": [
                {
                    "Effect": "Allow",
                    "Principal": {
                        "Service": "lambda.amazonaws.com"
                    },
                    "Action": "sts:AssumeRole"
                }
            ]
        }
    }
}
```

**Note**
Lambda automatically assumes your execution role when you invoke your function. You should avoid calling `sts:AssumeRole` manually in your function code. If your use case requires that the role assumes itself, you must include the role itself as a trusted principal in your role's trust policy. For more information on how to modify a role trust policy, see Modifying a role trust policy (console) in the IAM User Guide.

To add permissions to the role, use the **attach-policy-to-role** command. Start by adding the `AWSLambdaBasicExecutionRole` managed policy.

```
aws iam attach-role-policy --role-name lambda-ex --policy-arn arn:aws:iam::aws:policy/
service-role/AWSLambdaBasicExecutionRole
```

# Session duration for temporary security credentials

Lambda assumes the execution role associated with your function to fetch temporary security credentials which are then available as environment variables during a function's invocation. If you use these temporary credentials outside of Lambda, such as to create a presigned Amazon S3 URL, you can't control the session duration. The IAM maximum session duration setting doesn't apply to sessions that are assumed by AWS services such as Lambda. Use the sts:AssumeRole action if you need control over session duration.

# AWS managed policies for Lambda features

The following AWS managed policies provide permissions that are required to use Lambda features.

| Change | Description | Date |
|---|---|---|
| **AWSLambdaMSKExecutionRole** – Lambda added the kafka:DescribeClusterV2 permission to this policy. | `AWSLambdaMSKExecutionRole` grants permissions to read and access records from an Amazon Managed Streaming for Apache Kafka (Amazon MSK) cluster, manage elastic network interfaces (ENIs), and write to CloudWatch Logs. | June 17, 2022 |
| **AWSLambdaBasicExecutionRole** – Lambda started tracking changes to this policy. | `AWSLambdaBasicExecutionRole` grants permissions to upload logs to CloudWatch. | February 14, 2022 |

| Change | Description | Date |
| --- | --- | --- |
| **AWSLambdaDynamoDBExecutionRole** – Lambda started tracking changes to this policy. | `AWSLambdaDynamoDBExecutionRole` grants permissions to read records from an Amazon DynamoDB stream and write to CloudWatch Logs. | February 14, 2022 |
| **AWSLambdaKinesisExecutionRole** – Lambda started tracking changes to this policy. | `AWSLambdaKinesisExecutionRole` grants permissions to read events from an Amazon Kinesis data stream and write to CloudWatch Logs. | February 14, 2022 |
| **AWSLambdaMSKExecutionRole** – Lambda started tracking changes to this policy. | `AWSLambdaMSKExecutionRole` grants permissions to read and access records from an Amazon Managed Streaming for Apache Kafka (Amazon MSK) cluster, manage elastic network interfaces (ENIs), and write to CloudWatch Logs. | February 14, 2022 |
| **AWSLambdaSQSQueueExecutionRole** – Lambda started tracking changes to this policy. | `AWSLambdaSQSQueueExecutionRole` grants permissions to read a message from an Amazon Simple Queue Service (Amazon SQS) queue and write to CloudWatch Logs. | February 14, 2022 |
| **AWSLambdaVPCAccessExecutionRole** – Lambda started tracking changes to this policy. | `AWSLambdaVPCAccessExecutionRole` grants permissions to manage ENIs within an Amazon VPC and write to CloudWatch Logs. | February 14, 2022 |
| **AWSXRayDaemonWriteAccess** – Lambda started tracking changes to this policy. | `AWSXRayDaemonWriteAccess` grants permissions to upload trace data to X-Ray. | February 14, 2022 |
| **CloudWatchLambdaInsightsExecutionRolePolicy** – Lambda started tracking changes to this policy. | `CloudWatchLambdaInsightsExecutionRolePolicy` grants permissions to write runtime metrics to CloudWatch Lambda Insights. | February 14, 2022 |
| **AmazonS3ObjectLambdaExecutionRolePolicy** – Lambda started tracking changes to this policy. | `AmazonS3ObjectLambdaExecutionRolePolicy` grants permissions to interact with Amazon Simple Storage Service (Amazon S3) object Lambda and to write to CloudWatch Logs. | February 14, 2022 |

For some features, the Lambda console attempts to add missing permissions to your execution role in a customer managed policy. These policies can become numerous. To avoid creating extra policies, add the relevant AWS managed policies to your execution role before enabling features.

When you use an event source mapping (p. 236) to invoke your function, Lambda uses the execution role to read event data. For example, an event source mapping for Kinesis reads events from a data

stream and sends them to your function in batches. You can use event source mappings with the following services:

**Services that Lambda reads events from**

- Amazon DynamoDB (p. 559)
- Amazon Kinesis (p. 613)
- Amazon MQ (p. 638)
- Amazon Managed Streaming for Apache Kafka (Amazon MSK) (p. 646)
- Self-managed Apache Kafka (p. 600)
- Amazon Simple Queue Service (Amazon SQS) (p. 697)

In addition to the AWS managed policies, the Lambda console provides templates for creating a custom policy with permissions for additional use cases. When you create a function in the Lambda console, you can choose to create a new execution role with permissions from one or more templates. These templates are also applied automatically when you create a function from a blueprint, or when you configure options that require access to other services. Example templates are available in this guide's GitHub repository.

# Working with Lambda execution environment credentials

It's common for your Lambda function code to make API requests to other AWS services. To make these requests, Lambda generates an ephemeral set of credentials by assuming your function's execution role. Lambda also automatically injects the source function Amazon Resource Name (ARN) into the credentials context used to make the API request from your function code.

Lambda injects the source function ARN into the credentials context only if the request is an AWS API request that comes from within your execution environment. AWS API calls that Lambda makes outside of your execution environment on your behalf using the same execution role don't contain the source function ARN. Examples of such API calls outside the execution environment include:

- Calls to AWS Key Management Service (AWS KMS) to automatically encrypt and decrypt your environment variables.
- Calls to CloudWatch for logging.

With the source function ARN in the credentials context, you can verify whether a call to your resource came from a specific Lambda function's code. To verify this, use the `lambda:SourceFunctionArn` condition key in an IAM identity-based policy or service control policy (SCP).

> **Note**
> You cannot use the `lambda:SourceFunctionArn` condition key in resource-based policies.

With this condition key in your identity-based policies or SCPs, you can implement security controls for the API actions that your function code makes to other AWS services. This has a few key security applications, such as helping you identify the source of a credential leak.

> **Note**
> The `lambda:SourceFunctionArn` condition key is different from the `lambda:FunctionArn` and `aws:SourceArn` condition keys. The `lambda:FunctionArn` condition key applies only to event source mappings (p. 236) and helps define which functions your event source can invoke. The `aws:SourceArn` condition key applies only to policies where your Lambda function is the target resource, and helps define which other AWS services and resources can invoke that

function. The `lambda:SourceFunctionArn` condition key can apply to any identity-based policy or SCP to define the specific Lambda functions that have permissions to make specific AWS API calls to other resources.

To use `lambda:SourceFunctionArn` in your policy, include it as a condition with any of the ARN condition operators. The value of the key must be a valid ARN.

For example, suppose your Lambda function code makes an `s3:PutObject` call that targets a specific Amazon S3 bucket. You might want to allow only one specific Lambda function to have `s3:PutObject` access that bucket. In this case, your function's execution role should have a policy attached that looks like this:

**Example policy granting a specific Lambda function access to an Amazon S3 resource**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "ExampleSourceFunctionArn",
            "Effect": "Allow",
            "Action": "s3:PutObject",
            "Resource": "arn:aws:s3:::lambda_bucket/*",
            "Condition": {
                "ArnEquals": {
                    "lambda:SourceFunctionArn": "arn:aws:lambda:us-
east-1:123456789012:function:source_lambda"
                }
            }
        }
    ]
}
```

This policy allows only `s3:PutObject` access if the source is the Lambda function with ARN `arn:aws:lambda:us-east-1:123456789012:function:source_lambda`. This policy doesn't allow `s3:PutObject` access to any other calling identity. This is true even if a different function or entity makes an `s3:PutObject` call with the same execution role.

You can also use `lambda:SourceFunctionArn` in service control policies. For example, suppose you want to restrict access to your bucket to either a single Lambda function's code or to calls from a specific Amazon Virtual Private Cloud (VPC). The following SCP illustrates this.

**Example policy denying access to Amazon S3 under specific conditions**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Action": [
                "s3:*"
            ],
            "Resource": "arn:aws:s3:::lambda_bucket/*",
            "Effect": "Deny",
            "Condition": {
                "StringNotEqualsIfExists": {
                    "aws:SourceVpc": [
                        "vpc-12345678"
                    ]
                },
                "ArnNotEqualsIfExists": {
                    "lambda:SourceFunctionArn": "arn:aws:lambda:us-
east-1:123456789012:function:source_lambda"
```

```
                }
            }
        }
    ]
}
```

This policy denies all S3 actions unless they come from a specific Lambda function with ARN `arn:aws:lambda:*:123456789012:function:source_lambda`, or unless they come from the specified VPC. The `StringNotEqualsIfExists` operator tells IAM to process this condition only if the `aws:SourceVpc` key is present in the request. Similarly, IAM considers the `ArnNotEqualsIfExists` operator only if the `lambda:SourceFunctionArn` exists.

# Identity-based IAM policies for Lambda

You can use identity-based policies in AWS Identity and Access Management (IAM) to grant users in your account access to Lambda. Identity-based policies can apply to users directly, or to groups and roles that are associated with a user. You can also grant users in another account permission to assume a role in your account and access your Lambda resources.

Lambda provides AWS managed policies that grant access to Lambda API actions and, in some cases, access to other AWS services used to develop and manage Lambda resources. Lambda updates these managed policies as needed to ensure that your users have access to new features when they're released.

> **Note**
> The AWS managed policies **AWSLambdaFullAccess** and **AWSLambdaReadOnlyAccess** will be deprecated on March 1, 2021. After this date, you cannot attach these policies to new IAM users. For more information, see the related troubleshooting topic (p. 745).

- **AWSLambda_FullAccess** – Grants full access to Lambda actions and other AWS services used to develop and maintain Lambda resources. This policy was created by scoping down the previous policy **AWSLambdaFullAccess**.
- **AWSLambda_ReadOnlyAccess** – Grants read-only access to Lambda resources. This policy was created by scoping down the previous policy **AWSLambdaReadOnlyAccess**.
- **AWSLambdaRole** – Grants permissions to invoke Lambda functions.

AWS managed policies grant permission to API actions without restricting the Lambda functions or layers that a user can modify. For finer-grained control, you can create your own policies that limit the scope of a user's permissions.

**Sections**

- Function development (p. 59)
- Layer development and use (p. 62)
- Cross-account roles (p. 63)
- Condition keys for VPC settings (p. 63)

## Function development

Use identity-based policies to allow users to perform operations on Lambda functions.

> **Note**
> For a function defined as a container image, the user permission to access the image MUST be configured in the Amazon Elastic Container Registry For an example, see Amazon ECR permissions. (p. 137)

The following shows an example of a permissions policy with limited scope. It allows a user to create and manage Lambda functions named with a designated prefix (`intern-`), and configured with a designated execution role.

**Example Function development policy**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "ReadOnlyPermissions",
```

```
            "Effect": "Allow",
            "Action": [
                "lambda:GetAccountSettings",
                "lambda:GetEventSourceMapping",
                "lambda:GetFunction",
                "lambda:GetFunctionConfiguration",
                "lambda:GetFunctionCodeSigningConfig",
                "lambda:GetFunctionConcurrency",
                "lambda:ListEventSourceMappings",
                "lambda:ListFunctions",
                "lambda:ListTags",
                "iam:ListRoles"
            ],
            "Resource": "*"
        },
        {
            "Sid": "DevelopFunctions",
            "Effect": "Allow",
            "NotAction": [
                "lambda:AddPermission",
                "lambda:PutFunctionConcurrency"
            ],
            "Resource": "arn:aws:lambda:*:*:function:intern-*"
        },
        {
            "Sid": "DevelopEventSourceMappings",
            "Effect": "Allow",
            "Action": [
                "lambda:DeleteEventSourceMapping",
                "lambda:UpdateEventSourceMapping",
                "lambda:CreateEventSourceMapping"
            ],
            "Resource": "*",
            "Condition": {
                "StringLike": {
                    "lambda:FunctionArn": "arn:aws:lambda:*:*:function:intern-*"
                }
            }
        },
        {
            "Sid": "PassExecutionRole",
            "Effect": "Allow",
            "Action": [
                "iam:ListRolePolicies",
                "iam:ListAttachedRolePolicies",
                "iam:GetRole",
                "iam:GetRolePolicy",
                "iam:PassRole",
                "iam:SimulatePrincipalPolicy"
            ],
            "Resource": "arn:aws:iam::*:role/intern-lambda-execution-role"
        },
        {
            "Sid": "ViewLogs",
            "Effect": "Allow",
            "Action": [
                "logs:*"
            ],
            "Resource": "arn:aws:logs:*:*:log-group:/aws/lambda/intern-*"
        }
    ]
}
```

The permissions in the policy are organized into statements based on the resources and conditions (p. 74) that they support.

- `ReadOnlyPermissions` – The Lambda console uses these permissions when you browse and view functions. They don't support resource patterns or conditions.

```
"Action": [
    "lambda:GetAccountSettings",
    "lambda:GetEventSourceMapping",
    "lambda:GetFunction",
    "lambda:GetFunctionConfiguration",
    "lambda:GetFunctionCodeSigningConfig",
    "lambda:GetFunctionConcurrency",
    "lambda:ListEventSourceMappings",
    "lambda:ListFunctions",
    "lambda:ListTags",
    "iam:ListRoles"
],
"Resource": "*"
```

- `DevelopFunctions` – Use any Lambda action that operates on functions prefixed with `intern-`, *except* `AddPermission` and `PutFunctionConcurrency`. `AddPermission` modifies the resource-based policy (p. 68) on the function and can have security implications. `PutFunctionConcurrency` reserves scaling capacity for a function and can take capacity away from other functions.

```
"NotAction": [
    "lambda:AddPermission",
    "lambda:PutFunctionConcurrency"
],
"Resource": "arn:aws:lambda:*:*:function:intern-*"
```

- `DevelopEventSourceMappings` – Manage event source mappings on functions that are prefixed with `intern-`. These actions operate on event source mappings, but you can restrict them by function with a *condition*.

```
"Action": [
    "lambda:DeleteEventSourceMapping",
    "lambda:UpdateEventSourceMapping",
    "lambda:CreateEventSourceMapping"
],
"Resource": "*",
"Condition": {
    "StringLike": {
        "lambda:FunctionArn": "arn:aws:lambda:*:*:function:intern-*"
    }
}
```

- `PassExecutionRole` – View and pass only a role named `intern-lambda-execution-role`, which must be created and managed by a user with IAM permissions. `PassRole` is used when you assign an execution role to a function.

```
"Action": [
    "iam:ListRolePolicies",
    "iam:ListAttachedRolePolicies",
    "iam:GetRole",
    "iam:GetRolePolicy",
    "iam:PassRole",
    "iam:SimulatePrincipalPolicy"
],
```

```
            "Resource": "arn:aws:iam::*:role/intern-lambda-execution-role"
```

- `ViewLogs` – Use CloudWatch Logs to view logs for functions that are prefixed with `intern-`.

```
            "Action": [
                "logs:*"
            ],
            "Resource": "arn:aws:logs:*:*:log-group:/aws/lambda/intern-*"
```

This policy allows a user to get started with Lambda, without putting other users' resources at risk. It doesn't allow a user to configure a function to be triggered by or call other AWS services, which requires broader IAM permissions. It also doesn't include permission to services that don't support limited-scope policies, like CloudWatch and X-Ray. Use the read-only policies for these services to give the user access to metrics and trace data.

When you configure triggers for your function, you need access to use the AWS service that invokes your function. For example, to configure an Amazon S3 trigger, you need permission to use the Amazon S3 actions that manage bucket notifications. Many of these permissions are included in the **AWSLambdaFullAccess** managed policy. Example policies are available in this guide's GitHub repository.

# Layer development and use

The following policy grants a user permission to create layers and use them with functions. The resource patterns allow the user to work in any AWS Region and with any layer version, as long as the name of the layer starts with `test-`.

**Example layer development policy**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "PublishLayers",
            "Effect": "Allow",
            "Action": [
                "lambda:PublishLayerVersion"
            ],
            "Resource": "arn:aws:lambda:*:*:layer:test-*"
        },
        {
            "Sid": "ManageLayerVersions",
            "Effect": "Allow",
            "Action": [
                "lambda:GetLayerVersion",
                "lambda:DeleteLayerVersion"
            ],
            "Resource": "arn:aws:lambda:*:*:layer:test-*:*"
        }
    ]
}
```

You can also enforce layer use during function creation and configuration with the `lambda:Layer` condition. For example, you can prevent users from using layers published by other accounts. The following policy adds a condition to the `CreateFunction` and `UpdateFunctionConfiguration` actions to require that any layers specified come from account `123456789012`.

```
{
```

```
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "ConfigureFunctions",
            "Effect": "Allow",
            "Action": [
                "lambda:CreateFunction",
                "lambda:UpdateFunctionConfiguration"
            ],
            "Resource": "*",
            "Condition": {
                "ForAllValues:StringLike": {
                    "lambda:Layer": [
                        "arn:aws:lambda:*:123456789012:layer:*:*"
                    ]
                }
            }
        }
    ]
}
```

To ensure that the condition applies, verify that no other statements grant the user permission to these actions.

# Cross-account roles

You can apply any of the preceding policies and statements to a role, which you can then share with another account to give it access to your Lambda resources. Unlike an IAM user, a role doesn't have credentials for authentication. Instead, it has a *trust policy* that specifies who can assume the role and use its permissions.

You can use cross-account roles to give accounts that you trust access to Lambda actions and resources. If you just want to grant permission to invoke a function or use a layer, use resource-based policies (p. 68) instead.

For more information, see IAM roles in the *IAM User Guide*.

# Condition keys for VPC settings

You can use condition keys for VPC settings to provide additional permission controls for your Lambda functions. For example, you can enforce that all Lambda functions in your organization are connected to a VPC. You can also specify the subnets and security groups that the functions are allowed to use, or are denied from using.

For more information, see the section called “Using IAM condition keys for VPC settings” (p. 194).

# Attribute-based access control for Lambda

With attribute-based access control (ABAC), you can use tags to control access to your Lambda functions. You can attach tags to a Lambda function, pass them in certain API requests, or attach them to the AWS Identity and Access Management (IAM) principal making the request. For more information about how AWS grants attribute-based access, see Controlling access to AWS resources using tags in the *IAM User Guide*.

You can use ABAC to grant least privilege without specifying an Amazon Resource Name (ARN) or ARN pattern in the IAM policy. Instead, you can specify a tag in the condition element of an IAM policy to control access. Scaling is easier with ABAC because you don't have to update your IAM policies when you create new functions. Instead, add tags to the new functions to control access.

In Lambda, tags work at the function level. Tags aren't supported for layers, code signing configurations, or event source mappings. When you tag a function, those tags apply to all versions and aliases associated with the function. For information about how to tag functions, see Using tags on Lambda functions (p. 215).

You can use the following condition keys to control function actions:

- aws:ResourceTag/tag-key: Control access based on the tags that are attached to Lambda functions.
- aws:RequestTag/tag-key: Require tags to be present in a request, such as when creating a new function.
- aws:PrincipalTag/tag-key: Control what the IAM principal (the person making the request) is allowed to do based on the tags that are attached to their IAM user or role.
- aws:TagKeys: Control whether specific tag keys can be used in a request.

For a complete list of Lambda actions that support ABAC, see Function actions (p. 77) and check the **Condition** column in the table.

The following steps demonstrate one way to set up permissions using ABAC. In this example scenario, you'll create four IAM permissions policies. Then, you'll attach these policies to a new IAM role. Finally, you'll create an IAM user and give that user permission to assume the new role.

## Prerequisites

Make sure that you have a Lambda execution role (p. 52). You'll use this role when you grant IAM permissions and when you create a Lambda function.

## Step 1: Require tags on new functions

When using ABAC with Lambda, it's a best practice to require that all functions have tags. This helps ensure that your ABAC permissions policies work as expected.

Create an IAM policy similar to the following example. This policy uses the aws:RequestTag/tag-key and aws:TagKeys condition keys to require that new functions and the IAM principal creating the functions both have the `project` tag. The `ForAllValues` modifier ensures that `project` is the only allowed tag. If you don't include the `ForAllValues` modifier, users can add other tags to the function as long as they also pass `project`.

**Example – Require tags on new functions**

```
{
  "Version": "2012-10-17",
  "Statement": {
```

```
    "Effect": "Allow",
    "Action": [
      "lambda:CreateFunction",
      "lambda:TagResource"
    ],
    "Resource": "arn:aws:lambda:*:*:function:*",
    "Condition": {
      "StringEquals": {
        "aws:RequestTag/project": "${aws:PrincipalTag/project}"
      },
      "ForAllValues:StringEquals": {
        "aws:TagKeys": "project"
      }
    }
  }
}
```

# Step 2: Allow actions based on tags attached to a Lambda function and IAM principal

Create a second IAM policy using the aws:ResourceTag/tag-key condition key to require the principal's tag to match the tag that's attached to the function. The following example policy allows principals with the `project` tag to invoke functions with the `project` tag. If a function has any other tags, the action is denied.

**Example – Require matching tags on function and IAM principal**

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "lambda:InvokeFunction",
        "lambda:GetFunction"
      ],
      "Resource": "arn:aws:lambda:*:*:function:*",
      "Condition": {
        "StringEquals": {
          "aws:ResourceTag/project": "${aws:PrincipalTag/project}"
        }
      }
    }
  ]
}
```

# Step 3: Grant list permissions

Create a policy that allows the principal to list Lambda functions and IAM roles. This allows the principal to see all Lambda functions and IAM roles on the console and when calling the API actions.

**Example – Grant Lambda and IAM list permissions**

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "AllResourcesLambdaNoTags",
      "Effect": "Allow",
```

```
      "Action": [
        "lambda:GetAccountSettings",
        "lambda:ListFunctions",
        "iam:ListRoles"
      ],
      "Resource": "*"
    }
  ]
}
```

# Step 4: Grant IAM permissions

Create a policy that allows **iam:PassRole**. This permission is required when you assign an execution role to a function. In the following example policy, replace the example ARN with the ARN of your Lambda execution role.

> **Note**
> Do not use the `ResourceTag` condition key in a policy with the `iam:PassRole` action. You cannot use the tag on an IAM role to control access to who can pass that role. For more information about permissions required to pass a role to a service, see Granting a user permissions to pass a role to an AWS service.

**Example – Grant permission to pass the execution role**

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "VisualEditor0",
      "Effect": "Allow",
      "Action": [
        "iam:PassRole"
      ],
      "Resource": "arn:aws:iam::111122223333:role/lambda-ex"
    }
  ]
}
```

# Step 5: Create the IAM role

It's a best practice to use roles to delegate permissions. Create an IAM role called `abac-project-role`:

- On **Step 1: Select trusted entity**: Choose **AWS account** and then choose **This account**.
- On **Step 2: Add permissions**: Attach the four IAM policies that you created in the previous steps.
- On **Step 3: Name, review, and create**: Choose **Add tag**. For **Key**, enter `project`. Don't enter a **Value**.

# Step 6: Create the IAM user

Create an IAM user called `abac-test-user`. In the **Set permissions** section, choose **Attach existing policies directly** and then choose **Create policy**. Enter the following policy definition. Replace *111122223333* with your AWS account ID. This policy allows `abac-test-user` to assume `abac-project-role`.

**Example – Allow IAM user to assume ABAC role**

```
{
```

```
  "Version": "2012-10-17",
  "Statement": {
    "Effect": "Allow",
    "Action": "sts:AssumeRole",
    "Resource": "arn:aws:iam::111122223333:role/abac-project-role"
  }
}
```

# Step 7: Test the permissions

1. Sign in to the AWS console as `abac-test-user`. For more information, see Sign in as an IAM user.
2. Switch to the `abac-project-role` role. For more information, see Switching to a role (console).
3. Create a Lambda function (p. 215):
   - Under **Permissions**, choose **Change default execution role**, and then for **Execution role**, choose **Use an existing role**. Choose the same execution role that you used in Step 4: Grant IAM permissions (p. 66).
   - Under **Advanced settings**, choose **Enable tags** and then choose **Add new tag**. For **Key**, enter `project`. Don't enter a **Value**.
4. Test the function (p. 252).
5. Create a second Lambda function and add a different tag, such as `environment`. This operation should fail because the ABAC policy that you created in Step 1: Require tags on new functions (p. 64) only allows the principal to create functions with the `project` tag.
6. Create a third function without tags. This operation should fail because the ABAC policy that you created in Step 1: Require tags on new functions (p. 64) doesn't allow the principal to create functions without tags.

This authorization strategy allows you to control access without creating new policies for each new user. To grant access to new users, simply give them permission to assume the role that corresponds to their assigned project.

# Using resource-based policies for Lambda

Lambda supports resource-based permissions policies for Lambda functions and layers. Resource-based policies let you grant usage permission to other AWS accounts or organizations on a per-resource basis. You also use a resource-based policy to allow an AWS service to invoke your function on your behalf.

For Lambda functions, you can grant an account permission (p. 70) to invoke or manage a function. You can also use a single resource-based policy to grant permissions to an entire organization in AWS Organizations. You can also use resource-based policies to grant invoke permission to an AWS service (p. 69) that invokes a function in response to activity in your account.

### To view a function's resource-based policy

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **Permissions**.
4. Scroll down to **Resource-based policy** and then choose **View policy document**. The resource-based policy shows the permissions that are applied when another account or AWS service attempts to access the function. The following example shows a statement that allows Amazon S3 to invoke a function named `my-function` for a bucket named `my-bucket` in account `123456789012`.

   **Example Resource-based policy**

```
{
    "Version": "2012-10-17",
    "Id": "default",
    "Statement": [
        {
            "Sid": "lambda-allow-s3-my-function",
            "Effect": "Allow",
            "Principal": {
              "Service": "s3.amazonaws.com"
            },
            "Action": "lambda:InvokeFunction",
            "Resource":  "arn:aws:lambda:us-east-2:123456789012:function:my-function",
            "Condition": {
              "StringEquals": {
                "AWS:SourceAccount": "123456789012"
              },
              "ArnLike": {
                "AWS:SourceArn": "arn:aws:s3:::my-bucket"
              }
            }
        }
     ]
}
```

For Lambda layers, you can only use a resource-based policy on a specific layer version, instead of the entire layer. In addition to policies that grant permission to a single account or multiple accounts, for layers, you can also grant permission to all accounts in an organization.

> **Note**
> You can only update resource-based policies for Lambda resources within the scope of the AddPermission (p. 881) and AddLayerVersionPermission (p. 877) API actions. Currently, you can't author policies for your Lambda resources in JSON, or use conditions that don't map to parameters for those actions.

Resource-based policies apply to a single function, version, alias, or layer version. They grant permission to one or more services and accounts. For trusted accounts that you want to have access to multiple resources, or to use API actions that resource-based policies don't support, you can use cross-account roles (p. 59).

**Topics**


- Granting function access to AWS services (p. 69)
- Granting function access to an organization (p. 70)
- Granting function access to other accounts (p. 70)
- Granting layer access to other accounts (p. 72)
- Cleaning up resource-based policies (p. 72)


# Granting function access to AWS services

When you use an AWS service to invoke your function (p. 496), you grant permission in a statement on a resource-based policy. You can apply the statement to the entire function to be invoked or managed, or limit the statement to a single version or alias.

> **Note**
> When you add a trigger to your function with the Lambda console, the console updates the function's resource-based policy to allow the service to invoke it. To grant permissions to other accounts or services that aren't available in the Lambda console, you can use the AWS CLI.

Add a statement with the `add-permission` command. The simplest resource-based policy statement allows a service to invoke a function. The following command grants Amazon SNS permission to invoke a function named `my-function`.

```
aws lambda add-permission --function-name my-function --action lambda:InvokeFunction --
statement-id sns \
--principal sns.amazonaws.com --output text
```

You should see the following output:

```
{"Sid":"sns","Effect":"Allow","Principal":
{"Service":"sns.amazonaws.com"},"Action":"lambda:InvokeFunction","Resource":"arn:aws:lambda:us-
east-2:123456789012:function:my-function"}
```

This lets Amazon SNS call the `lambda:Invoke` API for the function, but it doesn't restrict the Amazon SNS topic that triggers the invocation. To ensure that your function is only invoked by a specific resource, specify the Amazon Resource Name (ARN) of the resource with the `source-arn` option. The following command only allows Amazon SNS to invoke the function for subscriptions to a topic named `my-topic`.

```
aws lambda add-permission --function-name my-function --action lambda:InvokeFunction --
statement-id sns-my-topic \
--principal sns.amazonaws.com --source-arn arn:aws:sns:us-east-2:123456789012:my-topic
```

Some services can invoke functions in other accounts. If you specify a source ARN that has your account ID in it, that isn't an issue. For Amazon S3, however, the source is a bucket whose ARN doesn't have an account ID in it. It's possible that you could delete the bucket and another account could create a bucket with the same name. Use the `source-account` option with your account ID to ensure that only resources in your account can invoke the function.

```
aws lambda add-permission --function-name my-function --action lambda:InvokeFunction --
statement-id s3-account \
```

```
--principal s3.amazonaws.com --source-arn arn:aws:s3:::my-bucket-123456 --source-
account 123456789012
```

# Granting function access to an organization

To grant permissions to an organization in AWS Organizations, specify the organization ID as the `principal-org-id`. The following AddPermission (p. 881) AWS CLI command grants invocation access to all users in organization `o-a1b2c3d4e5f`.

```
aws lambda add-permission --function-name example \
--statement-id PrincipalOrgIDExample --action lambda:InvokeFunction \
--principal * --principal-org-id o-a1b2c3d4e5f
```

**Note**
In this command, `Principal` is `*`. This means that all users in the organization `o-a1b2c3d4e5f` get function invocation permissions. If you specify an AWS account or role as the `Principal`, then only that principal gets function invocation permissions, but only if they are also part of the `o-a1b2c3d4e5f` organization.

This command creates a resource-based policy that looks like the following:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "PrincipalOrgIDExample",
            "Effect": "Allow",
            "Principal": "*",
            "Action": "lambda:InvokeFunction",
            "Resource": "arn:aws:lambda:us-west-2:123456789012:function:example",
            "Condition": {
                "StringEquals": {
                    "aws:PrincipalOrgID": "o-a1b2c3d4e5f"
                }
            }
        }
    ]
}
```

For more information, see aws:PrincipalOrgID in the AWS Identity and Access Management user guide.

# Granting function access to other accounts

To grant permissions to another AWS account, specify the account ID as the `principal`. The following example grants account `111122223333` permission to invoke `my-function` with the `prod` alias.

```
aws lambda add-permission --function-name my-function:prod --statement-id xaccount --action
 lambda:InvokeFunction \
--principal 111122223333 --output text
```

You should see the following output:

```
{"Sid":"xaccount","Effect":"Allow","Principal":
{"AWS":"arn:aws:iam::111122223333:root"},"Action":"lambda:InvokeFunction","Resource":"arn:aws:lambda:us
east-2:123456789012:function:my-function"}
```

The resource-based policy grants permission for the other account to access the function, but doesn't allow users in that account to exceed their permissions. Users in the other account must have the corresponding user permissions (p. 59) to use the Lambda API.

To limit access to a user or role in another account, specify the full ARN of the identity as the principal. For example, `arn:aws:iam::123456789012:user/developer`.

The alias (p. 175) limits which version the other account can invoke. It requires the other account to include the alias in the function ARN.

```
aws lambda invoke --function-name arn:aws:lambda:us-west-2:123456789012:function:my-
function:prod out
```

You should see the following output:

```
{
    "StatusCode": 200,
    "ExecutedVersion": "1"
}
```

The function owner can then update the alias to point to a new version without the caller needing to change the way they invoke your function. This ensures that the other account doesn't need to change its code to use the new version, and it only has permission to invoke the version of the function associated with the alias.

You can grant cross-account access for most API actions that operate on an existing function (p. 77). For example, you could grant access to `lambda:ListAliases` to let an account get a list of aliases, or `lambda:GetFunction` to let them download your function code. Add each permission separately, or use `lambda:*` to grant access to all actions for the specified function.

### Cross-account APIs

Currently, Lambda doesn't support cross-account actions for all of its APIs via resource-based policies. The following APIs are supported:

- Invoke (p. 993)
- GetFunction (p. 958)
- GetFunctionConfiguration (p. 967)
- UpdateFunctionCode (p. 1088)
- DeleteFunction (p. 931)
- PublishVersion (p. 1042)
- ListVersionsByFunction (p. 1033)
- CreateAlias (p. 886)
- GetAlias (p. 947)
- ListAliases (p. 1001)
- UpdateAlias (p. 1071)
- DeleteAlias (p. 921)
- GetPolicy (p. 988)
- PutFunctionConcurrency (p. 1053)
- DeleteFunctionConcurrency (p. 935)
- ListTags (p. 1031)
- TagResource (p. 1067)
- UntagResource (p. 1069)

To grant other accounts permission for multiple functions, or for actions that don't operate on a function, we recommend that you use IAM roles (p. 59).

# Granting layer access to other accounts

To grant layer-usage permission to another account, add a statement to the layer version's permissions policy using the **add-layer-version-permission** command. In each statement, you can grant permission to a single account, all accounts, or an organization.

```
aws lambda add-layer-version-permission --layer-name xray-sdk-nodejs --statement-id
 xaccount \
--action lambda:GetLayerVersion  --principal 111122223333 --version-number 1 --output text
```

You should see output similar to the following:

```
e210ffdc-e901-43b0-824b-5fcd0dd26d16    {"Sid":"xaccount","Effect":"Allow","Principal":
{"AWS":"arn:aws:iam::111122223333:root"},"Action":"lambda:GetLayerVersion","Resource":"arn:aws:lambda:u
east-2:123456789012:layer:xray-sdk-nodejs:1"}
```

Permissions apply only to a single layer version. Repeat the process each time that you create a new layer version.

To grant permission to all accounts in an organization, use the `organization-id` option. The following example grants all accounts in an organization permission to use version 3 of a layer.

```
aws lambda add-layer-version-permission --layer-name my-layer \
--statement-id engineering-org --version-number 3 --principal '*' \
--action lambda:GetLayerVersion --organization-id o-t194hfs8cz --output text
```

You should see the following output:

```
b0cd9796-d4eb-4564-939f-de7fe0b42236    {"Sid":"engineering-
org","Effect":"Allow","Principal":"*","Action":"lambda:GetLayerVersion","Resource":"arn:aws:lambda:us-
east-2:123456789012:layer:my-layer:3","Condition":{"StringEquals":{"aws:PrincipalOrgID":"o-
t194hfs8cz"}}}"
```

To grant permission to all AWS accounts, use `*` for the principal, and omit the organization ID. For multiple accounts or organizations, you need to add multiple statements.

# Cleaning up resource-based policies

To view a function's resource-based policy, use the `get-policy` command.

```
aws lambda get-policy --function-name my-function --output text
```

You should see the following output:

```
{"Version":"2012-10-17","Id":"default","Statement":
[{"Sid":"sns","Effect":"Allow","Principal":
{"Service":"s3.amazonaws.com"},"Action":"lambda:InvokeFunction","Resource":"arn:aws:lambda:us-
east-2:123456789012:function:my-function","Condition":{"ArnLike":
{"AWS:SourceArn":"arn:aws:sns:us-east-2:123456789012:lambda*"}}}]}      7c681fc9-b791-4e91-
acdf-eb847fdaa0f0
```

For versions and aliases, append the version number or alias to the function name.

```
aws lambda get-policy --function-name my-function:PROD
```

To remove permissions from your function, use `remove-permission`.

```
aws lambda remove-permission --function-name example --statement-id sns
```

Use the `get-layer-version-policy` command to view the permissions on a layer.

```
aws lambda get-layer-version-policy --layer-name my-layer --version-number 3 --output text
```

You should see the following output:

```
b0cd9796-d4eb-4564-939f-de7fe0b42236    {"Sid":"engineering-
org","Effect":"Allow","Principal":"*","Action":"lambda:GetLayerVersion","Resource":"arn:aws:lambda:us-
west-2:123456789012:layer:my-layer:3","Condition":{"StringEquals":{"aws:PrincipalOrgID":"o-
t194hfs8cz"}}}"
```

Use `remove-layer-version-permission` to remove statements from the policy.

```
aws lambda remove-layer-version-permission --layer-name my-layer --version-number 3 --
statement-id engineering-org
```

# Resources and conditions for Lambda actions

You can restrict the scope of a user's permissions by specifying resources and conditions in an AWS Identity and Access Management (IAM) policy. Each action in a policy supports a combination of resource and condition types that varies depending on the behavior of the action.

Every IAM policy statement grants permission to an action that's performed on a resource. When the action doesn't act on a named resource, or when you grant permission to perform the action on all resources, the value of the resource in the policy is a wildcard (`*`). For many actions, you can restrict the resources that a user can modify by specifying the Amazon Resource Name (ARN) of a resource, or an ARN pattern that matches multiple resources.

To restrict permissions by resource, specify the resource by ARN.

### Lambda resource ARN format

- Function – `arn:aws:lambda:us-west-2:123456789012:function:my-function`
- Function version – `arn:aws:lambda:us-west-2:123456789012:function:my-function:1`
- Function alias – `arn:aws:lambda:us-west-2:123456789012:function:my-function:TEST`
- Event source mapping – `arn:aws:lambda:us-west-2:123456789012:event-source-mapping:fa123456-14a1-4fd2-9fec-83de64ad683de6d47`
- Layer – `arn:aws:lambda:us-west-2:123456789012:layer:my-layer`
- Layer version – `arn:aws:lambda:us-west-2:123456789012:layer:my-layer:1`

For example, the following policy allows a user in AWS account `123456789012` to invoke a function named `my-function` in the US West (Oregon) AWS Region.

### Example invoke function policy

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "Invoke",
            "Effect": "Allow",
            "Action": [
                "lambda:InvokeFunction"
            ],
            "Resource": "arn:aws:lambda:us-west-2:123456789012:function:my-function"
        }
    ]
}
```

This is a special case where the action identifier (`lambda:InvokeFunction`) differs from the API operation (Invoke (p. 993)). For other actions, the action identifier is the operation name prefixed by `lambda:`.

### Sections

- Policy conditions (p. 75)
- Function resource names (p. 75)
- Function actions (p. 77)
- Event source mapping actions (p. 79)
- Layer actions (p. 79)

# Policy conditions

Conditions are an optional policy element that applies additional logic to determine if an action is allowed. In addition to common conditions that all actions support, Lambda defines condition types that you can use to restrict the values of additional parameters on some actions.

For example, the `lambda:Principal` condition lets you restrict the service or account that a user can grant invocation access to on a function's resource-based policy (p. 68). The following policy lets a user grant permission to Amazon Simple Notification Service (Amazon SNS) topics to invoke a function named `test`.

**Example manage function policy permissions**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "ManageFunctionPolicy",
            "Effect": "Allow",
            "Action": [
                "lambda:AddPermission",
                "lambda:RemovePermission"
            ],
            "Resource": "arn:aws:lambda:us-west-2:123456789012:function:test:*",
            "Condition": {
                "StringEquals": {
                    "lambda:Principal": "sns.amazonaws.com"
                }
            }
        }
    ]
}
```

The condition requires that the principal is Amazon SNS and not another service or account. The resource pattern requires that the function name is `test` and includes a version number or alias. For example, `test:v1`.

For more information on resources and conditions for Lambda and other AWS services, see Actions, resources, and condition keys for AWS services in the *Service Authorization Reference*.

# Function resource names

You reference a Lambda function in a policy statement using an Amazon Resource Name (ARN). The format of a function ARN depends on whether you are referencing the whole function (unqualified) or a function version (p. 173) or alias (p. 175) (qualified).

When making Lambda API calls, users can specify a version or alias by passing a version ARN or alias ARN in the GetFunction (p. 958) `FunctionName` parameter, or by setting a value in the GetFunction (p. 958) `Qualifier` parameter. Lambda makes authorization decisions by comparing the resource element in the IAM policy with both the `FunctionName` and `Qualifier` passed in API calls. If there is a mismatch, Lambda denies the request.

Whether you are allowing or denying an action on your function, you must use the correct function ARN types in your policy statement to achieve the results that you expect. For example, if your policy references the unqualified ARN, Lambda accepts requests that reference the unqualified ARN but denies requests that reference a qualified ARN.

> **Note**
> You can't use a wildcard character (*) to match the account ID. For more information on accepted syntax, see IAM JSON policy reference in the *IAM User Guide*.

**Example allowing invocation of an unqualified ARN**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": "lambda:InvokeFunction",
            "Resource": "arn:aws:lambda:us-west-2:123456789012:function:myFunction"
        }
    ]
}
```

If your policy references a specific qualified ARN, Lambda accepts requests that reference that ARN but denies requests that reference the unqualified ARN or a different qualified ARN, for example, `myFunction:2`.

**Example allowing invocation of a specific qualified ARN**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": "lambda:InvokeFunction",
            "Resource": "arn:aws:lambda:us-west-2:123456789012:function:myFunction:1"
        }
    ]
}
```

If your policy references any qualified ARN using `:*`, Lambda accepts any qualified ARN but denies requests that reference the unqualified ARN.

**Example allowing invocation of any qualified ARN**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": "lambda:InvokeFunction",
            "Resource": "arn:aws:lambda:us-west-2:123456789012:function:myFunction:*"
        }
    ]
}
```

If your policy references any ARN using `*`, Lambda accepts any qualified or unqualified ARN.

**Example allowing invocation of any qualified or unqualified ARN**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": "lambda:InvokeFunction",
            "Resource": "arn:aws:lambda:us-west-2:123456789012:function:myFunction*"
        }
    ]
}
```

# Function actions

Actions that operate on a function can be restricted to a specific function by function, version, or alias ARN, as described in the following table. Actions that don't support resource restrictions are granted for all resources (`*`).

**Function actions**

| Action | Resource | Condition |
|---|---|---|
| AddPermission (p. 881)<br>RemovePermission (p. 1065) | Function<br>Function version<br>Function alias | `lambda:Principal`<br>`aws:ResourceTag/${TagKey}`<br>`lambda:FunctionUrlAuthType` |
| Invoke (p. 993)<br>**Permission:** `lambda:InvokeFunction` | Function<br>Function version<br>Function alias | `aws:ResourceTag/${TagKey}` |
| CreateFunction (p. 904) | Function | `lambda:CodeSigningConfigArn`<br>`lambda:Layer`<br>`lambda:VpcIds`<br>`lambda:SubnetIds`<br>`lambda:SecurityGroupIds`<br>`aws:ResourceTag/${TagKey}`<br>`aws:RequestTag/${TagKey}`<br>`aws:TagKeys` |
| UpdateFunctionConfiguration (p. 1098) | Function | `lambda:CodeSigningConfigArn`<br>`lambda:Layer`<br>`lambda:VpcIds`<br>`lambda:SubnetIds`<br>`lambda:SecurityGroupIds`<br>`aws:ResourceTag/${TagKey}` |
| CreateAlias (p. 886)<br>DeleteAlias (p. 921)<br>DeleteFunction (p. 931)<br>DeleteFunctionCodeSigningConfig<br>DeleteFunctionConcurrency (p. 935)<br>GetAlias (p. 947) | Function | `aws:ResourceTag/${TagKey}` |

| Action | Resource | Condition |
| --- | --- | --- |
| GetFunction (p. 958)<br>GetFunctionCodeSigningConfig<br>GetFunctionConcurrency<br>GetFunctionConfiguration (p. 967)<br>GetPolicy (p. 988)<br>ListProvisionedConcurrencyConfigs<br>ListAliases (p. 1001)<br>ListTags (p. 1031)<br>ListVersionsByFunction (p. 1033)<br>PublishVersion (p. 1042)<br>PutFunctionCodeSigningConfig<br>PutFunctionConcurrency (p. 1053)<br>UpdateAlias (p. 1071)<br>UpdateFunctionCode (p. 1088) | | |
| CreateFunctionUrlConfig<br>DeleteFunctionUrlConfig<br>GetFunctionUrlConfig<br>UpdateFunctionUrlConfig | Function<br>Function alias | `lambda:FunctionUrlAuthType`<br>`lambda:FunctionArn` |
| ListFunctionUrlConfigs | Function | `lambda:FunctionUrlAuthType` |
| DeleteProvisionedConcurrencyConfig<br>GetProvisionedConcurrencyConfig<br>PutProvisionedConcurrencyConfig | Function alias<br>Function version | `aws:ResourceTag/${TagKey}` |
| GetAccountSettings (p. 945)<br>ListFunctions (p. 1013) | * | None |
| TagResource (p. 1067) | Function | `aws:ResourceTag/${TagKey}`<br>`aws:RequestTag/${TagKey}`<br>`aws:TagKeys` |
| UntagResource (p. 1069) | Function | `aws:ResourceTag/${TagKey}`<br>`aws:TagKeys` |

# Event source mapping actions

For event source mappings (p. 236), you can restrict delete and update permissions to a specific event source. The `lambda:FunctionArn` condition lets you restrict which functions a user can configure an event source to invoke.

For these actions, the resource is the event source mapping, so Lambda provides a condition that lets you restrict permission based on the function that the event source mapping invokes.

**Event source mapping actions**

| Action | Resource | Condition |
|---|---|---|
| DeleteEventSourceMapping (p. 925)<br>UpdateEventSourceMapping (p. 1078) | Event source mapping | `lambda:FunctionArn` |
| CreateEventSourceMapping (p. 893) | * | `lambda:FunctionArn` |
| GetEventSourceMapping (p. 952)<br>ListEventSourceMappings (p. 1006) | * | None |

# Layer actions

Layer actions let you restrict the layers that a user can manage or use with a function. Actions related to layer use and permissions act on a version of a layer, while `PublishLayerVersion` acts on a layer name. You can use either with wildcards to restrict the layers that a user can work with by name.

> **Note**
> The GetLayerVersion (p. 980) action also covers GetLayerVersionByArn (p. 983). Lambda does not support `GetLayerVersionByArn` as an IAM action.

**Layer actions**

| Action | Resource | Condition |
|---|---|---|
| AddLayerVersionPermission (p. 877)<br>RemoveLayerVersionPermission (p. 1063)<br>GetLayerVersion (p. 980)<br>GetLayerVersionPolicy (p. 986)<br>DeleteLayerVersion (p. 941) | Layer version | None |
| ListLayerVersions (p. 1025)<br>PublishLayerVersion (p. 1037) | Layer | None |
| ListLayers (p. 1022) | * | None |

# Using permissions boundaries for AWS Lambda applications

When you create an application (p. 764) in the AWS Lambda console, Lambda applies a *permissions boundary* to the application's IAM roles. The permissions boundary limits the scope of the execution role (p. 52) that the application's template creates for each of its functions, and any roles that you add to the template. The permissions boundary prevents users with write access to the application's Git repository from escalating the application's permissions beyond the scope of its own resources.

The application templates in the Lambda console include a global property that applies a permissions boundary to all functions that they create.

```
Globals:
  Function:
    PermissionsBoundary: !Sub 'arn:${AWS::Partition}:iam::${AWS::AccountId}:policy/
${AppId}-${AWS::Region}-PermissionsBoundary'
```

The boundary limits the permissions of the functions' roles. You can add permissions to a function's execution role in the template, but that permission is only effective if it's also allowed by the permissions boundary. The role that AWS CloudFormation assumes to deploy the application enforces the use of the permissions boundary. That role only has permission to create and pass roles that have the application's permissions boundary attached.

By default, an application's permissions boundary enables functions to perform actions on the resources in the application. For example, if the application includes an Amazon DynamoDB table, the boundary allows access to any API action that can be restricted to operate on specific tables with resource-level permissions. You can only use actions that don't support resource-level permissions if they're specifically permitted in the boundary. These include Amazon CloudWatch Logs and AWS X-Ray API actions for logging and tracing.

### Example permissions boundary

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Action": [
                "*"
            ],
            "Resource": [
                "arn:aws:lambda:us-east-2:123456789012:function:my-app-getAllItemsFunction-
*",
                "arn:aws:lambda:us-east-2:123456789012:function:my-app-getByIdFunction-*",
                "arn:aws:lambda:us-east-2:123456789012:function:my-app-putItemFunction-*",
                "arn:aws:dynamodb:us-east-1:123456789012:table/my-app-SampleTable-*"
            ],
            "Effect": "Allow",
            "Sid": "StackResources"
        },
        {
            "Action": [
                "logs:CreateLogGroup",
                "logs:CreateLogStream",
                "logs:DescribeLogGroups",
                "logs:PutLogEvents",
                "xray:Put*"
            ],
            "Resource": "*",
```

```
            "Effect": "Allow",
            "Sid": "StaticPermissions"
        },
        ...
    ]
}
```

To access other resources or API actions, you or an administrator must expand the permissions boundary to include those resources. You might also need to update the execution role or deployment role of an application to allow the use of additional actions.

- **Permissions boundary** – Extend the application's permissions boundary when you add resources to your application, or the execution role needs access to more actions. In IAM, add resources to the boundary to allow the use of API actions that support resource-level permissions on that resource's type. For actions that don't support resource-level permissions, add them in a statement that isn't scoped to any resource.
- **Execution role** – Extend a function's execution role when it needs to use additional actions. In the application template, add policies to the execution role. The intersection of permissions in the boundary and execution role is granted to the function.
- **Deployment role** – Extend the application's deployment role when it needs additional permissions to create or configure resources. In IAM, add policies to the application's deployment role. The deployment role needs the same user permissions that you need to deploy or update an application in AWS CloudFormation.

For a tutorial that walks through adding resources to an application and extending its permissions, see ??? (p. 764).

For more information, see Permissions boundaries for IAM entities in the IAM User Guide.

# Lambda runtimes

Lambda supports multiple languages through the use of runtimes (p. 13). For a function defined as a container image (p. 136), you choose a runtime and the Linux distribution when you create the container image (p. 143). To change the runtime, you create a new container image.

When you use a .zip file archive for the deployment package, you choose a runtime when you create the function. To change the runtime, you can update your function's configuration (p. 132). The runtime is paired with one of the Amazon Linux distributions. The underlying execution environment provides additional libraries and environment variables (p. 166) that you can access from your function code.

### Amazon Linux 2

- Image – Custom
- Linux kernel – 4.14

### Amazon Linux

- Image – amzn-ami-hvm-2018.03.0.20220802.0-x86_64-gp2
- Linux kernel – 4.14

Lambda invokes your function in an execution environment (p. 100). The execution environment provides a secure and isolated runtime environment that manages the resources required to run your function. Lambda re-uses the execution environment from a previous invocation if one is available, or it can create a new execution environment.

A runtime can support a single version of a language, multiple versions of a language, or multiple languages. Runtimes specific to a language or framework version are deprecated (p. 83) when the version reaches end of life.

To use other languages in Lambda, you can implement a custom runtime (p. 90). The Lambda execution environment provides a runtime interface (p. 115) for getting invocation events and sending responses. You can deploy a custom runtime alongside your function code, or in a layer (p. 156).

> **Note**
> For new regions, Lambda will not support runtimes that are set to be deprecated within the next six months.

### Supported Runtimes

| Name | Identifier | SDK | Operating system | Architectures | Deprecation |
|---|---|---|---|---|---|
| Node.js 16 | `nodejs16.x` | 2.1083.0 | Amazon Linux 2 | x86_64, arm64 | |
| Node.js 14 | `nodejs14.x` | 2.1055.0 | Amazon Linux 2 | x86_64, arm64 | |
| Node.js 12 | `nodejs12.x` | 2.1055.0 | Amazon Linux 2 | x86_64, arm64 | Nov 14, 2022 |
| Python 3.9 | `python3.9` | boto3-1.20.32 botocore-1.23.32 | Amazon Linux 2 | x86_64, arm64 | |

| Name | Identifier | SDK | Operating system | Architectures | Deprecation |
|---|---|---|---|---|---|
| Python 3.8 | `python3.8` | boto3-1.20.32 botocore-1.23.32 | Amazon Linux 2 | x86_64, arm64 | |
| Python 3.7 | `python3.7` | boto3-1.20.32 botocore-1.23.32 | Amazon Linux | x86_64 | |
| Java 11 | `java11` | | Amazon Linux 2 | x86_64, arm64 | |
| Java 8 | `java8.al2` | | Amazon Linux 2 | x86_64, arm64 | |
| Java 8 | `java8` | | Amazon Linux | x86_64 | |
| .NET Core 3.1 | `dotnetcore3.1` | | Amazon Linux 2 | x86_64, arm64 | Jan 20, 2023 |
| .NET 6 | `dotnet6` | | Amazon Linux 2 | x86_64, arm64 | |
| .NET 5 | `dotnet5.0` | | Amazon Linux 2 | x86_64 | |
| Go 1.x | `go1.x` | | Amazon Linux | x86_64 | |
| Ruby 2.7 | `ruby2.7` | 3.1.0 | Amazon Linux 2 | x86_64, arm64 | |
| Custom Runtime | `provided.al2` | | Amazon Linux 2 | x86_64, arm64 | |
| Custom Runtime | `provided` | | Amazon Linux | x86_64 | |

# Runtime deprecation policy

Lambda runtimes (p. 82) for .zip file archives are built around a combination of operating system, programming language, and software libraries that are subject to maintenance and security updates. When security updates are no longer available for a component of a runtime, Lambda deprecates the runtime.

Deprecation (end of support) for a runtime occurs in two phases.

Phase 1 - Lambda no longer applies security patches or other updates to the runtime. You can no longer **create** functions that use the runtime, but you can continue to update existing functions. This includes updating the runtime version, and rolling back to the previous runtime version. Note that functions that use a deprecated runtime are no longer eligible for technical support.

Phase 2 - you can no longer **create or update** functions that use the runtime. To update a function, you need to migrate it to a supported runtime version. After you migrate the function to a supported runtime version, you cannot rollback the function to the previous runtime. Phase 2 starts at least 30 days after the start of Phase 1.

Lambda does not block invocations of functions that use deprecated runtime versions. Function invocations continue indefinitely after the runtime version reaches end of support. However, AWS

strongly recommends that you migrate functions to a supported runtime version so that you continue to receive security patches and remain eligible for technical support.

In the table below, each phase starts at midnight (Pacific time zone) on the specified date. The following runtimes have reached end of support:

### Deprecated runtimes

| Name | Identifier | Operating system | Deprecation Phase 1 | Deprecation Phase 2 |
|---|---|---|---|---|
| Python 3.6 | `python3.6` | Amazon Linux | Jul 18, 2022 | Aug 17, 2022 |
| Python 2.7 | `python2.7` | Amazon Linux | Jul 15, 2021 | May 30, 2022 |
| .NET Core 2.1 | `dotnetcore2.1` | Amazon Linux | Jan 5, 2022 | Apr 13, 2022 |
| Ruby 2.5 | `ruby2.5` | Amazon Linux | Jul 30, 2021 | Mar 31, 2022 |
| Node.js 10 | `nodejs10.x` | Amazon Linux 2 | Jul 30, 2021 | Feb 14, 2022 |
| Node.js 8.10 | `nodejs8.10` | Amazon Linux | | Mar 6, 2020 |
| Node.js 4.3 | `nodejs4.3` | Amazon Linux | | Mar 5, 2020 |
| Node.js 6.10 | `nodejs6.10` | Amazon Linux | | Aug 12, 2019 |
| .NET Core 1.0 | `dotnetcore1.0` | Amazon Linux | | Jul 30, 2019 |
| .NET Core 2.0 | `dotnetcore2.0` | Amazon Linux | | May 30, 2019 |
| Node.js 4.3 edge | `nodejs4.3-edge` | Amazon Linux | | Apr 30, 2019 |
| Node.js 0.10 | `nodejs` | Amazon Linux | | Oct 31, 2016 |

In almost all cases, the end-of-life date of a language version or operating system is known well in advance. Lambda notifies you by email if you have functions using a runtime that is scheduled for end of support in the next 60 days. In rare cases, advance notice of support ending might not be possible. For example, security issues that require a backwards-incompatible update, or a runtime component that doesn't provide a long-term support (LTS) schedule.

### Language and framework support policies

- **Node.js** – github.com
- **Python** – devguide.python.org
- **Ruby** – www.ruby-lang.org
- **Java** – www.oracle.com and Corretto FAQs
- **Go** – golang.org
- **.NET Core** – dotnet.microsoft.com

**Topics**

- Modifying the runtime environment (p. 85)
- Custom AWS Lambda runtimes (p. 90)
- Tutorial – Publishing a custom runtime (p. 92)
- Using AVX2 vectorization in Lambda (p. 98)

# Modifying the runtime environment

You can use internal extensions (p. 254) to modify the runtime process. Internal extensions are not separate processes—they run as part of the runtime process.

Lambda provides language-specific environment variables (p. 166) that you can set to add options and tools to the runtime. Lambda also provides wrapper scripts (p. 87), which allow Lambda to delegate the runtime startup to your script. You can create a wrapper script to customize the runtime startup behavior.

## Language-specific environment variables

Lambda supports configuration-only ways to enable code to be pre-loaded during function initialization through the following language-specific environment variables:

- `JAVA_TOOL_OPTIONS` – On Java, Lambda supports this environment variable to set additional command-line variables in Lambda. This environment variable allows you to specify the initialization of tools, specifically the launching of native or Java programming language agents using the `agentlib` or `javaagent` options.
- `NODE_OPTIONS` – On Node.js 10x and above, Lambda supports this environment variable.
- `DOTNET_STARTUP_HOOKS` – On .NET Core 3.1 and above, this environment variable specifies a path to an assembly (dll) that Lambda can use.

Using language-specific environment variables is the preferred way to set startup properties.

### Example: Intercept Lambda invokes with `javaagent`

The Java virtual machine (JVM) tries to locate the class that was specified with the `javaagent` parameter to the JVM, and invoke its `premain` method before the application's entry point.

The following example uses Byte Buddy, a library for creating and modifying Java classes during the runtime of a Java application without the help of a compiler. Byte Buddy offers an additional API for generating Java agents. In this example, the `Agent` class intercepts every call of the `handleRequest` method made to the RequestStreamHandler class. This class is used internally in the runtime to wrap the handler invocations.

```
import com.amazonaws.services.lambda.runtime.RequestStreamHandler;
import net.bytebuddy.agent.builder.AgentBuilder;
import net.bytebuddy.asm.Advice;
import net.bytebuddy.matcher.ElementMatchers;

import java.lang.instrument.Instrumentation;

public class Agent {

    public static void premain(String agentArgs, Instrumentation inst) {
        new AgentBuilder.Default()
            .with(new AgentBuilder.InitializationStrategy.SelfInjection.Eager())
            .type(ElementMatchers.isSubTypeOf(RequestStreamHandler.class))
            .transform((builder, typeDescription, classLoader, module) -> builder
                .method(ElementMatchers.nameContains("handleRequest"))
                .intercept(Advice.to(TimerAdvice.class)))
            .installOn(inst);
    }
}
```

The agent in the preceding example uses the `TimerAdvice` method. `TimerAdvice` measures how many milliseconds are spent with the method call and logs the method time and details, such as name and passed arguments.

```
import static net.bytebuddy.asm.Advice.AllArguments;
import static net.bytebuddy.asm.Advice.Enter;
import static net.bytebuddy.asm.Advice.OnMethodEnter;
import static net.bytebuddy.asm.Advice.OnMethodExit;
import static net.bytebuddy.asm.Advice.Origin;

public class TimerAdvice {

    @OnMethodEnter
    static long enter() {
        return System.currentTimeMillis();
    }

    @OnMethodExit
    static void exit(@Origin String method, @Enter long start, @AllArguments Object[] args)
 {
        StringBuilder sb = new StringBuilder();
        for (Object arg : args) {
            sb.append(arg);
            sb.append(", ");
        }
        System.out.println(method + " method with args: " + sb.toString() + " took " +
 (System.currentTimeMillis() - start) + " milliseconds ");
    }
}
```

The `TimerAdvice` method above has the following dependencies.

```
*'com.amazonaws'*, *name*: *'aws-lambda-java-core'*, *version*: *'1.2.1'*
*'net.bytebuddy'*, *name*: *'byte-buddy-dep'*, *version*: *'1.10.14'*
*'net.bytebuddy'*, *name*: *'byte-buddy-agent'*, *version*: *'1.10.14'*
```

After you create a layer that contains the agent JAR, you can pass the JAR name to the runtime's JVM by setting an environment variable.

```
JAVA_TOOL_OPTIONS=-javaagent:"/opt/ExampleAgent-0.0.jar"
```

After invoking the function with `{key=lambdaInput}`, you can find the following line in the logs:

```
public java.lang.Object lambdainternal.EventHandlerLoader
$PojoMethodRequestHandler.handleRequest
 (java.lang.Object,com.amazonaws.services.lambda.runtime.Context) method with args:
  {key=lambdaInput}, lambdainternal.api.LambdaContext@4d9d1b69, took 106 milliseconds
```

## Example: Adding a shutdown hook to the JVM runtime process

When an extension is registered during a `Shutdown` event, the runtime process gets up to 500 ms to handle graceful shutdown. You can hook into the runtime process, and when the JVM begins its shutdown process, it starts all registered hooks. To register a shutdown hook, you must register as

an extension (p. 110). You do not need to explicitly register for the `Shutdown` event, as that is automatically sent to the runtime.

```
import java.lang.instrument.Instrumentation;

public class Agent {

    public static void premain(String agentArgs, Instrumentation inst) {
//      Register the extension.
//      ...

//      Register the shutdown hook
        addShutdownHook();
    }

    private static void addShutdownHook() {
//      Shutdown hooks get up to 500 ms to handle graceful shutdown before the runtime is
 terminated.
//
//      You can use this time to egress any remaining telemetry, close open database
 connections, etc.
        Runtime.getRuntime().addShutdownHook(new Thread(() -> {
//            Inside the shutdown hook's thread we can perform any remaining task which
 needs to be done.
        }));
    }

}
```

## Example: Retrieving the InvokedFunctionArn

```
@OnMethodEnter
    static long enter() {
        String invokedFunctionArn = null;
        for (Object arg : args) {
            if (arg instanceof Context) {
                Context context = (Context) arg;
                invokedFunctionArn = context.getInvokedFunctionArn();
            }
        }
    }
```

# Wrapper scripts

You can create a *wrapper script* to customize the runtime startup behavior of your Lambda function. A wrapper script enables you to set configuration parameters that cannot be set through language-specific environment variables.

**Note**
Invocations may fail if the wrapper script does not successfully start the runtime process.

The following Lambda runtimes (p. 82) support wrapper scripts:

- Node.js 14.x
- Node.js 12.x

- Node.js 10.x
- Python 3.9
- Python 3.8
- Ruby 2.7
- Java 11
- Java 8 (`java8.al2`)
- .NET Core 3.1

When you use a wrapper script for your function, Lambda starts the runtime using your script. Lambda sends to your script the path to the interpreter and all of the original arguments for the standard runtime startup. Your script can extend or transform the startup behavior of the program. For example, the script can inject and alter arguments, set environment variables, or capture metrics, errors, and other diagnostic information.

You specify the script by setting the value of the `AWS_LAMBDA_EXEC_WRAPPER` environment variable as the file system path of an executable binary or script.

## Example: Create and use a wrapper script with Python 3.8

In the following example, you create a wrapper script to start the Python interpreter with the `-X importtime` option. When you run the function, Lambda generates a log entry to show the duration of the import time for each import.

**To create and use a wrapper script with Python 3.8**

1. To create the wrapper script, paste the following code into a file named `importtime_wrapper`:

```
#!/bin/bash

# the path to the interpreter and all of the originally intended arguments
args=("$@")

# the extra options to pass to the interpreter
extra_args=("-X" "importtime")

# insert the extra options
args=("${args[@]:0:$#-1}" "${extra_args[@]}" "${args[@]: -1}")

# start the runtime with the extra options
exec "${args[@]}"
```

2. To give the script executable permissions, enter `chmod +x importtime_wrapper` from the command line.
3. Deploy the script as a Lambda layer (p. 156).
4. Create a function using the Lambda console.
   a. Open the Lambda console.
   b. Choose **Create function**.
   c. Under **Basic information**, for **Function name**, enter **`wrapper-test-function`**.
   d. For **Runtime**, choose **Python 3.8**.
   e. Choose **Create function**.
5. Add the layer to your function.
   a. Choose your function, and then choose **Code** if it is not already selected.

b. Choose **Add a layer**.
c. Under **Choose a layer**, choose the **Name** and **Version** of the compatible layer that you created earlier.
d. Choose **Add**.

6. Add the code and the environment variable to your function.

a. In the function code editor (p. 38), paste the following function code:

```
import json

  def lambda_handler(event, context):
      # TODO implement
      return {
          'statusCode': 200,
          'body': json.dumps('Hello from Lambda!')
      }
```

b. Choose **Save**.
c. Under **Environment variables**, choose **Edit**.
d. Choose **Add environment variable**.
e. For **Key**, enter `AWS_LAMBDA_EXEC_WRAPPER`.
f. For **Value**, enter `/opt/importtime_wrapper`.
g. Choose **Save**.

7. To run the function, choose **Test**.

Because your wrapper script started the Python interpreter with the `-X importtime` option, the logs show the time required for each import. For example:

```
...
2020-06-30T18:48:46.780+01:00 import time: 213 | 213 | simplejson
2020-06-30T18:48:46.780+01:00 import time: 50 | 263 | simplejson.raw_json
...
```

# Custom AWS Lambda runtimes

You can implement an AWS Lambda runtime in any programming language. A runtime is a program that runs a Lambda function's handler method when the function is invoked. You can include a runtime in your function's deployment package in the form of an executable file named `bootstrap`.

A runtime is responsible for running the function's setup code, reading the handler name from an environment variable, and reading invocation events from the Lambda runtime API. The runtime passes the event data to the function handler, and posts the response from the handler back to Lambda.

Your custom runtime runs in the standard Lambda execution environment (p. 82). It can be a shell script, a script in a language that's included in Amazon Linux, or a binary executable file that's compiled in Amazon Linux.

To get started with custom runtimes, see Tutorial – Publishing a custom runtime (p. 92). You can also explore a custom runtime implemented in C++ at awslabs/aws-lambda-cpp on GitHub.

**Topics**


- Using a custom runtime (p. 90)
- Building a custom runtime (p. 90)


## Using a custom runtime

To use a custom runtime, set your function's runtime to `provided`. The runtime can be included in your function's deployment package, or in a layer (p. 156).

**Example function.zip**

```
.
### bootstrap
### function.sh
```

If there's a file named `bootstrap` in your deployment package, Lambda runs that file. If not, Lambda looks for a runtime in the function's layers. If the bootstrap file isn't found or isn't executable, your function returns an error upon invocation.

## Building a custom runtime

A custom runtime's entry point is an executable file named `bootstrap`. The bootstrap file can be the runtime, or it can invoke another file that creates the runtime. The following example uses a bundled version of Node.js to run a JavaScript runtime in a separate file named `runtime.js`.

**Example bootstrap**

```
#!/bin/sh
cd $LAMBDA_TASK_ROOT
./node-v11.1.0-linux-x64/bin/node runtime.js
```

Your runtime code is responsible for completing some initialization tasks. Then it processes invocation events in a loop until it's terminated. The initialization tasks run once per instance of the function (p. 100) to prepare the environment to handle invocations.

**Initialization tasks**

- **Retrieve settings** – Read environment variables to get details about the function and environment.

- `_HANDLER` – The location to the handler, from the function's configuration. The standard format is *`file`*`.`*`method`*, where `file` is the name of the file without an extension, and `method` is the name of a method or function that's defined in the file.
- `LAMBDA_TASK_ROOT` – The directory that contains the function code.
- `AWS_LAMBDA_RUNTIME_API` – The host and port of the runtime API.

See Defined runtime environment variables (p. 169) for a full list of available variables.

- **Initialize the function** – Load the handler file and run any global or static code that it contains. Functions should create static resources like SDK clients and database connections once, and reuse them for multiple invocations.
- **Handle errors** – If an error occurs, call the initialization error (p. 116) API and exit immediately.

Initialization counts towards billed execution time and timeout. When an execution triggers the initialization of a new instance of your function, you can see the initialization time in the logs and AWS X-Ray trace (p. 715).

### Example log

```
REPORT RequestId: f8ac1208... Init Duration: 48.26 ms   Duration: 237.17 ms   Billed
 Duration: 300 ms   Memory Size: 128 MB   Max Memory Used: 26 MB
```

While it runs, a runtime uses the Lambda runtime interface (p. 115) to manage incoming events and report errors. After completing initialization tasks, the runtime processes incoming events in a loop. In your runtime code, perform the following steps in order.

### Processing tasks

- **Get an event** – Call the next invocation (p. 115) API to get the next event. The response body contains the event data. Response headers contain the request ID and other information.
- **Propagate the tracing header** – Get the X-Ray tracing header from the `Lambda-Runtime-Trace-Id` header in the API response. Set the `_X_AMZN_TRACE_ID` environment variable locally with the same value. The X-Ray SDK uses this value to connect trace data between services.
- **Create a context object** – Create an object with context information from environment variables and headers in the API response.
- **Invoke the function handler** – Pass the event and context object to the handler.
- **Handle the response** – Call the invocation response (p. 116) API to post the response from the handler.
- **Handle errors** – If an error occurs, call the invocation error (p. 117) API.
- **Cleanup** – Release unused resources, send data to other services, or perform additional tasks before getting the next event.

You can include the runtime in your function's deployment package, or distribute the runtime separately in a function layer. For an example walkthrough, see Tutorial – Publishing a custom runtime (p. 92).

# Tutorial – Publishing a custom runtime

In this tutorial, you create a Lambda function with a custom runtime. You start by including the runtime in the function's deployment package. Then you migrate it to a layer that you manage independently from the function. Finally, you share the runtime layer with the world by updating its resource-based permissions policy.

## Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

You need an IAM role to create a Lambda function. The role needs permission to send logs to CloudWatch Logs and access the AWS services that your function uses. If you don't have a role for function development, create one now.

**To create an execution role**

1. Open the roles page in the IAM console.
2. Choose **Create role**.
3. Create a role with the following properties.

   - **Trusted entity** – **Lambda**.
   - **Permissions** – **AWSLambdaBasicExecutionRole**.
   - **Role name** – **`lambda-role`**.

   The **AWSLambdaBasicExecutionRole** policy has the permissions that the function needs to write logs to CloudWatch Logs.

## Create a function

Create a Lambda function with a custom runtime. This example includes two files, a runtime `bootstrap` file, and a function handler. Both are implemented in Bash.

The runtime loads a function script from the deployment package. It uses two variables to locate the script. `LAMBDA_TASK_ROOT` tells it where the package was extracted, and `_HANDLER` includes the name of the script.

### Example bootstrap

```
#!/bin/sh

set -euo pipefail

# Initialization - load function handler
source $LAMBDA_TASK_ROOT/"$(echo $_HANDLER | cut -d. -f1).sh"

# Processing
while true
do
  HEADERS="$(mktemp)"
  # Get an event. The HTTP request will block until one is received
  EVENT_DATA=$(curl -sS -LD "$HEADERS" -X GET "http://${AWS_LAMBDA_RUNTIME_API}/2018-06-01/
runtime/invocation/next")

  # Extract request ID by scraping response headers received above
  REQUEST_ID=$(grep -Fi Lambda-Runtime-Aws-Request-Id "$HEADERS" | tr -d '[:space:]' | cut
 -d: -f2)

  # Run the handler function from the script
  RESPONSE=$($(echo "$_HANDLER" | cut -d. -f2) "$EVENT_DATA")

  # Send the response
  curl -X POST "http://${AWS_LAMBDA_RUNTIME_API}/2018-06-01/runtime/invocation/$REQUEST_ID/
response"  -d "$RESPONSE"
done
```

After loading the script, the runtime processes events in a loop. It uses the runtime API to retrieve an invocation event from Lambda, passes the event to the handler, and posts the response back to Lambda. To get the request ID, the runtime saves the headers from the API response to a temporary file, and reads the `Lambda-Runtime-Aws-Request-Id` header from the file.

> **Note**
> Runtimes have additional responsibilities, including error handling, and providing context information to the handler. For details, see Building a custom runtime (p. 90).

The script defines a handler function that takes event data, logs it to `stderr`, and returns it.

### Example function.sh

```
function handler () {
  EVENT_DATA=$1
  echo "$EVENT_DATA" 1>&2;
  RESPONSE="Echoing request: '$EVENT_DATA'"

  echo $RESPONSE
}
```

Save both files in a project directory named `runtime-tutorial`.

```
runtime-tutorial
# bootstrap
# function.sh
```

Make the files executable and add them to a .zip file archive.

```
runtime-tutorial$ chmod 755 function.sh bootstrap
runtime-tutorial$ zip function.zip function.sh bootstrap
```

```
  adding: function.sh (deflated 24%)
  adding: bootstrap (deflated 39%)
```

Create a function named `bash-runtime`.

```
runtime-tutorial$ aws lambda create-function --function-name bash-runtime \
--zip-file fileb://function.zip --handler function.handler --runtime provided \
--role arn:aws:iam::123456789012:role/lambda-role
{
    "FunctionName": "bash-runtime",
    "FunctionArn": "arn:aws:lambda:us-west-2:123456789012:function:bash-runtime",
    "Runtime": "provided",
    "Role": "arn:aws:iam::123456789012:role/lambda-role",
    "Handler": "function.handler",
    "CodeSha256": "mv/xRv84LPCxdpcbKvmwuuFzwo7sLwUO1VxcUv3wKlM=",
    "Version": "$LATEST",
    "TracingConfig": {
        "Mode": "PassThrough"
    },
    "RevisionId": "2e1d51b0-6144-4763-8e5c-7d5672a01713",
    ...
}
```

Invoke the function and verify the response.

```
runtime-tutorial$ aws lambda invoke --function-name bash-runtime --payload
 '{"text":"Hello"}' response.txt --cli-binary-format raw-in-base64-out
{
    "StatusCode": 200,
    "ExecutedVersion": "$LATEST"
}
runtime-tutorial$ cat response.txt
Echoing request: '{"text":"Hello"}'
```

# Create a layer

To separate the runtime code from the function code, create a layer that only contains the runtime. Layers let you develop your function's dependencies independently, and can reduce storage usage when you use the same layer with multiple functions.

Create a layer archive that contains the `bootstrap` file.

```
runtime-tutorial$ zip runtime.zip bootstrap
  adding: bootstrap (deflated 39%)
```

Create a layer with the `publish-layer-version` command.

```
runtime-tutorial$ aws lambda publish-layer-version --layer-name bash-runtime --zip-file
 fileb://runtime.zip
 {
    "Content": {
        "Location": "https://awslambda-us-west-2-layers.s3.us-west-2.amazonaws.com/
snapshots/123456789012/bash-runtime-018c209b...",
        "CodeSha256": "bXVLhHi+D3H1QbDARUVPrDwlC7bssPxySQqt1QZqusE=",
        "CodeSize": 584,
        "UncompressedCodeSize": 0
    },
    "LayerArn": "arn:aws:lambda:us-west-2:123456789012:layer:bash-runtime",
    "LayerVersionArn": "arn:aws:lambda:us-west-2:123456789012:layer:bash-runtime:1",
```

```
    "Description": "",
    "CreatedDate": "2018-11-28T07:49:14.476+0000",
    "Version": 1
}
```

This creates the first version of the layer.

# Update the function

To use the runtime layer with the function, configure the function to use the layer, and remove the runtime code from the function.

Update the function configuration to pull in the layer.

```
runtime-tutorial$ aws lambda update-function-configuration --function-name bash-runtime \
--layers arn:aws:lambda:us-west-2:123456789012:layer:bash-runtime:1
{
    "FunctionName": "bash-runtime",
    "Layers": [
        {
            "Arn": "arn:aws:lambda:us-west-2:123456789012:layer:bash-runtime:1",
            "CodeSize": 584,
            "UncompressedCodeSize": 679
        }
    ]
    ...
}
```

This adds the runtime to the function in the `/opt` directory. Lambda uses this runtime, but only if you remove it from the function's deployment package. Update the function code to only include the handler script.

```
runtime-tutorial$ zip function-only.zip function.sh
  adding: function.sh (deflated 24%)
runtime-tutorial$ aws lambda update-function-code --function-name bash-runtime --zip-file
 fileb://function-only.zip
{
    "FunctionName": "bash-runtime",
    "CodeSize": 270,
    "Layers": [
        {
            "Arn": "arn:aws:lambda:us-west-2:123456789012:layer:bash-runtime:7",
            "CodeSize": 584,
            "UncompressedCodeSize": 679
        }
    ]
    ...
}
```

Invoke the function to verify that it works with the runtime layer.

```
runtime-tutorial$ aws lambda invoke --function-name bash-runtime --payload
 '{"text":"Hello"}' response.txt --cli-binary-format raw-in-base64-out
{
    "StatusCode": 200,
    "ExecutedVersion": "$LATEST"
}
runtime-tutorial$ cat response.txt
Echoing request: '{"text":"Hello"}'
```

# Update the runtime

To log information about the execution environment, update the runtime script to output environment variables.

**Example bootstrap**

```
#!/bin/sh

set -euo pipefail

echo "##  Environment variables:"
env

# Initialization - load function handler
source $LAMBDA_TASK_ROOT/"$(echo $_HANDLER | cut -d. -f1).sh"
...
```

Create a second version of the layer with the new code.

```
runtime-tutorial$ zip runtime.zip bootstrap
updating: bootstrap (deflated 39%)
runtime-tutorial$ aws lambda publish-layer-version --layer-name bash-runtime --zip-file
 fileb://runtime.zip
```

Configure the function to use the new version of the layer.

```
runtime-tutorial$ aws lambda update-function-configuration --function-name bash-runtime \
--layers arn:aws:lambda:us-west-2:123456789012:layer:bash-runtime:2
```

# Share the layer

Add a permission statement to your runtime layer to share it with other accounts.

```
runtime-tutorial$ aws lambda add-layer-version-permission --layer-name bash-runtime --
version-number 2 \
--principal "*" --statement-id publish --action lambda:GetLayerVersion
{
    "Statement": "{\"Sid\":\"publish\",\"Effect\":\"Allow\",\"Principal\":\"*\",\"Action\":
\"lambda:GetLayerVersion\",\"Resource\":\"arn:aws:lambda:us-west-2:123456789012:layer:bash-
runtime:2\"}",
    "RevisionId": "9d5fe08e-2a1e-4981-b783-37ab551247ff"
}
```

You can add multiple statements that each grant permission to a single account, accounts in an organization, or all accounts.

# Clean up

Delete each version of the layer.

```
runtime-tutorial$ aws lambda delete-layer-version --layer-name bash-runtime --version-
number 1
runtime-tutorial$ aws lambda delete-layer-version --layer-name bash-runtime --version-
number 2
```

Because the function holds a reference to version 2 of the layer, it still exists in Lambda. The function continues to work, but functions can no longer be configured to use the deleted version. If you then modify the list of layers on the function, you must specify a new version or omit the deleted layer.

Delete the tutorial function with the `delete-function` command.

```
runtime-tutorial$ aws lambda delete-function --function-name bash-runtime
```

# Using AVX2 vectorization in Lambda

Advanced Vector Extensions 2 (AVX2) is a vectorization extension to the Intel x86 instruction set that can perform single instruction multiple data (SIMD) instructions over vectors of 256 bits. For vectorizable algorithms with highly parallelizable operation, using AVX2 can enhance CPU performance, resulting in lower latencies and higher throughput. Use the AVX2 instruction set for compute-intensive workloads such as machine learning inferencing, multimedia processing, scientific simulations, and financial modeling applications.

**Note**
Lambda arm64 uses NEON SIMD architecture and does not support the x86 AVX2 extensions.

To use AVX2 with your Lambda function, make sure that your function code is accessing AVX2-optimized code. For some languages, you can install the AVX2-supported version of libraries and packages. For other languages, you can recompile your code and dependencies with the appropriate compiler flags set (if the compiler supports auto-vectorization). You can also compile your code with third-party libraries that use AVX2 to optimize math operations. For example, Intel Math Kernel Library (Intel MKL), OpenBLAS (Basic Linear Algebra Subprograms), and AMD BLAS-like Library Instantiation Software (BLIS). Auto-vectorized languages, such as Java, automatically use AVX2 for computations.

You can create new Lambda workloads or move existing AVX2-enabled workloads to Lambda at no additional cost.

For more information about AVX2, see Advanced Vector Extensions 2 in Wikipedia.

## Compiling from source

If your Lambda function uses a C or C++ library to perform compute-intensive vectorizable operations, you can set the appropriate compiler flags and recompile the function code. Then, the compiler automatically vectorizes your code.

For the `gcc` or `clang` compiler, add `-march=haswell` to the command or set `-mavx2` as a command option.

```
~ gcc -march=haswell main.c
or
~ gcc -mavx2 main.c

~ clang -march=haswell main.c
or
~ clang -mavx2 main.c
```

To use a specific library, follow instructions in the library's documentation to compile and build the library. For example, to build TensorFlow from source, you can follow the installation instructions on the TensorFlow website. Make sure to use the `-march=haswell` compile option.

## Enabling AVX2 for Intel MKL

Intel MKL is a library of optimized math operations that implicitly use AVX2 instructions when the compute platform supports them. Frameworks such as PyTorch build with Intel MKL by default, so you don't need to enable AVX2.

Some libraries, such as TensorFlow, provide options in their build process to specify Intel MKL optimization. For example, with TensorFlow, use the `--config=mkl` option.

You can also build popular scientific Python libraries, such as SciPy and NumPy, with Intel MKL. For instructions on building these libraries with Intel MKL, see Numpy/Scipy with Intel MKL and Intel Compilers on the Intel website.

For more information about Intel MKL and similar libraries, see Math Kernel Library in Wikipedia, the OpenBLAS website, and the AMD BLIS repository on GitHub.

# AVX2 support in other languages

If you don't use C or C++ libraries and don't build with Intel MKL, you can still get some AVX2 performance improvement for your applications. Note that the actual improvement depends on the compiler or interpreter's ability to utilize the AVX2 capabilities on your code.

Python

Python users generally use SciPy and NumPy libraries for compute-intensive workloads. You can compile these libraries to enable AVX2, or you can use the Intel MKL-enabled versions of the libraries.

Node

For compute-intensive workloads, use AVX2-enabled or Intel MKL-enabled versions of the libraries that you need.

Java

Java's JIT compiler can auto-vectorize your code to run with AVX2 instructions. For information about detecting vectorized code, see the Code vectorization in the JVM presentation on the OpenJDK website.

Go

The standard Go compiler doesn't currently support auto-vectorization, but you can use gccgo, the GCC compiler for Go. Set the `-mavx2` option:

```
gcc -o avx2 -mavx2 -Wall main.c
```

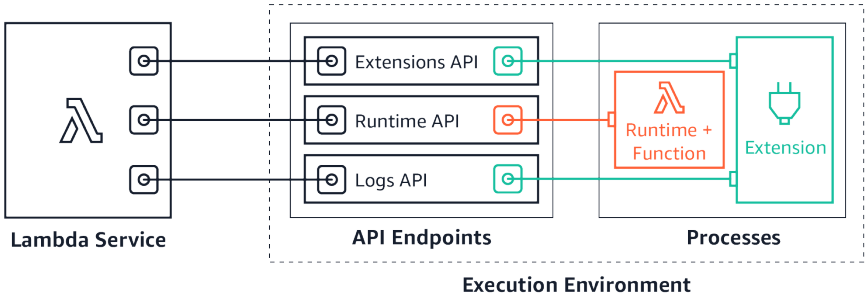
Intrinsics

It's possible to use intrinsic functions in many languages to manually vectorize your code to use AVX2. However, we don't recommend this approach. Manually writing vectorized code takes significant effort. Also, debugging and maintaining such code is more difficult than using code that depends on auto-vectorization.

# AWS Lambda execution environment

Lambda invokes your function in an execution environment, which provides a secure and isolated runtime environment. The execution environment manages the resources required to run your function. The execution environment also provides lifecycle support for the function's runtime and any external extensions (p. 254) associated with your function.

The function's runtime communicates with Lambda using the Runtime API (p. 115). Extensions communicate with Lambda using the Extensions API (p. 101). Extensions can also receive log messages from the function by subscribing to logs using the Logs API (p. 120).




When you create your Lambda function, you specify configuration information, such as the amount of memory available and the maximum execution time allowed for your function. Lambda uses this information to set up the execution environment.

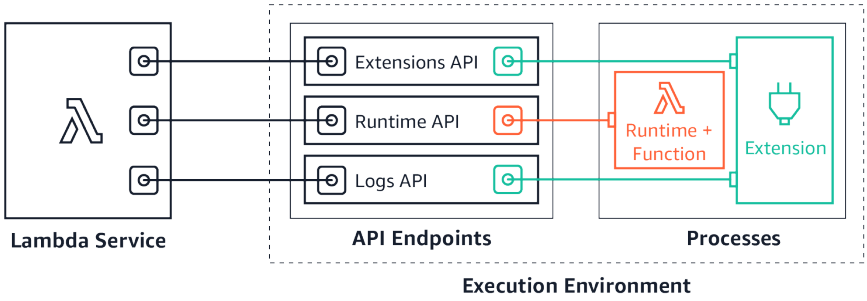
The function's runtime and each external extension are processes that run within the execution environment. Permissions, resources, credentials, and environment variables are shared between the function and the extensions.

**Topics**


- Lambda Extensions API (p. 101)
- AWS Lambda runtime API (p. 115)
- Lambda Logs API (p. 120)
- AWS Lambda extensions partners (p. 127)
- Lambda execution environment lifecycle (p. 128)

# Lambda Extensions API

Lambda function authors use extensions to integrate Lambda with their preferred tools for monitoring, observability, security, and governance. Function authors can use extensions from AWS, AWS Partners (p. 127), and open-source projects. For more information on using extensions, see Introducing AWS Lambda Extensions on the AWS Compute Blog.




As an extension author, you can use the Lambda Extensions API to integrate deeply into the Lambda execution environment (p. 100). Your extension can register for function and execution environment lifecycle events. In response to these events, you can start new processes, run logic, and control and participate in all phases of the Lambda lifecycle: initialization, invocation, and shutdown. In addition, you can use the Runtime Logs API (p. 120) to receive a stream of logs.

An extension runs as an independent process in the execution environment and can continue to run after the function invocation is fully processed. Because extensions run as processes, you can write them in a different language than the function. We recommend that you implement extensions using a compiled language. In this case, the extension is a self-contained binary that is compatible with supported runtimes. All Lambda runtimes (p. 82) support extensions. If you use a non-compiled language, ensure that you include a compatible runtime in the extension.

Lambda also supports *internal extensions*. An internal extension runs as a separate thread in the runtime process. The runtime starts and stops the internal extension. An alternative way to integrate with the Lambda environment is to use language-specific environment variables and wrapper scripts (p. 85). You can use these to configure the runtime environment and modify the startup behavior of the runtime process.

You can add extensions to a function in two ways. For a function deployed as a .zip file archive (p. 35), you deploy your extension as a layer (p. 156). For a function defined as a container image, you add the extensions (p. 256) to your container image.

> **Note**
> For example extensions and wrapper scripts, see AWS Lambda Extensions on the AWS Samples GitHub repository.

**Topics**

- Lambda execution environment lifecycle (p. 101)
- Extensions API reference (p. 110)

# Lambda execution environment lifecycle

The lifecycle of the execution environment includes the following phases:

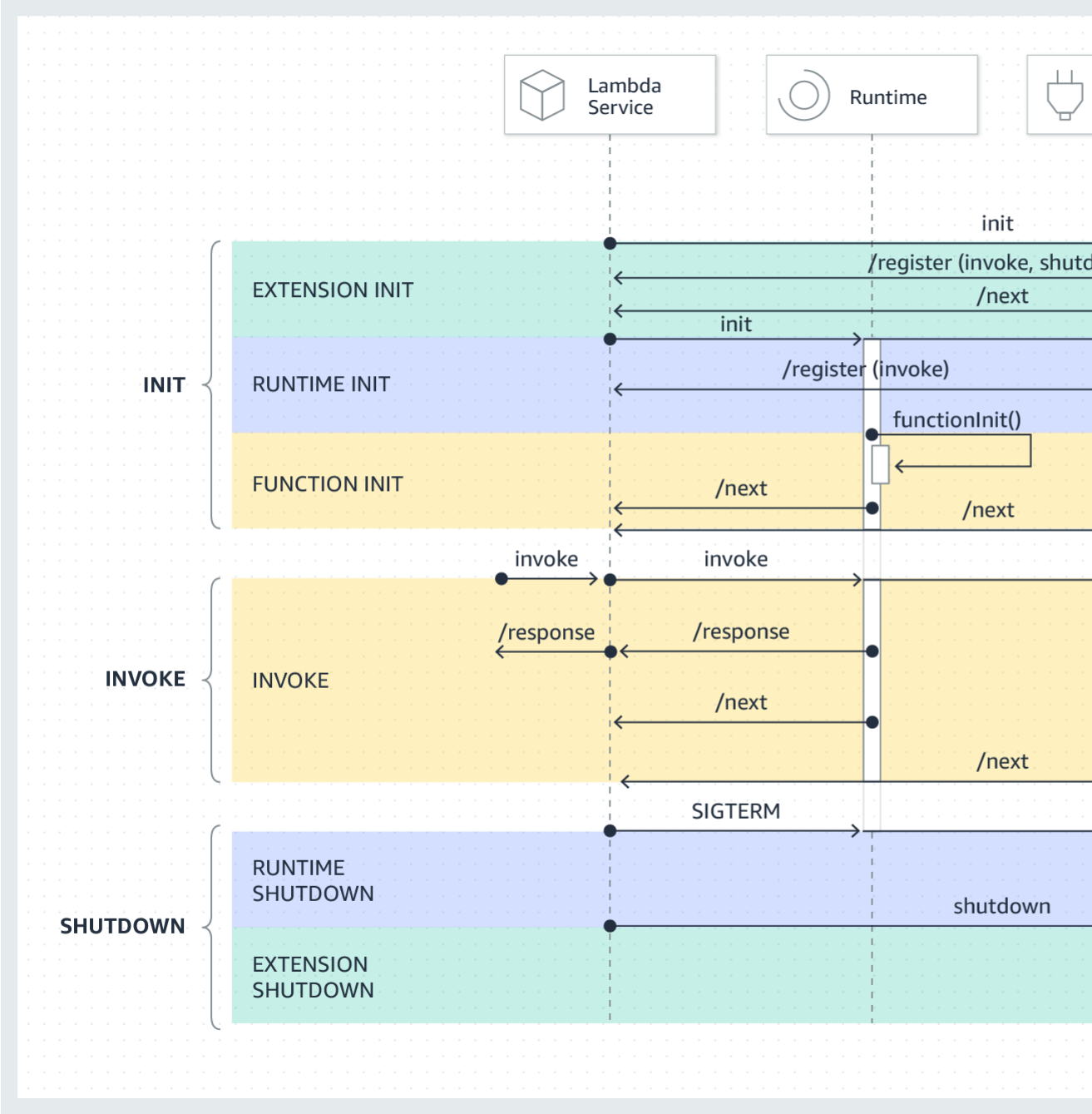
- **`Init`**: In this phase, Lambda creates or unfreezes an execution environment with the configured resources, downloads the code for the function and all layers, initializes any extensions, initializes the

runtime, and then runs the function's initialization code (the code outside the main handler). The `Init` phase happens either during the first invocation, or in advance of function invocations if you have enabled provisioned concurrency (p. 183).

The `Init` phase is split into three sub-phases: `Extension init`, `Runtime init`, and `Function init`. These sub-phases ensure that all extensions and the runtime complete their setup tasks before the function code runs.

- **`Invoke`**: In this phase, Lambda invokes the function handler. After the function runs to completion, Lambda prepares to handle another function invocation.
- **`Shutdown`**: This phase is triggered if the Lambda function does not receive any invocations for a period of time. In the `Shutdown` phase, Lambda shuts down the runtime, alerts the extensions to let them stop cleanly, and then removes the environment. Lambda sends a `Shutdown` event to each extension, which tells the extension that the environment is about to be shut down.

Each phase starts with an event from Lambda to the runtime and to all registered extensions. The runtime and each extension signal completion by sending a `Next` API request. Lambda freezes the execution environment when each process has completed and there are no pending events.




**Topics**


- Init phase (p. 104)
- Invoke phase (p. 105)
- Shutdown phase (p. 107)
- Permissions and configuration (p. 109)
- Failure handling (p. 109)
- Troubleshooting extensions (p. 110)

## Init phase

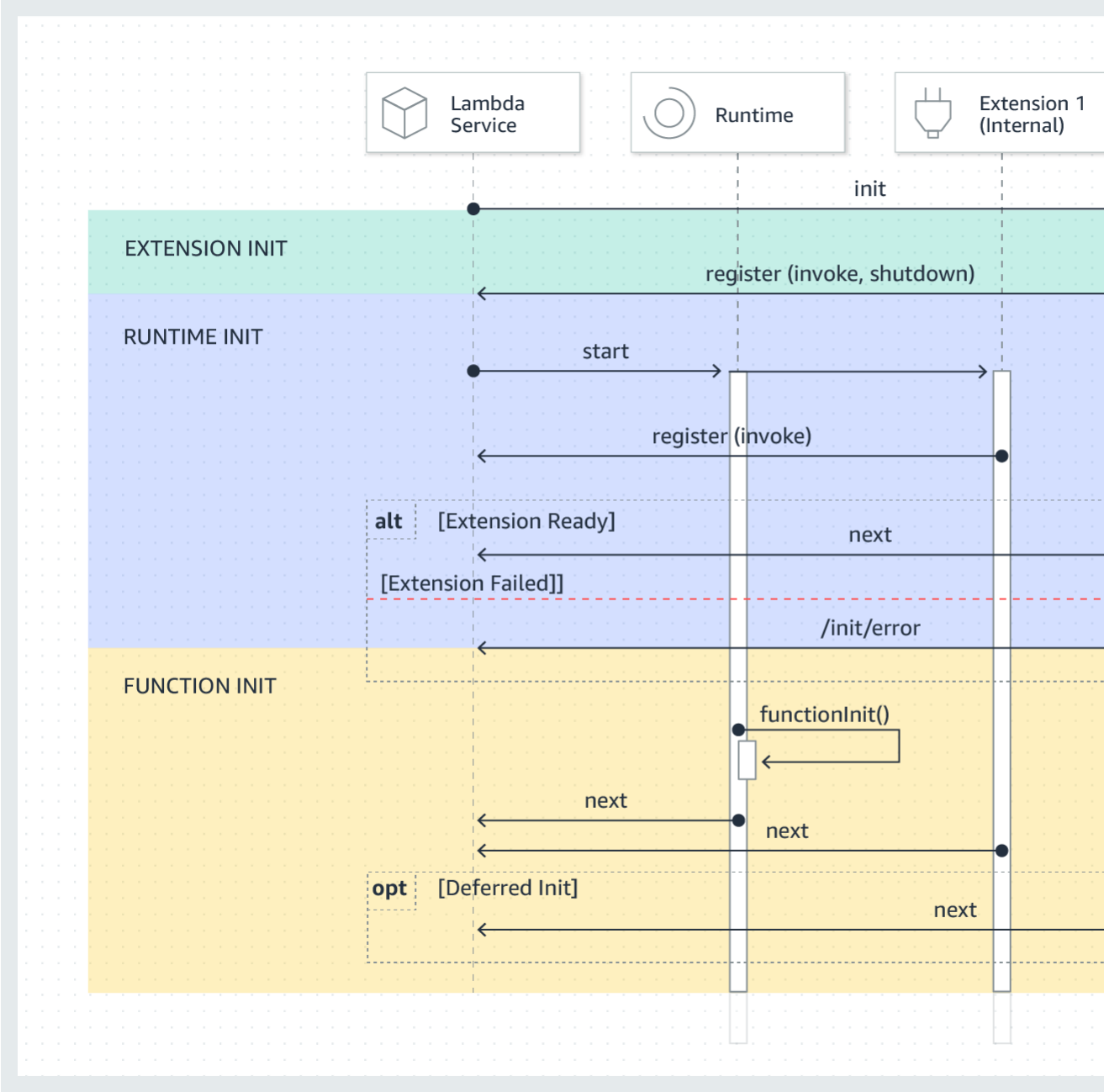
During the `Extension init` phase, each extension needs to register with Lambda to receive events. Lambda uses the full file name of the extension to validate that the extension has completed the bootstrap sequence. Therefore, each `Register` API call must include the `Lambda-Extension-Name` header with the full file name of the extension.

You can register up to 10 extensions for a function. This limit is enforced through the `Register` API call.

After each extension registers, Lambda starts the `Runtime init` phase. The runtime process calls `functionInit` to start the `Function init` phase.

The `Init` phase completes after the runtime and each registered extension indicate completion by sending a `Next` API request.

**Note**
Extensions can complete their initialization at any point in the `Init` phase.



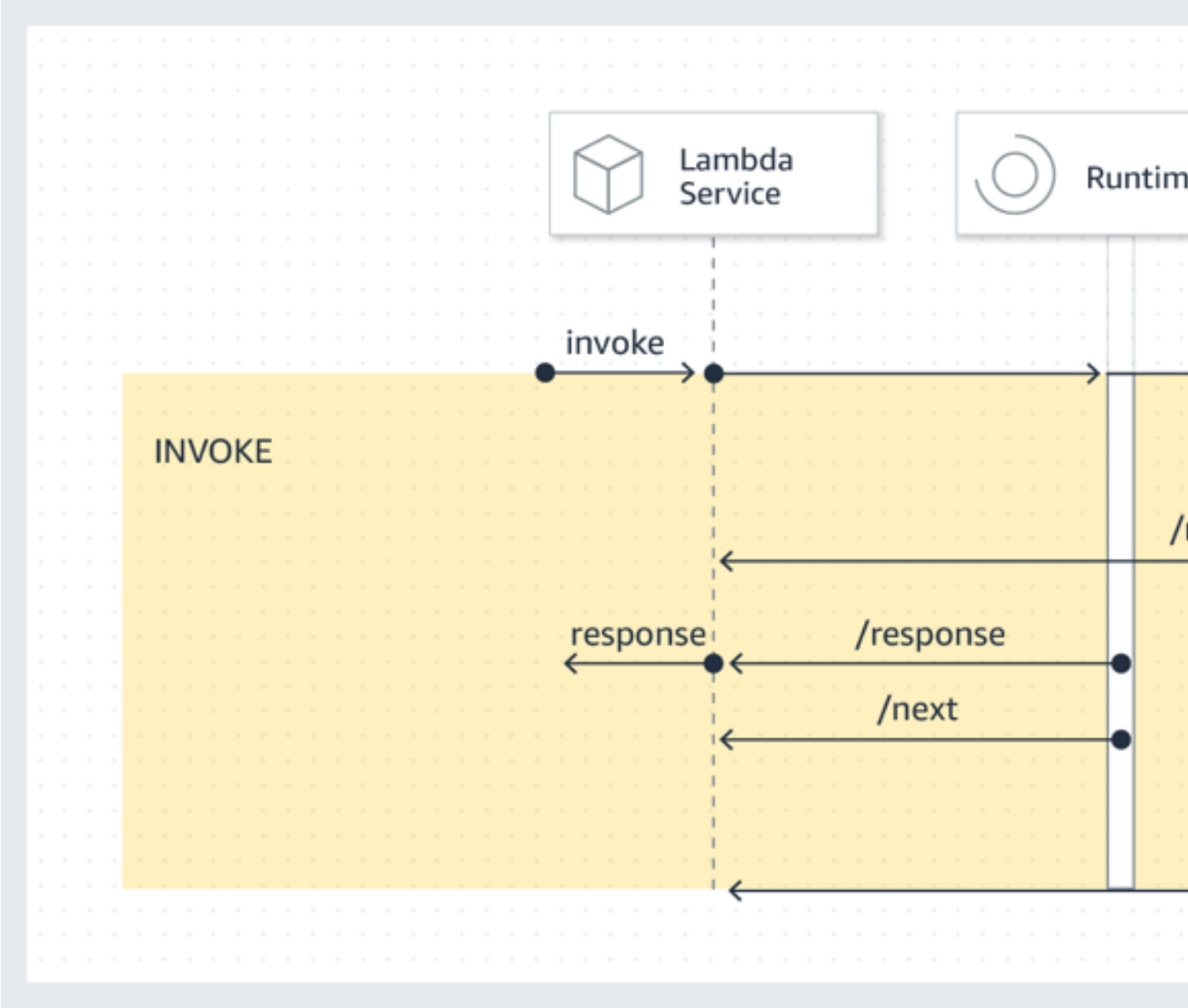

## Invoke phase

When a Lambda function is invoked in response to a `Next` API request, Lambda sends an `Invoke` event to the runtime and to each extension that is registered for the `Invoke` event.

During the invocation, external extensions run in parallel with the function. They also continue running after the function has completed. This enables you to capture diagnostic information or to send logs, metrics, and traces to a location of your choice.

After receiving the function response from the runtime, Lambda returns the response to the client, even if extensions are still running.

The `Invoke` phase ends after the runtime and all extensions signal that they are done by sending a `Next` API request.




**Event payload**: The event sent to the runtime (and the Lambda function) carries the entire request, headers (such as `RequestId`), and payload. The event sent to each extension contains metadata that describes the event content. This lifecycle event includes the type of the event, the time that the function times out (`deadlineMs`), the `requestId`, the invoked function's Amazon Resource Name (ARN), and tracing headers.

Extensions that want to access the function event body can use an in-runtime SDK that communicates with the extension. Function developers use the in-runtime SDK to send the payload to the extension when the function is invoked.

Here is an example payload:

```
{
    "eventType": "INVOKE",
    "deadlineMs": 676051,
    "requestId": "3da1f2dc-3222-475e-9205-e2e6c6318895",
    "invokedFunctionArn": "arn:aws:lambda:us-east-1:123456789012:function:ExtensionTest",
```

```
    "tracing": {
        "type": "X-Amzn-Trace-Id",
        "value":
"Root=1-5f35ae12-0c0fec141ab77a00bc047aa2;Parent=2be948a625588e32;Sampled=1"
    }
}
```

**Duration limit**: The function's timeout setting limits the duration of the entire `Invoke` phase. For example, if you set the function timeout as 360 seconds, the function and all extensions need to complete within 360 seconds. Note that there is no independent post-invoke phase. The duration is the sum of all invocation time (runtime + extensions) and is not calculated until the function and all extensions have finished running.

**Performance impact and extension overhead**: Extensions can impact function performance. As an extension author, you have control over the performance impact of your extension. For example, if your extension performs compute-intensive operations, the function's duration increases because the extension and the function code share the same CPU resources. In addition, if your extension performs extensive operations after the function invocation completes, the function duration increases because the `Invoke` phase continues until all extensions signal that they are completed.

> **Note**
> Lambda allocates CPU power in proportion to the function's memory setting. You might see increased execution and initialization duration at lower memory settings because the function and extension processes are competing for the same CPU resources. To reduce the execution and initialization duration, try increasing the memory setting.

To help identify the performance impact introduced by extensions on the `Invoke` phase, Lambda outputs the `PostRuntimeExtensionsDuration` metric. This metric measures the cumulative time spent between the runtime `Next` API request and the last extension `Next` API request. To measure the increase in memory used, use the `MaxMemoryUsed` metric. For more information about function metrics, see Working with Lambda function metrics (p. 727).

Function developers can run different versions of their functions side by side to understand the impact of a specific extension. We recommend that extension authors publish expected resource consumption to make it easier for function developers to choose a suitable extension.

## Shutdown phase

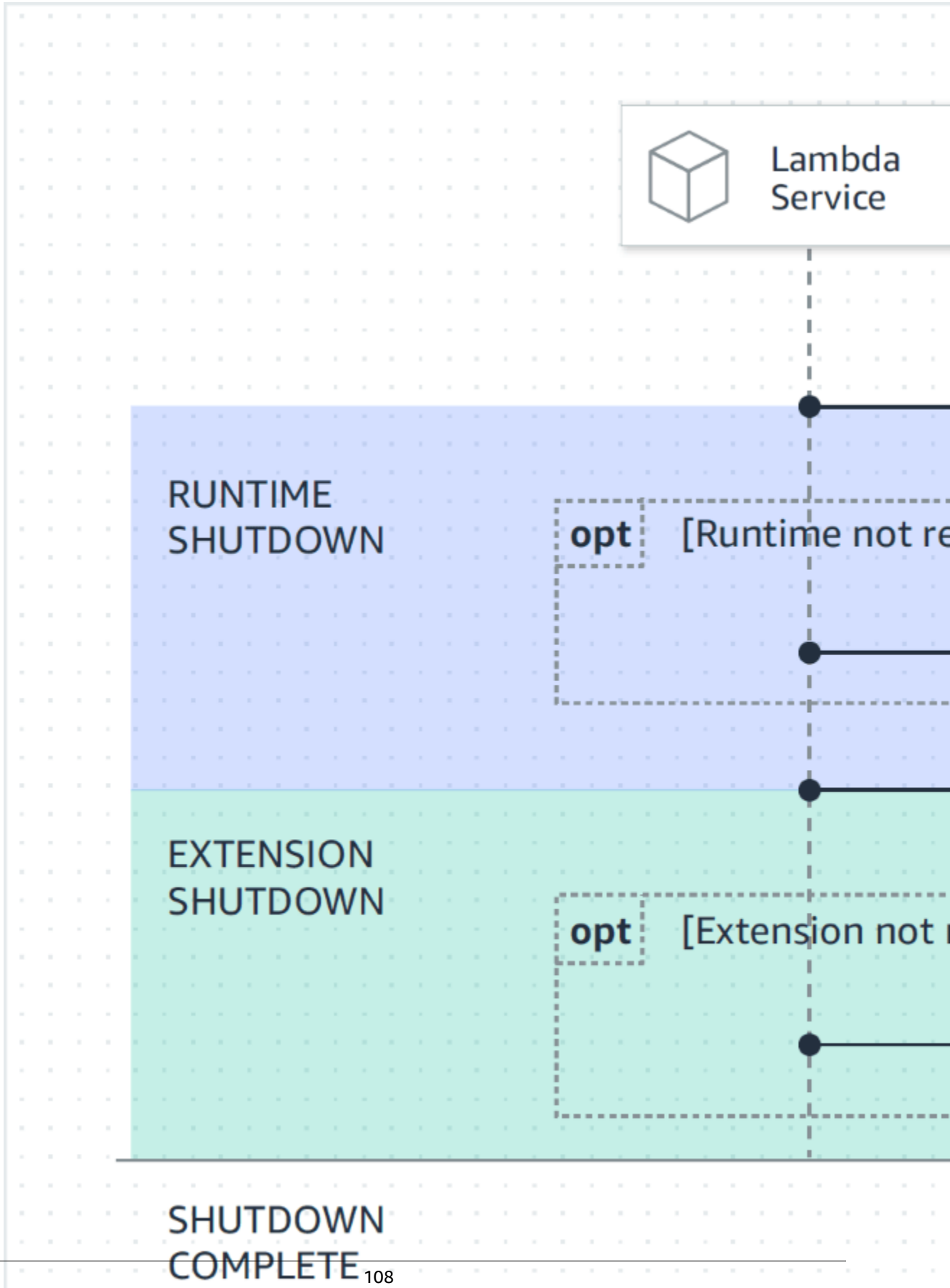
When Lambda is about to shut down the runtime, it sends a `Shutdown` to each registered external extension. Extensions can use this time for final cleanup tasks. The `Shutdown` event is sent in response to a `Next` API request.

**Duration limit**: The maximum duration of the `Shutdown` phase depends on the configuration of registered extensions:

- 0 ms – A function with no registered extensions
- 500 ms – A function with a registered internal extension
- 2,000 ms – A function with one or more registered external extensions

For a function with external extensions, Lambda reserves up to 300 ms (500 ms for a runtime with an internal extension) for the runtime process to perform a graceful shutdown. Lambda allocates the remainder of the 2,000 ms limit for external extensions to shut down.

If the runtime or an extension does not respond to the `Shutdown` event within the limit, Lambda ends the process using a `SIGKILL` signal.


Lambda
Service
RUNTIME
SHUTDOWN
opt
[Runtime not re
EXTENSION
SHUTDOWN
opt
[Extension not
SHUTDOWN
COMPLETE

**Event payload**: The `Shutdown` event contains the reason for the shutdown and the time remaining in milliseconds.

The `shutdownReason` includes the following values:

- SPINDOWN – Normal shutdown
- TIMEOUT – Duration limit timed out
- FAILURE – Error condition, such as an `out-of-memory` event

```
{
  "eventType": "SHUTDOWN",
  "shutdownReason": "reason for shutdown",
  "deadlineMs": "the time and date that the function times out in Unix time milliseconds"
}
```

## Permissions and configuration

Extensions run in the same execution environment as the Lambda function. Extensions also share resources with the function, such as CPU, memory, and `/tmp` disk storage. In addition, extensions use the same AWS Identity and Access Management (IAM) role and security context as the function.

**File system and network access permissions**: Extensions run in the same file system and network name namespace as the function runtime. This means that extensions need to be compatible with the associated operating system. If an extension requires any additional outbound network traffic rules, you must apply these rules to the function configuration.

> **Note**
> Because the function code directory is read-only, extensions cannot modify the function code.

**Environment variables**: Extensions can access the function's environment variables (p. 166), except for the following variables that are specific to the runtime process:

- `AWS_EXECUTION_ENV`
- `AWS_LAMBDA_LOG_GROUP_NAME`
- `AWS_LAMBDA_LOG_STREAM_NAME`
- `AWS_XRAY_CONTEXT_MISSING`
- `AWS_XRAY_DAEMON_ADDRESS`
- `LAMBDA_RUNTIME_DIR`
- `LAMBDA_TASK_ROOT`
- `_AWS_XRAY_DAEMON_ADDRESS`
- `_AWS_XRAY_DAEMON_PORT`
- `_HANDLER`

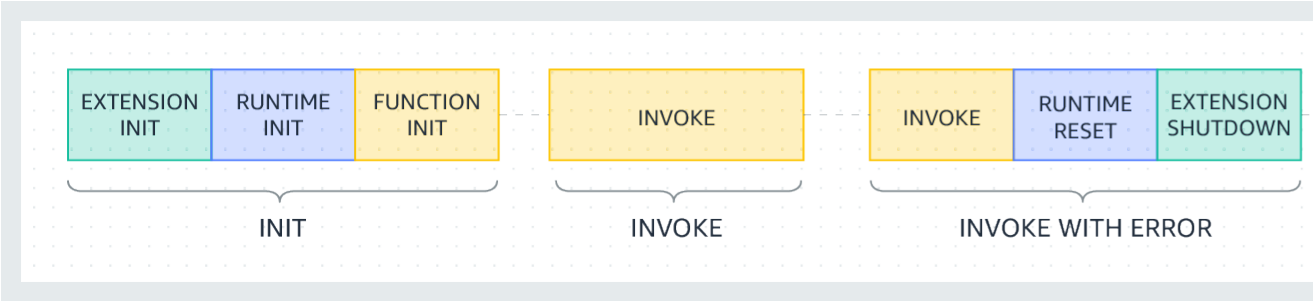
## Failure handling

**Initialization failures**: If an extension fails, Lambda restarts the execution environment to enforce consistent behavior and to encourage fail fast for extensions. Also, for some customers, the extensions must meet mission-critical needs such as logging, security, governance, and telemetry collection.

**Invoke failures** (such as out of memory, function timeout): Because extensions share resources with the runtime, memory exhaustion affects them. When the runtime fails, all extensions and the runtime itself

participate in the `Shutdown` phase. In addition, the runtime is restarted—either automatically as part of the current invocation, or via a deferred re-initialization mechanism.

If there is a failure (such as a function timeout or runtime error) during `Invoke`, the Lambda service performs a reset. The reset behaves like a `Shutdown` event. First, Lambda shuts down the runtime, then it sends a `Shutdown` event to each registered external extension. The event includes the reason for the shutdown. If this environment is used for a new invocation, the extension and runtime are re-initialized as part of the next invocation.




**Extension logs**: Lambda sends the log output of extensions to CloudWatch Logs. Lambda also generates an additional log event for each extension during `Init`. The log event records the name and registration preference (event, config) on success, or the failure reason on failure.

## Troubleshooting extensions

- If a `Register` request fails, make sure that the `Lambda-Extension-Name` header in the `Register` API call contains the full file name of the extension.
- If the `Register` request fails for an internal extension, make sure that the request does not register for the `Shutdown` event.

# Extensions API reference

The OpenAPI specification for the extensions API version **2020-01-01** is available here: extensions-api.zip

You can retrieve the value of the API endpoint from the `AWS_LAMBDA_RUNTIME_API` environment variable. To send a `Register` request, use the prefix `2020-01-01/` before each API path. For example:

```
http://${AWS_LAMBDA_RUNTIME_API}/2020-01-01/extension/register
```

**API methods**

- Register (p. 110)
- Next (p. 111)
- Init error (p. 112)
- Exit error (p. 113)

## Register

During `Extension init`, all extensions need to register with Lambda to receive events. Lambda uses the full file name of the extension to validate that the extension has completed the bootstrap sequence. Therefore, each `Register` API call must include the `Lambda-Extension-Name` header with the full file name of the extension.

Internal extensions are started and stopped by the runtime process, so they are not permitted to register for the `Shutdown` event.

**Path** – `/extension/register`

**Method** – **POST**

**Headers**

`Lambda-Extension-Name` – The full file name of the extension. Required: yes. Type: string.

**Body parameters**

`events` – Array of the events to register for. Required: no. Type: array of strings. Valid strings: `INVOKE`, `SHUTDOWN`.

### Response headers

- `Lambda-Extension-Identifier` – Generated unique agent identifier (UUID string) that is required for all subsequent requests.

### Response codes

- 200 – Response body contains the function name, function version, and handler name.
- 400 – Bad Request
- 403 – Forbidden
- 500 – Container error. Non-recoverable state. Extension should exit promptly.

### Example Example request body

```
{
    'events': [ 'INVOKE', 'SHUTDOWN']
}
```

### Example Example response body

```
{
    "functionName": "helloWorld",
    "functionVersion": "$LATEST",
    "handler": "lambda_function.lambda_handler"
}
```

## Next

Extensions send a `Next` API request to receive the next event, which can be an `Invoke` event or a `Shutdown` event. The response body contains the payload, which is a JSON document that contains event data.

The extension sends a `Next` API request to signal that it is ready to receive new events. This is a blocking call.

Do not set a timeout on the GET call, as the extension can be suspended for a period of time until there is an event to return.

**Path** – `/extension/event/next`

**Method** – **GET**

**Parameters**

`Lambda-Extension-Identifier` – Unique identifier for extension (UUID string). Required: yes. Type: UUID string.

### Response header

- `Lambda-Extension-Identifier` – Unique agent identifier (UUID string).

### Response codes

- 200 – Response contains information about the next event (`EventInvoke` or `EventShutdown`).
- 403 – Forbidden
- 500 – Container error. Non-recoverable state. Extension should exit promptly.

## Init error

The extension uses this method to report an initialization error to Lambda. Call it when the extension fails to initialize after it has registered. After Lambda receives the error, no further API calls succeed. The extension should exit after it receives the response from Lambda.

**Path** – `/extension/init/error`

**Method** – **POST**

**Headers**

`Lambda-Extension-Identifier` – Unique identifier for extension. Required: yes. Type: UUID string.

`Lambda-Extension-Function-Error-Type` – Error type that the extension encountered. Required: yes.

This header consists of a string value. Lambda accepts any string, but we recommend a format of <category.reason>. For example:

- Extension.NoSuchHandler
- Extension.APIKeyNotFound
- Extension.ConfigInvalid
- Extension.UnknownReason

**Body parameters**

`ErrorRequest` – Information about the error. Required: no.

This field is a JSON object with the following structure:

```
{
      errorMessage: string (text description of the error),
      errorType: string,
      stackTrace: array of strings
}
```

Note that Lambda accepts any value for `errorType`.

The following example shows a Lambda function error message in which the function could not parse the event data provided in the invocation.

**Example Function error**

```
{
      "errorMessage" : "Error parsing event data.",
      "errorType" : "InvalidEventDataException",
      "stackTrace": [ ]
}
```

**Response body**

- `Lambda-Extension-Identifier` – Unique agent identifier (UUID string).

**Response codes**

- 202 – Accepted
- 400 – Bad Request
- 403 – Forbidden
- 500 – Container error. Non-recoverable state. Extension should exit promptly.

## Exit error

The extension uses this method to report an error to Lambda before exiting. Call it when you encounter an unexpected failure. After Lambda receives the error, no further API calls succeed. The extension should exit after it receives the response from Lambda.

**Path** – `/extension/exit/error`

**Method** – **POST**

**Headers**

`Lambda-Extension-Identifier` – Unique identifier for extension. Required: yes. Type: UUID string.

`Lambda-Extension-Function-Error-Type` – Error type that the extension encountered. Required: yes.

This header consists of a string value. Lambda accepts any string, but we recommend a format of <category.reason>. For example:

- Extension.NoSuchHandler
- Extension.APIKeyNotFound
- Extension.ConfigInvalid
- Extension.UnknownReason

**Body parameters**

`ErrorRequest` – Information about the error. Required: no.

This field is a JSON object with the following structure:

```
{
      errorMessage: string (text description of the error),
```

```
      errorType: string,
      stackTrace: array of strings
}
```

Note that Lambda accepts any value for `errorType`.

The following example shows a Lambda function error message in which the function could not parse the event data provided in the invocation.

### Example Function error

```
{
      "errorMessage" : "Error parsing event data.",
      "errorType" : "InvalidEventDataException",
      "stackTrace": [ ]
}
```

### Response body

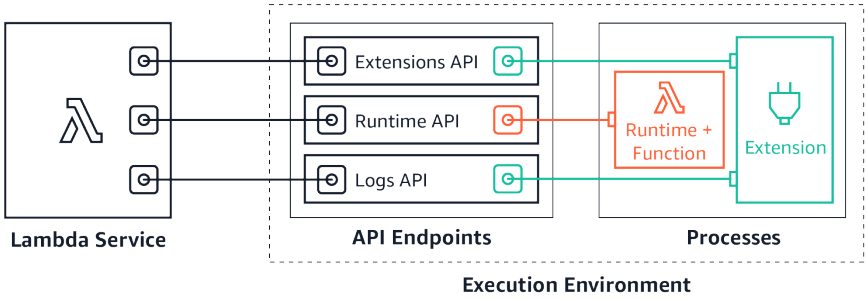
- `Lambda-Extension-Identifier` – Unique agent identifier (UUID string).

### Response codes

- 202 – Accepted
- 400 – Bad Request
- 403 – Forbidden
- 500 – Container error. Non-recoverable state. Extension should exit promptly.

# AWS Lambda runtime API

AWS Lambda provides an HTTP API for custom runtimes (p. 90) to receive invocation events from Lambda and send response data back within the Lambda execution environment (p. 82).




The OpenAPI specification for the runtime API version **2018-06-01** is available in runtime-api.zip

To create an API request URL, runtimes get the API endpoint from the `AWS_LAMBDA_RUNTIME_API` environment variable, add the API version, and add the desired resource path.

### Example Request

```
curl "http://${AWS_LAMBDA_RUNTIME_API}/2018-06-01/runtime/invocation/next"
```

### API methods

- Next invocation (p. 115)
- Invocation response (p. 116)
- Initialization error (p. 116)
- Invocation error (p. 117)

## Next invocation

**Path** – `/runtime/invocation/next`

**Method** – **GET**

The runtime sends this message to Lambda to request an invocation event. The response body contains the payload from the invocation, which is a JSON document that contains event data from the function trigger. The response headers contain additional data about the invocation.

### Response headers

- `Lambda-Runtime-Aws-Request-Id` – The request ID, which identifies the request that triggered the function invocation.

  For example, `8476a536-e9f4-11e8-9739-2dfe598c3fcd`.
- `Lambda-Runtime-Deadline-Ms` – The date that the function times out in Unix time milliseconds.

  For example, `1542409706888`.
- `Lambda-Runtime-Invoked-Function-Arn` – The ARN of the Lambda function, version, or alias that's specified in the invocation.

For example, `arn:aws:lambda:us-east-2:123456789012:function:custom-runtime`.

- `Lambda-Runtime-Trace-Id` – The AWS X-Ray tracing header.

  For example, `Root=1-5bef4de7-ad49b0e87f6ef6c87fc2e700;Parent=9a9197af755a6419;Sampled=1`.
- `Lambda-Runtime-Client-Context` – For invocations from the AWS Mobile SDK, data about the client application and device.
- `Lambda-Runtime-Cognito-Identity` – For invocations from the AWS Mobile SDK, data about the Amazon Cognito identity provider.

Do not set a timeout on the `GET` request as the response may be delayed. Between when Lambda bootstraps the runtime and when the runtime has an event to return, the runtime process may be frozen for several seconds.

The request ID tracks the invocation within Lambda. Use it to specify the invocation when you send the response.

The tracing header contains the trace ID, parent ID, and sampling decision. If the request is sampled, the request was sampled by Lambda or an upstream service. The runtime should set the `_X_AMZN_TRACE_ID` with the value of the header. The X-Ray SDK reads this to get the IDs and determine whether to trace the request.

# Invocation response

**Path** – `/runtime/invocation/AwsRequestId/response`

**Method** – **POST**

After the function has run to completion, the runtime sends an invocation response to Lambda. For synchronous invocations, Lambda sends the response to the client.

**Example success request**

```
REQUEST_ID=156cb537-e2d4-11e8-9b34-d36013741fb9
curl -X POST  "http://${AWS_LAMBDA_RUNTIME_API}/2018-06-01/runtime/invocation/$REQUEST_ID/
response"  -d "SUCCESS"
```

# Initialization error

If the function returns an error or the runtime encounters an error during initialization, the runtime uses this method to report the error to Lambda.

**Path** – `/runtime/init/error`

**Method** – **POST**

**Headers**

`Lambda-Runtime-Function-Error-Type` – Error type that the runtime encountered. Required: no.

This header consists of a string value. Lambda accepts any string, but we recommend a format of <category.reason>. For example:

- Runtime.NoSuchHandler
- Runtime.APIKeyNotFound

- Runtime.ConfigInvalid
- Runtime.UnknownReason

#### Body parameters

`ErrorRequest` – Information about the error. Required: no.

This field is a JSON object with the following structure:

```
{
      errorMessage: string (text description of the error),
      errorType: string,
      stackTrace: array of strings
}
```

Note that Lambda accepts any value for `errorType`.

The following example shows a Lambda function error message in which the function could not parse the event data provided in the invocation.

#### Example Function error

```
{
      "errorMessage" : "Error parsing event data.",
      "errorType" : "InvalidEventDataException",
      "stackTrace": [ ]
}
```

#### Response body parameters

- `StatusResponse` – String. Status information, sent with 202 response codes.
- `ErrorResponse` – Additional error information, sent with the error response codes. ErrorResponse contains an error type and an error message.

#### Response codes

- 202 – Accepted
- 403 – Forbidden
- 500 – Container error. Non-recoverable state. Runtime should exit promptly.

#### Example initialization error request

```
ERROR="{\"errorMessage\" : \"Failed to load function.\", \"errorType\" :
 \"InvalidFunctionException\"}"
curl -X POST "http://${AWS_LAMBDA_RUNTIME_API}/2018-06-01/runtime/init/error" -d "$ERROR"
 --header "Lambda-Runtime-Function-Error-Type: Unhandled"
```

## Invocation error

If the function returns an error or the runtime encounters an error, the runtime uses this method to report the error to Lambda.

**Path** – `/runtime/invocation/`*`AwsRequestId`*`/error`

**Method – POST**

**Headers**

`Lambda-Runtime-Function-Error-Type` – Error type that the runtime encountered. Required: no.

This header consists of a string value. Lambda accepts any string, but we recommend a format of <category.reason>. For example:

- Runtime.NoSuchHandler
- Runtime.APIKeyNotFound
- Runtime.ConfigInvalid
- Runtime.UnknownReason

**Body parameters**

`ErrorRequest` – Information about the error. Required: no.

This field is a JSON object with the following structure:

```
{
      errorMessage: string (text description of the error),
      errorType: string,
      stackTrace: array of strings
}
```

Note that Lambda accepts any value for `errorType`.

The following example shows a Lambda function error message in which the function could not parse the event data provided in the invocation.

### Example Function error

```
{
      "errorMessage" : "Error parsing event data.",
      "errorType" : "InvalidEventDataException",
      "stackTrace": [ ]
}
```

### Response body parameters

- `StatusResponse` – String. Status information, sent with 202 response codes.
- `ErrorResponse` – Additional error information, sent with the error response codes. ErrorResponse contains an error type and an error message.

### Response codes

- 202 – Accepted
- 400 – Bad Request
- 403 – Forbidden
- 500 – Container error. Non-recoverable state. Runtime should exit promptly.

### Example error request

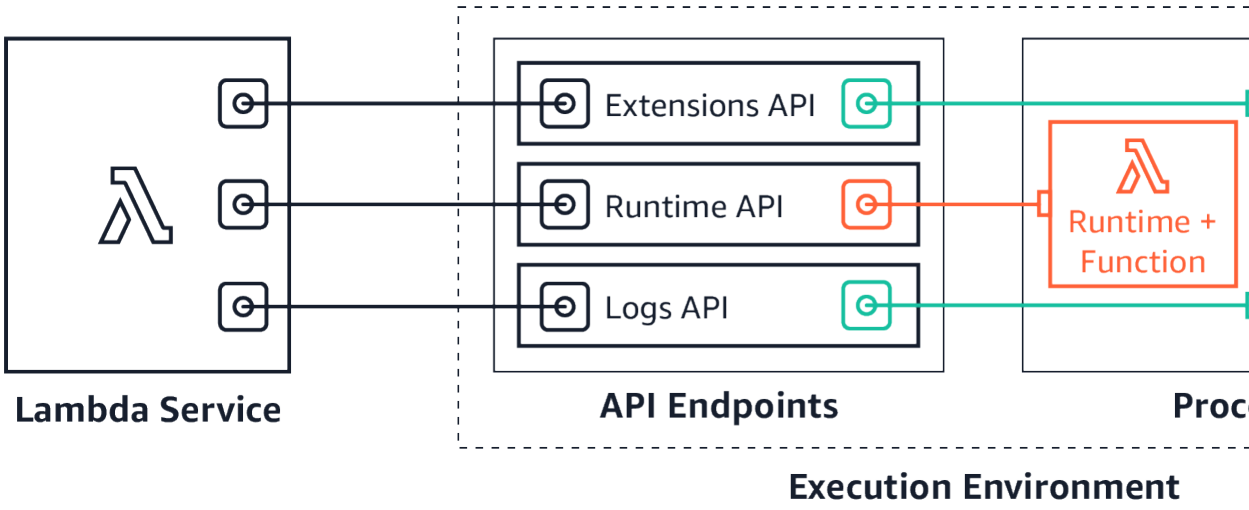
```
REQUEST_ID=156cb537-e2d4-11e8-9b34-d36013741fb9
```

```
ERROR="{\"errorMessage\" : \"Error parsing event data.\", \"errorType\" :
 \"InvalidEventDataException\"}"
curl -X POST "http://${AWS_LAMBDA_RUNTIME_API}/2018-06-01/runtime/invocation/$REQUEST_ID/
error" -d "$ERROR" --header "Lambda-Runtime-Function-Error-Type: Unhandled"
```

# Lambda Logs API

Lambda automatically captures runtime logs and streams them to Amazon CloudWatch. This log stream contains the logs that your function code and extensions generate, and also the logs that Lambda generates as part of the function invocation.

Lambda extensions (p. 101) can use the Lambda Runtime Logs API to subscribe to log streams directly from within the Lambda execution environment (p. 100). Lambda streams the logs to the extension, and the extension can then process, filter, and send the logs to any preferred destination.




The Logs API allows extensions to subscribe to three different logs streams:

- Function logs that the Lambda function generates and writes to `stdout` or `stderr`.
- Extension logs that extension code generates.
- Lambda platform logs, which record events and errors related to invocations and extensions.

> **Note**
> Lambda sends all logs to CloudWatch, even when an extension subscribes to one or more of the log streams.

**Topics**

- Subscribing to receive logs (p. 121)
- Memory usage (p. 121)
- Destination protocols (p. 121)
- Buffering configuration (p. 121)
- Example subscription (p. 122)
- Sample code for Logs API (p. 122)
- Logs API reference (p. 123)
- Log messages (p. 124)

# Subscribing to receive logs

A Lambda extension can subscribe to receive logs by sending a subscription request to the Logs API.

To subscribe to receive logs, you need the extension identifier (`Lambda-Extension-Identifier`). First register the extension (p. 110) to receive the extension identifier. Then subscribe to the Logs API during initialization (p. 128). After the initialization phase completes, Lambda does not process subscription requests.

> **Note**
> Logs API subscription is idempotent. Duplicate subscribe requests do not result in duplicate subscriptions.

# Memory usage

Memory usage increases linearly as the number of subscribers increases. Subscriptions consume memory resources because each subscription opens a new memory buffer to store the logs. To help optimize memory usage, you can adjust the buffering configuration (p. 121). Buffer memory usage counts towards overall memory consumption in the execution environment.

# Destination protocols

You can choose one of the following protocols to receive the logs:

1. **HTTP** (recommended) – Lambda delivers logs to a local HTTP endpoint (`http://sandbox.localdomain:${PORT}/${PATH}`) as an array of records in JSON format. The `$PATH` parameter is optional. Note that only HTTP is supported, not HTTPS. You can choose to receive logs through PUT or POST.
2. **TCP** – Lambda delivers logs to a TCP port in Newline delimited JSON (NDJSON) format.

We recommend using HTTP rather than TCP. With TCP, the Lambda platform cannot acknowledge when it delivers logs to the application layer. Therefore, you might lose logs if your extension crashes. HTTP does not share this limitation.

We also recommend setting up the local HTTP listener or the TCP port before subscribing to receive logs. During setup, note the following:

- Lambda sends logs only to destinations that are inside the execution environment.
- Lambda retries the attempt to send the logs (with backoff) if there is no listener, or if the POST or PUT request results in an error. If the log subscriber crashes, it continues to receive logs after Lambda restarts the execution environment.
- Lambda reserves port 9001. There are no other port number restrictions or recommendations.

# Buffering configuration

Lambda can buffer logs and deliver them to the subscriber. You can configure this behavior in the subscription request by specifying the following optional fields. Note that Lambda uses the default value for any field that you do not specify.

- **timeoutMs** – The maximum time (in milliseconds) to buffer a batch. Default: 1,000. Minimum: 25. Maximum: 30,000.
- **maxBytes** – The maximum size (in bytes) of the logs to buffer in memory. Default: 262,144. Minimum: 262,144. Maximum: 1,048,576.

- **maxItems** – The maximum number of events to buffer in memory. Default: 10,000. Minimum: 1,000. Maximum: 10,000.

During buffering configuration, note the following points:

- Lambda flushes the logs if any of the input streams are closed, for example, if the runtime crashes.
- Each subscriber can specify a different buffering configuration in their subscription request.
- Consider the buffer size that you need for reading the data. Expect to receive payloads as large as `2*maxBytes+metadata`, where `maxBytes` is configured in the subscribe request. For example, Lambda adds the following metadata bytes to each record:

```
{
"time": "2020-08-20T12:31:32.123Z",
"type": "function",
"record": "Hello World"
}
```

- If the subscriber cannot process incoming logs quickly enough, Lambda might drop logs to keep memory utilization bounded. To indicate the number of dropped records, Lambda sends a `platform.logsDropped` log.

# Example subscription

The following example shows a request to subscribe to the platform and function logs.

```
PUT http://${AWS_LAMBDA_RUNTIME_API}/2020-08-15/logs HTTP/1.1
{ "schemaVersion": "2020-08-15",
  "types": [
      "platform",
      "function"
    ],
  "buffering": {
      "maxItems": 1000,
      "maxBytes": 262144,
      "timeoutMs": 100
    },
  "destination": {
    "protocol": "HTTP",
    "URI": "http://sandbox.localdomain:8080/lambda_logs"
  }
}
```

If the request succeeds, the subscriber receives an HTTP 200 success response.

```
HTTP/1.1 200 OK
"OK"
```

# Sample code for Logs API

For sample code showing how to send logs to a custom destination, see Using AWS Lambda extensions to send logs to custom destinations on the AWS Compute Blog.

For Python and Go code examples showing how to develop a basic Lambda extension and subscribe to the Logs API, see AWS Lambda Extensions on the AWS Samples GitHub repository. For more information about building a Lambda extension, see the section called “Extensions API” (p. 101).

# Logs API reference

You can retrieve the Logs API endpoint from the `AWS_LAMBDA_RUNTIME_API` environment variable. To send an API request, use the prefix `2020-08-15/` before the API path. For example:

```
http://${AWS_LAMBDA_RUNTIME_API}/2020-08-15/logs
```

The OpenAPI specification for the Logs API version **2020-08-15** is available here: logs-api-request.zip

## Subscribe

To subscribe to one or more of the log streams available in the Lambda execution environment, extensions send a Subscribe API request.

**Path** – `/logs`

**Method** – **PUT**

**Body parameters**

`destination` – See the section called “Destination protocols” (p. 121). Required: yes. Type: strings.

`buffering` – See the section called “Buffering configuration” (p. 121). Required: no. Type: strings.

`types` – An array of the types of logs to receive. Required: yes. Type: array of strings. Valid values: "platform", "function", "extension".

`schemaVersion` – Required: no. Default value: "2020-08-15". Set to "2021-03-18" for the extension to receive `platform.runtimeDone` (p. 126) messages.

**Response parameters**

The OpenAPI specifications for the subscription responses version **2020-08-15** are available for the HTTP and TCP protocols:

- HTTP: logs-api-http-response.zip
- TCP: logs-api-tcp-response.zip

**Response codes**

- 200 – Request completed successfully
- 202 – Request accepted. Response to a subscription request during local testing.
- 4XX – Bad Request
- 500 – Service error

If the request succeeds, the subscriber receives an HTTP 200 success response.

```
HTTP/1.1 200 OK
"OK"
```

If the request fails, the subscriber receives an error response. For example:

```
HTTP/1.1 400 OK
```

```
{
    "errorType": "Logs.ValidationError",
    "errorMessage": URI port is not provided; types should not be empty"
}
```

# Log messages

The Logs API allows extensions to subscribe to three different logs streams:

- Function – Logs that the Lambda function generates and writes to `stdout` or `stderr`.
- Extension – Logs that extension code generates.
- Platform – Logs that the runtime platform generates, which record events and errors related to invocations and extensions.

**Topics**


- Function logs (p. 124)
- Extension logs (p. 124)
- Platform logs (p. 124)


## Function logs

The Lambda function and internal extensions generate function logs and write them to `stdout` or `stderr`.

The following example shows the format of a function log message. { "time": "2020-08-20T12:31:32.123Z", "type": "function", "record": "ERROR encountered. Stack trace:\n\my-function (line 10)\n" }

## Extension logs

Extensions can generate extension logs. The log format is the same as for a function log.

## Platform logs

Lambda generates log messages for platform events such as `platform.start`, `platform.end`, and `platform.fault`.

Optionally, you can subscribe to the **2021-03-18** version of the Logs API schema, which includes the `platform.runtimeDone` log message.

### Example platform log messages

The following example shows the platform start and platform end logs. These logs indicate the invocation start time and invocation end time for the invocation that the requestId specifies.

```
{
    "time": "2020-08-20T12:31:32.123Z",
    "type": "platform.start",
    "record": {"requestId": "6f7f0961f83442118a7af6fe80b88d56"}
}
{
    "time": "2020-08-20T12:31:32.123Z",
    "type": "platform.end",
    "record": {"requestId": "6f7f0961f83442118a7af6fe80b88d56"}
```

```
}
```

The platform report log includes metrics about the invocation that the requestId specifies. The `initDurationMs` field is included in the log only if the invocation included a cold start. If AWS X-Ray tracing is active, the log includes X-Ray metadata. The following example shows a platform report log for an invocation that included a cold start.

```
{
    "time": "2020-08-20T12:31:32.123Z",
    "type": "platform.report",
    "record": {"requestId": "6f7f0961f83442118a7af6fe80b88d56",
        "metrics": {"durationMs": 101.51,
            "billedDurationMs": 300,
            "memorySizeMB": 512,
            "maxMemoryUsedMB": 33,
            "initDurationMs": 116.67
        }
    }
}
```

The platform fault log captures runtime or execution environment errors. The following example shows a platform fault log message.

```
{
    "time": "2020-08-20T12:31:32.123Z",
    "type": "platform.fault",
    "record": "RequestId: d783b35e-a91d-4251-af17-035953428a2c Process exited before
 completing request"
}
```

Lambda generates a platform extension log when an extension registers with the extensions API. The following example shows a platform extension message.

```
{
    "time": "2020-08-20T12:31:32.123Z",
    "type": "platform.extension",
    "record": {"name": "Foo.bar",
        "state": "Ready",
        "events": ["INVOKE", "SHUTDOWN"]
     }
}
```

Lambda generates a platform logs subscription log when an extension subscribes to the logs API. The following example shows a logs subscription message.

```
{
    "time": "2020-08-20T12:31:32.123Z",
    "type": "platform.logsSubscription",
    "record": {"name": "Foo.bar",
        "state": "Subscribed",
        "types": ["function", "platform"],
    }
}
```

Lambda generates a platform logs dropped log when an extension is not able to process the number of logs that it is receiving. The following example shows a `platform.logsDropped` log message.

```
{
```

```
    "time": "2020-08-20T12:31:32.123Z",
    "type": "platform.logsDropped",
    "record": {"reason": "Consumer seems to have fallen behind as it has not acknowledged
 receipt of logs.",
        "droppedRecords": 123,
        "droppedBytes" 12345
    }
}
```

## Platform `runtimeDone` messages

If you set the schema version to "2021-03-18" in the subscribe request, Lambda sends a `platform.runtimeDone` message after the function invocation completes either successfully or with an error. The extension can use this message to stop all the telemetry collection for this function invocation.

The OpenAPI specification for the Log event type in schema version **2021-03-18** is available here: schema-2021-03-18.zip

Lambda generates the `platform.runtimeDone` log message when the runtime sends a `Next` or `Error` runtime API request. The `platform.runtimeDone` log informs consumers of the Logs API that the function invocation completes. Extensions can use this information to decide when to send all the telemetry collected during that invocation.

### Examples

Lambda sends the `platform.runtimeDone` message after the runtime sends the NEXT request when the function invocation completes. The following examples show messages for each of the status values: success, failure, and timeout.

**Example Example success message**

```
{
    "time": "2021-02-04T20:00:05.123Z",
    "type": "platform.runtimeDone",
    "record": {
       "requestId":"6f7f0961f83442118a7af6fe80b88",
       "status": "success"
    }
}
```

**Example Example failure message**

```
{
   "time": "2021-02-04T20:00:05.123Z",
   "type": "platform.runtimeDone",
   "record": {
      "requestId":"6f7f0961f83442118a7af6fe80b88",
      "status": "failure"
   }
}
```

**Example Example timeout message**

```
{
   "time": "2021-02-04T20:00:05.123Z",
   "type": "platform.runtimeDone",
   "record": {
      "requestId":"6f7f0961f83442118a7af6fe80b88",
```

```
        "status": "timeout"
    }
}
```

# AWS Lambda extensions partners

AWS Lambda has partnered with several third party entities to provide extensions to integrate with your Lambda functions. The following list details third party extensions that are ready for you to use at any time.

- AppDynamics – Provides automatic instrumentation of Node.js or Python Lambda functions, providing visibility and alerting on function performance.
- Check Point CloudGuard – An extension-based runtime solution that offers full lifecycle security for serverless applications.
- Datadog – Provides comprehensive, real-time visibility to your serverless applications through the use of metrics, traces, and logs.
- Dynatrace – Provides visibility into traces and metrics, and leverages AI for automated error detection and root cause analysis across the entire application stack.
- Epsagon – Listens to invocation events, stores traces, and sends them in parallel to Lambda function executions.
- Fastly– Protects your Lambda functions from suspicious activity, such as injection-style attacks, account takeover via credential stuffing, malicious bots, and API abuse.
- HashiCorp Vault – Manages secrets and makes them available for developers to use within function code, without making functions Vault aware.
- Honeycomb – Observability tool for debugging your app stack.
- Lumigo – Profiles Lambda function invocations and collects metrics for troubleshooting issues in serverless and microservice environments.
- New Relic – Runs alongside Lambda functions, automatically collecting, enhancing, and transporting telemetry to New Relic's unified observability platform.
- Sentry – Diagnose, fix, and optimize performance of Lambda functions.
- Site24x7 – Achieve real-time observability into your Lambda environments
- Splunk – Collects high-resolution, low-latency metrics for efficient and effective monitoring of Lambda functions.
- Sumo Logic – Provides visibility into the health and performance of serverless applications.
- Thundra – Provides asynchronous telemetry reporting, such as traces, metrics, and logs.

## AWS managed extensions

AWS provides its own managed extensions, including:

- AWS AppConfig – Use feature flags and dynamic data to update your Lambda functions. You can also use this extension to update other dynamic configuration, such as ops throttling and tuning.
- Amazon CodeGuru Profiler – Improves application performance and reduces cost by pinpointing an application's most expensive line of code and providing recommendations for improving code.
- CloudWatch Lambda Insights – Monitor, troubleshoot, and optimize the performance of your Lambda functions through automated dashboards.
- AWS Distro for Open Telemetry – Enables functions to send trace data to AWS monitoring services such as AWS X-Ray, and to destinations that support OpenTelemetry such as Honeycomb and Lightstep.

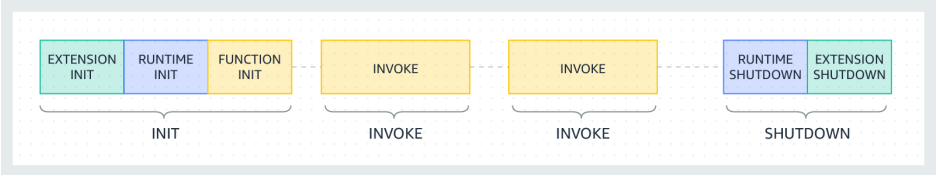
For additional extensions samples and demo projects, see AWS Lambda Extensions.

# Lambda execution environment lifecycle

The lifecycle of the execution environment includes the following phases:

- **`Init`**: In this phase, Lambda creates or unfreezes an execution environment with the configured resources, downloads the code for the function and all layers, initializes any extensions, initializes the runtime, and then runs the function's initialization code (the code outside the main handler). The `Init` phase happens either during the first invocation, or in advance of function invocations if you have enabled provisioned concurrency (p. 183).

  The `Init` phase is split into three sub-phases: `Extension init`, `Runtime init`, and `Function init`. These sub-phases ensure that all extensions and the runtime complete their setup tasks before the function code runs.
- **`Invoke`**: In this phase, Lambda invokes the function handler. After the function runs to completion, Lambda prepares to handle another function invocation.
- **`Shutdown`**: This phase is triggered if the Lambda function does not receive any invocations for a period of time. In the `Shutdown` phase, Lambda shuts down the runtime, alerts the extensions to let them stop cleanly, and then removes the environment. Lambda sends a `Shutdown` event to each extension, which tells the extension that the environment is about to be shut down.




Each phase starts with an event that Lambda sends to the runtime and to all registered extensions. The runtime and each extension indicate completion by sending a `Next` API request. Lambda freezes the execution environment when the runtime and each extension have completed and there are no pending events.

**Topics**

- Init phase (p. 128)
- Invoke phase (p. 105)
- Shutdown phase (p. 107)

## Init phase

In the `Init` phase, Lambda performs three tasks:

- Start all extensions (`Extension init`)
- Bootstrap the runtime (`Runtime init`)
- Run the function's static code (`Function init`)

The `Init` phase ends when the runtime and all extensions signal that they are ready by sending a `Next` API request. The `Init` phase is limited to 10 seconds. If all three tasks do not complete within 10 seconds, Lambda retries the `Init` phase at the time of the first function invocation.

# Invoke phase

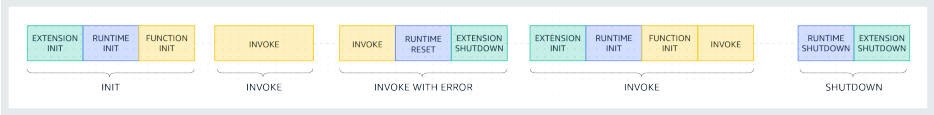
When a Lambda function is invoked in response to a `Next` API request, Lambda sends an `Invoke` event to the runtime and to each extension.

The function's timeout setting limits the duration of the entire `Invoke` phase. For example, if you set the function timeout as 360 seconds, the function and all extensions need to complete within 360 seconds. Note that there is no independent post-invoke phase. The duration is the sum of all invocation time (runtime + extensions) and is not calculated until the function and all extensions have finished executing.

The invoke phase ends after the runtime and all extensions signal that they are done by sending a `Next` API request.

If the Lambda function crashes or times out during the `Invoke` phase, Lambda resets the execution environment. The reset behaves like a `Shutdown` event. First, Lambda shuts down the runtime. Then Lambda sends a `Shutdown` event to each registered external extension. The event includes the reason for the shutdown. If another `Invoke` event results in this execution environment being reused, Lambda initializes the runtime and extensions as part of the next invocation.

**Note**
The Lambda reset does not clear the `/tmp` directory content prior to the next init phase. This behavior is consistent with the regular shutdown phase.




# Shutdown phase

When Lambda is about to shut down the runtime, it sends a `Shutdown` event to each registered external extension. Extensions can use this time for final cleanup tasks. The `Shutdown` event is a response to a `Next` API request.

**Duration**: The entire `Shutdown` phase is capped at 2 seconds. If the runtime or any extension does not respond, Lambda terminates it via a signal (`SIGKILL`).

After the function and all extensions have completed, Lambda maintains the execution environment for some time in anticipation of another function invocation. In effect, Lambda freezes the execution environment. When the function is invoked again, Lambda thaws the environment for reuse. Reusing the execution environment has the following implications:

- Objects declared outside of the function's handler method remain initialized, providing additional optimization when the function is invoked again. For example, if your Lambda function establishes a database connection, instead of reestablishing the connection, the original connection is used in subsequent invocations. We recommend adding logic in your code to check if a connection exists before creating a new one.
- Each execution environment provides between 512 MB and 10,240 MB, in 1-MB increments, of disk space in the `/tmp` directory. The directory content remains when the execution environment is frozen, providing a transient cache that can be used for multiple invocations. You can add extra code to check if the cache has the data that you stored. For more information on deployment size limits, see Lambda quotas (p. 796).
- Background processes or callbacks that were initiated by your Lambda function and did not complete when the function ended resume if Lambda reuses the execution environment. Make sure that any background processes or callbacks in your code are complete before the code exits.

When you write your function code, do not assume that Lambda automatically reuses the execution environment for subsequent function invocations. Other factors may dictate a need for Lambda to

create a new execution environment, which can lead to unexpected results, such as database connection failures.

# Deploying Lambda functions

You can deploy code to your Lambda function by uploading a zip file archive, or by creating and uploading a container image.

## .zip file archives

A .zip file archive includes your application code and its dependencies. When you author functions using the Lambda console or a toolkit, Lambda automatically creates a .zip file archive of your code.

When you create functions with the Lambda API, command line tools, or the AWS SDKs, you must create a deployment package. You also must create a deployment package if your function uses a compiled language, or to add dependencies to your function. To deploy your function's code, you upload the deployment package from Amazon Simple Storage Service (Amazon S3) or your local machine.

You can upload a .zip file as your deployment package using the Lambda console, AWS Command Line Interface (AWS CLI), or to an Amazon Simple Storage Service (Amazon S3) bucket.

## Container images

You can package your code and dependencies as a container image using tools such as the Docker command line interface (CLI). You can then upload the image to your container registry hosted on Amazon Elastic Container Registry (Amazon ECR).

AWS provides a set of open-source base images that you can use to build the container image for your function code. You can also use alternative base images from other container registries. AWS also provides an open-source runtime client that you add to your alternative base image to make it compatible with the Lambda service.

Additionally, AWS provides a runtime interface emulator for you to test your functions locally using tools such as the Docker CLI.

> **Note**
> You create each container image to be compatible with one of the instruction set architectures that Lambda supports. Lambda provides base images for each of the instruction set architectures and Lambda also provides base images that support both architectures. The image that you build for your function must target only one of the architectures.

There is no additional charge for packaging and deploying functions as container images. When a function deployed as a container image is invoked, you pay for invocation requests and execution duration. You do incur charges related to storing your container images in Amazon ECR. For more information, see Amazon ECR pricing.

**Topics**


- Deploying Lambda functions as .zip file archives (p. 132)
- Deploying Lambda functions as container images (p. 136)

# Deploying Lambda functions as .zip file archives

When you create a Lambda function, you package your function code into a deployment package. Lambda supports two types of deployment packages: container images (p. 35) and .zip file archives (p. 35). The workflow to create a function depends on the deployment package type. To configure a function defined as a container image, see the section called "Container images" (p. 136).

You can use the Lambda console and the Lambda API to create a function defined with a .zip file archive. You can also upload an updated .zip file to change the function code.

> **Note**
> You cannot convert an existing container image function to use a .zip file archive. You must create a new function.

**Topics**


- Creating the function (p. 132)
- Using the console code editor (p. 133)
- Updating function code (p. 133)
- Changing the runtime or runtime version (p. 134)
- Changing the architecture (p. 134)
- Using the Lambda API (p. 134)
- AWS CloudFormation (p. 135)


## Creating the function

When you create a function defined with a .zip file archive, you choose a code template, the language version, and the execution role for the function. You add your function code after Lambda creates the function.

**To create the function**

1. Open the Functions page of the Lambda console.
2. Choose **Create function**.
3. Choose **Author from scratch** or **Use a blueprint** to create your function.
4. Under **Basic information**, do the following:
   a. For **Function name**, enter the function name. Function names are limited to 64 characters in length.
   b. For **Runtime**, choose the language version to use for your function.
   c. (Optional) For **Architecture**, choose the instruction set architecture to use for your function. The default architecture is x86_64. When you build the deployment package for your function, make sure that it is compatible with this instruction set architecture (p. 23).
5. (Optional) Under **Permissions**, expand **Change default execution role**. You can create a new **Execution role** or use an existing role.
6. (Optional) Expand **Advanced settings**. You can choose a **Code signing configuration** for the function. You can also configure an (Amazon VPC) for the function to access.
7. Choose **Create function**.

Lambda creates the new function. You can now use the console to add the function code and configure other function parameters and features. For code deployment instructions, see the handler page for the runtime your function uses.

Node.js

Deploy Node.js Lambda functions with .zip file archives (p. 288)

Python

Deploy Python Lambda functions with .zip file archives (p. 330)

Ruby

Deploy Ruby Lambda functions with .zip file archives (p. 358)

Java

Deploy Java Lambda functions with .zip or JAR file archives (p. 386)

Go

Deploy Go Lambda functions with .zip file archives (p. 427)

C#

Deploy C# Lambda functions with .zip file archives (p. 458)

PowerShell

Deploy PowerShell Lambda functions with .zip file archives (p. 483)

# Using the console code editor

The console creates a Lambda function with a single source file. For scripting languages, you can edit this file and add more files using the built-in code editor (p. 38). To save your changes, choose **Save**. Then, to run your code, choose **Test**.

> **Note**
> The Lambda console uses AWS Cloud9 to provide an integrated development environment in the browser. You can also use AWS Cloud9 to develop Lambda functions in your own environment. For more information, see Working with Lambda Functions in the AWS Cloud9 user guide.

When you save your function code, the Lambda console creates a .zip file archive deployment package. When you develop your function code outside of the console (using an IDE) you need to create a deployment package (p. 288) to upload your code to the Lambda function.

# Updating function code

For scripting languages (Node.js, Python, and Ruby), you can edit your function code in the embedded code editor (p. 38). If the code is larger than 3MB, or if you need to add libraries, or for languages that the editor doesn't support (Java, Go, C#), you must upload your function code as a .zip archive. If the .zip file archive is smaller than 50 MB, you can upload the .zip file archive from your local machine. If the file is larger than 50 MB, upload the file to the function from an Amazon S3 bucket.

### To upload function code as a .zip archive

1. Open the Functions page of the Lambda console.
2. Choose the function to update and choose the **Code** tab.
3. Under **Code source**, choose **Upload from**.
4. Choose **.zip file**, and then choose **Upload**.

   - In the file chooser, select the new image version, choose **Open**, and then choose **Save**.

5. (Alternative to step 4) Choose **Amazon S3 location**.
   - In the text box, enter the S3 link URL of the .zip file archive, then choose **Save**.

# Changing the runtime or runtime version

If you update the function configuration to use a new runtime version, you may need to update the function code to be compatible with the new version. If you update the function configuration to use a different runtime, you **must** provide new function code that is compatible with the runtime and architecture. For instructions on how to create a deployment package for the function code, see the handler page for the runtime that the function uses.

### To change the runtime or runtime version

1. Open the Functions page of the Lambda console.
2. Choose the function to update and choose the **Code** tab.
3. Scroll down to the **Runtime settings** section, which is under the code editor.
4. Choose **Edit**.
   a. For **Runtime**, select the runtime version.
   b. For **Handler**, specify file name and handler for your function.
   c. For **Architecture**, choose the instruction set architecture to use for your function.
5. Choose **Save**.

# Changing the architecture

Before you can change the instruction set architecture, you need to ensure that your function's code is compatible with the target architecture.

If you use Node.js, Python, or Ruby and you edit your function code in the embedded editor (p. 38), the existing code may run without modification.

However, if you provide your function code using a .zip file archive deployment package, you must prepare a new .zip file archive that is compiled and built correctly for the target runtime and instruction-set architecture. For instructions, see the handler page for your function runtime.

### To change the instruction set architecture

1. Open the Functions page of the Lambda console.
2. Choose the function to update and choose the **Code** tab.
3. Under **Runtime settings**, choose **Edit**.
4. For **Architecture**, choose the instruction set architecture to use for your function.
5. Choose **Save**.

# Using the Lambda API

To create and configure a function that uses a .zip file archive, use the following API operations:

- CreateFunction (p. 904)
- UpdateFunctionCode (p. 1088)
- UpdateFunctionConfiguration (p. 1098)

# AWS CloudFormation

You can use AWS CloudFormation to create a Lambda function that uses a .zip file archive. In your AWS CloudFormation template, the `AWS::Lambda::Function` resource specifies the Lambda function. For descriptions of the properties in the `AWS::Lambda::Function` resource, see AWS::Lambda::Function in the *AWS CloudFormation User Guide*.

In the `AWS::Lambda::Function` resource, set the following properties to create a function defined as a .zip file archive:

- AWS::Lambda::Function
  - PackageType – Set to `Zip`.
  - Code – Enter the Amazon S3 bucket name and .zip file name in the `S3Bucket` and `S3Key`fields. For Node.js or Python, you can provide inline source code of your Lambda function.
  - Runtime – Set the runtime value.
  - Architecture – Set the architecture value to `arm64` to use the AWS Graviton2 processor. By default, the architecture value is `x86_64`.

# Deploying Lambda functions as container images

When you create a Lambda function, you package your function code into a deployment package. Lambda supports two types of deployment packages: container images (p. 35) and .zip file archives (p. 35). The workflow to create a function is different depending on the deployment package type. To configure a function defined as a .zip file archive, see the section called ".zip file archives" (p. 132).

You can use the Lambda console and the Lambda API to create a function defined as a container image, update and test the image code, and configure other function settings.

> **Note**
> You cannot convert an existing container image function to use a .zip file archive. You must create a new function.

When you select an image using an image tag, Lambda translates the tag to the underlying image digest. To retrieve the digest for your image, use the GetFunctionConfiguration (p. 967) API operation. To update the function to a newer image version, you must use the Lambda console to update the function code (p. 141), or use the UpdateFunctionCode (p. 1088) API operation. Configuration operations such as UpdateFunctionConfiguration (p. 1098) do not update the function's container image.

**Topics**


- Prerequisites (p. 136)
- Permissions (p. 136)
- Creating the function (p. 138)
- Testing the function (p. 139)
- Overriding container settings (p. 140)
- Updating function code (p. 141)
- Using the Lambda API (p. 141)
- AWS CloudFormation (p. 142)


## Prerequisites

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

Before you create the function, you must create a container image and upload it to Amazon ECR (p. 143).

## Permissions

Make sure that the permissions for the IAM user or role that creates the function contain the AWS managed policies `GetRepositoryPolicy` and `SetRepositoryPolicy`.

For example, use the IAM console to create a role with the following policy:

```
{
"Version": "2012-10-17",
"Statement": [
  {
  "Sid": "VisualEditor0",
  "Effect": "Allow",
  "Action": ["ecr:SetRepositoryPolicy","ecr:GetRepositoryPolicy"],
  "Resource": "arn:aws:ecr:<region>:<account>:repository/<repo name>/"
  }
]
}
```

# Amazon ECR permissions

For a function in the same account as the container image in Amazon ECR, you can add `ecr:BatchGetImage` and `ecr:GetDownloadUrlForLayer` permissions to your Amazon ECR repository. The following example shows the minimum policy:

```
{
        "Sid": "LambdaECRImageRetrievalPolicy",
        "Effect": "Allow",
        "Principal": {
          "Service": "lambda.amazonaws.com"
        },
        "Action": [
          "ecr:BatchGetImage",
          "ecr:GetDownloadUrlForLayer"
        ]
    }
```

For more information about Amazon ECR repository permissions, see Repository policies in the *Amazon Elastic Container Registry User Guide*.

If the Amazon ECR repository does not include these permissions, Lambda adds `ecr:BatchGetImage` and `ecr:GetDownloadUrlForLayer` to the container image repository permissions. Lambda can add these permissions only if the Principal calling Lambda has `ecr:getRepositoryPolicy` and `ecr:setRepositoryPolicy` permissions.

To view or edit your Amazon ECR repository permissions, follow the directions in Setting a repository policy statement in the *Amazon Elastic Container Registry User Guide*.

## Amazon ECR cross-account permissions

A different account in the same region can create a function that uses a container image owned by your account. In the following example, your Amazon ECR repository permissions policy needs the following statements to grant access to account number 123456789012.

- **CrossAccountPermission** – Allows account 123456789012 to create and update Lambda functions that use images from this ECR repository.
- **LambdaECRImageCrossAccountRetrievalPolicy** – Lambda will eventually set a function's state to inactive if it is not invoked for an extended period. This statement is required so that Lambda can retrieve the container image for optimization and caching on behalf of the function owned by 123456789012.

**Example Add cross-account permission to your repository**

```
{"Version": "2012-10-17",
```

```
"Statement": [
  {
    "Sid": "CrossAccountPermission",
    "Effect": "Allow",
    "Action": [
      "ecr:BatchGetImage",
      "ecr:GetDownloadUrlForLayer"
    ],
    "Principal": {
      "AWS": "arn:aws:iam::123456789012:root"
    }
  },
  {
    "Sid": "LambdaECRImageCrossAccountRetrievalPolicy",
    "Effect": "Allow",
    "Action": [
      "ecr:BatchGetImage",
      "ecr:GetDownloadUrlForLayer"
    ],
    "Principal": {
        "Service": "lambda.amazonaws.com"
    },
    "Condition": {
      "StringLike": {
        "aws:sourceARN":
          "arn:aws:lambda:us-east-1:123456789012:function:*"
      }
    }
  }
]
}
```

To give access to multiple accounts, you add the account IDs to the Principal list in the `CrossAccountPermission` policy and to the Condition evaluation list in the `LambdaECRImageCrossAccountRetrievalPolicy`.

If you are working with multiple accounts in an AWS Organization, we recommend that you enumerate each account ID in the ECR permissions policy. This approach aligns with the AWS security best practice of setting narrow permissions in IAM policies.

# Creating the function

To create a function defined as a container image, you must first create the image (p. 143) and then store the image in the Amazon ECR repository.

**To create the function**

1. Open the Functions page of the Lambda console.
2. Choose **Create function**.
3. Choose the **Container image** option.
4. Under **Basic information**, do the following:

   a. For **Function name**, enter the function name.

   b. For **Container image URI**, provide a container image that is compatible with the instruction set architecture that you want for your function code.

      You can enter the Amazon ECR image URI or browse for the Amazon ECR image.

      - Enter the Amazon ECR image URI.
      - Or, to browse an Amazon ECR repository for the image, choose **Browse images**. Select the Amazon ECR repository from the dropdown list, and then select the image.

5. (Optional) To override configuration settings that are included in the Dockerfile, expand **Container image overrides**. You can override any of the following settings:

   - For **Entrypoint**, enter the full path of the runtime executable. The following example shows an entrypoint for a Node.js function:

     ```
     "/usr/bin/npx", "aws-lambda-ric"
     ```

   - For **Command**, enter additional parameters to pass in to the image with **Entrypoint**. The following example shows a command for a Node.js function:

     ```
     "app.handler"
     ```

   - For **Working directory**, enter the full path of the working directory for the function. The following example shows the working directory for an AWS base image for Lambda:

     ```
     "/var/task"
     ```

     **Note**
     For the override settings, make sure that you enclose each string in quotation marks (" ").

6. (Optional) For **Architecture**, choose the instruction set architecture for the function. The default architecture is x86_64. Note: when you build the container image for your function, make sure that it is compatible with this instruction set architecture (p. 23).
7. (Optional) Under **Permissions**, expand **Change default execution role**. Then, choose to create a new **Execution role**, or to use an existing role.
8. Choose **Create function**.

Lambda creates your function and an execution role (p. 52) that grants the function permission to upload logs. Lambda assumes the execution role when you invoke your function, and uses the execution role to create credentials for the AWS SDK and to read data from event sources.

When you deploy code as a container image to a Lambda function, the image undergoes an optimization process for running on Lambda. This process can take a few seconds, during which the function is in pending state. When the optimization process completes, the function enters the active state.

# Testing the function

Invoke your Lambda function using the sample event data provided in the console.

### To invoke a function

1. After selecting your function, choose the **Test** tab.
2. In the **Test event** section, choose **New event**. In **Template**, leave the default **hello-world** option. Enter a **Name** for this test and note the following sample event template:

   ```
   {
       "key1": "value1",
       "key2": "value2",
       "key3": "value3"
   }
   ```

3. Choose **Save changes**, and then choose **Test**. Each user can create up to 10 test events per function. Those test events are not available to other users.

Lambda runs your function on your behalf. The function handler receives and then processes the sample event.

4. Upon successful completion, view the results in the console.

   - The **Execution result** shows the execution status as **succeeded**. To view the function execution results, expand **Details**. Note that the **logs** link opens the **Log groups** page in the CloudWatch console.
   - The **Summary** section shows the key information reported in the **Log output** section (the *REPORT* line in the execution log).
   - The **Log output** section shows the log that Lambda generates for each invocation. The function writes these logs to CloudWatch. The Lambda console shows these logs for your convenience. Choose **Click here** to add logs to the CloudWatch log group and open the **Log groups** page in the CloudWatch console.

5. Run the function (choose **Test**) a few more times to gather some metrics that you can view in the next step.
6. Choose the **Monitor** tab. This page shows graphs for the metrics that Lambda sends to CloudWatch.




For more information on these graphs, see Monitoring functions on the Lambda console (p. 719).

# Overriding container settings

You can use the Lambda console or the Lambda API to override the following container image settings:

- ENTRYPOINT – Specifies the absolute path of the entry point to the application.
- CMD – Specifies parameters that you want to pass in with ENTRYPOINT.
- WORKDIR – Specifies the absolute path of the working directory.
- ENV – Specifies an environment variable for the Lambda function.

Any values that you provide in the Lambda console or the Lambda API override the values in the Dockerfile (p. 150).

### To override the configuration values in the container image

1. Open the Functions page of the Lambda console.
2. Choose the function to update.
3. Under **Image configuration**, choose **Edit**.

4. Enter new values for any of the override settings, and then choose **Save**.
5. (Optional) To add or override environment variables, under **Environment variables**, choose **Edit**.

   For more information, see the section called “Environment variables” (p. 166).

# Updating function code

After you deploy a container image to a function, the image is read-only. To update the function code, you must first deploy a new image version. Create a new image version (p. 143), and then store the image in the Amazon ECR repository.

**To configure the function to use an updated container image**

1. Open the Functions page of the Lambda console.
2. Choose the function to update.
3. Under **Image**, choose **Deploy new image**.
4. Choose **Browse images**.
5. In the **Select container image** dialog box, select the Amazon ECR repository from the dropdown list, and then select the new image version.
6. Choose **Save**.

## Function version $LATEST

When you publish a function version, the code and most of the configuration settings are locked to maintain a consistent experience for users of that version. You can change the code and many configuration settings only on the unpublished version of the function. By default, the console displays configuration information for the unpublished version of the function. To view the versions of a function, choose **Qualifiers**. The unpublished version is named **$LATEST**.

Note that Amazon Elastic Container Registry (Amazon ECR) also uses a *latest* tag to denote the latest version of the container image. Be careful not to confuse this tag with the **$LATEST** function version.

For more information about managing versions, see Lambda function versions (p. 173).

# Using the Lambda API

To manage functions defined as container images, use the following API operations:

- CreateFunction (p. 904)
- UpdateFunctionCode (p. 1088)
- UpdateFunctionConfiguration (p. 1098)

To create a function defined as container image, use the `create-function` command. Set the `package-type` to `Image` and specify your container image URI using the `code` parameter.

When you create the function, you can specify the instruction set architecture. The default architecture is `x86-64`. Make sure that the code in your container image is compatible with the architecture.

You can create the function from the same account as the container registry or from a different account in the same region as the container registry in Amazon ECR. For cross-account access, adjust the Amazon ECR permissions (p. 137) for the image.

```
aws lambda create-function --region sa-east-1 --function-name my-function \
```

```
    --package-type Image  \
    --code ImageUri=<ECR Image URI>   \
    --role arn:aws:iam::123456789012:role/lambda-ex
```

To update the function code, use the `update-function-code` command. Specify the container image location using the `image-uri` parameter.

**Note**
You cannot change the `package-type` of a function.

```
aws lambda update-function-code --region sa-east-1 --function-name my-function \
    --image-uri <ECR Image URI>   \
```

To update the function parameters, use the `update-function-configuration` operation. Specify `EntryPoint` and `Command` as arrays of strings, and `WorkingDirectory` as a string.

```
aws lambda update-function-configuration  --function-name my-function \
--image-config '{"EntryPoint": ["/usr/bin/npx", "aws-lambda-ric"],  \
                 "Command":   ["app.handler"] ,          \
                  "WorkingDirectory": "/var/task"}'
```

# AWS CloudFormation

You can use AWS CloudFormation to create Lambda functions defined as container images. In your AWS CloudFormation template, the `AWS::Lambda::Function` resource specifies the Lambda function. For descriptions of the properties in the `AWS::Lambda::Function` resource, see AWS::Lambda::Function in the *AWS CloudFormation User Guide*.

In the `AWS::Lambda::Function` resource, set the following properties to create a function defined as a container image:

- AWS::Lambda::Function
  - PackageType – Set to `Image`.
  - Code – Enter your container image URI in the `ImageUri` field.
  - ImageConfig – (Optional) Override the container image configuration properties.

The `ImageConfig` property in `AWS::Lambda::Function` contains the following fields:

- Command – Specifies parameters that you want to pass in with `EntryPoint`.
- EntryPoint – Specifies the entry point to the application.
- WorkingDirectory – Specifies the working directory.

**Note**
If you declare an `ImageConfig` property in your AWS CloudFormation template, you must provide values for all three of the `ImageConfig` properties.

For more information, see ImageConfig in the *AWS CloudFormation User Guide*.

# Creating Lambda container images

AWS provides a set of open-source base images (p. 144) that you can use to create your container image. These base images include a runtime interface client (p. 145) to manage the interaction between Lambda and your function code.

For example applications, including a Node.js example and a Python example, see Container image support for Lambda on the AWS Blog.

> **Note**
> Container images aren't supported for Lambda functions in the Middle East (UAE) Region.

**Topics**


- Base images for Lambda (p. 144)
- Testing Lambda container images locally (p. 146)
- Prerequisites (p. 149)
- Image types (p. 149)
- Container tools (p. 149)
- Container image settings (p. 150)
- Creating images from AWS base images (p. 150)
- Creating images from alternative base images (p. 152)
- Upload the image to the Amazon ECR repository (p. 153)
- Create an image using the AWS SAM toolkit (p. 154)

# Base images for Lambda

AWS provides a set of open-source base images that you can use. You can also use a preferred community or private base image. Lambda provides client software that you add to your preferred base image to make it compatible with the Lambda service.

> **Note**
> Each base image is compatible with one or more of the instruction set architectures that Lambda supports. You need to build the function image for only one architcture. Lambda does not support multi-architecture images.

**Topics**


- AWS base images for Lambda (p. 144)
- Base images for custom runtimes (p. 144)
- Runtime interface clients (p. 145)
- Runtime interface emulator (p. 145)


## AWS base images for Lambda

You can use one of the AWS base images for Lambda to build the container image for your function code. The base images are preloaded with a language runtime and other components required to run a container image on Lambda. You add your function code and dependencies to the base image and then package it as a container image.

AWS will maintain and regularly update these images. In addition, AWS will release AWS base images when any new managed runtime becomes available.

Lambda provides base images for the following runtimes:

- Node.js (p. 291)
- Python (p. 335)
- Java (p. 393)
- .NET (p. 463)
- Go (p. 431)
- Ruby (p. 361)

## Base images for custom runtimes

AWS provides base images that contain the required Lambda components and the Amazon Linux or Amazon Linux2 operating system. You can add your preferred runtime, dependencies and code to these images.

| Tags | Runtime | Operating system |
|---|---|---|
| al2 | provided.al2 | Amazon Linux 2 |
| alami | provided | Amazon Linux |

Amazon ECR Public Gallery: gallery.ecr.aws/lambda/provided

# Runtime interface clients

The runtime interface client in your container image manages the interaction between Lambda and your function code. The Runtime API (p. 115), along with the Extensions API (p. 101), defines a simple HTTP interface for runtimes to receive invocation events from Lambda and respond with success or failure indications.

Each of the AWS base images for Lambda include a runtime interface client. If you choose one of the base images for custom runtimes or an alternative base image, you need to add the appropriate runtime interface client.

For your convenience, Lambda provides an open source runtime interface client for each of the supported Lambda runtimes:

- Node.js (p. 292)
- Python (p. 337)
- Java (p. 394)
- .NET (p. 464)
- Go (p. 432)
- Ruby (p. 362)

# Runtime interface emulator

Lambda provides a runtime interface emulator (RIE) for you to test your function locally. The AWS base images for Lambda and base images for custom runtimes include the RIE. For other base images, you can download the Runtime interface emulator from the AWS GitHub repository.

# Testing Lambda container images locally

The AWS Lambda Runtime Interface Emulator (RIE) is a proxy for the Lambda Runtime API that allows you to locally test your Lambda function packaged as a container image. The emulator is a lightweight web server that converts HTTP requests into JSON events to pass to the Lambda function in the container image.

The AWS base images for Lambda include the RIE component. If you use an alternate base image, you can test your image without adding RIE to the image. You can also build the RIE component into your base image. AWS provides an open-sourced RIE component on the AWS GitHub repository. Note that there are separate RIE components for the x86-64 architecture and the arm64 architecture.

You can use the emulator to test whether your function code is compatible with the Lambda environment. Also use the emulator to test that your Lambda function runs to completion successfully and provides the expected output. If you build extensions and agents into your container image, you can use the emulator to test that the extensions and agents work correctly with the Lambda Extensions API.

For examples of how to use the RIE, see Container image support for Lambda on the AWS Blog.

**Topics**


- Guidelines for using the RIE (p. 146)
- Environment variables (p. 146)
- Test an image with RIE included in the image (p. 147)
- Build RIE into your base image (p. 147)
- Test an image without adding RIE to the image (p. 148)


## Guidelines for using the RIE

Note the following guidelines when using the Runtime Interface Emulator:

- The RIE does not emulate Lambda's security and authentication configurations, or Lambda orchestration.
- Lambda provides an emulator for each of the instruction set architectures.
- The emulator does not support AWS X-Ray tracing or other Lambda integrations.

## Environment variables

The runtime interface emulator supports a subset of environment variables (p. 166) for the Lambda function in the local running image.

If your function uses security credentials, you can configure the credentials by setting the following environment variables:

- `AWS_ACCESS_KEY_ID`
- `AWS_SECRET_ACCESS_KEY`
- `AWS_SESSION_TOKEN`
- `AWS_REGION`

To set the function timeout, configure `AWS_LAMBDA_FUNCTION_TIMEOUT`. Enter the maximum number of seconds that you want to allow the function to run.

The emulator does not populate the following Lambda environment variables. However, you can set them to match the values that you expect when the function runs in the Lambda service:

- `AWS_LAMBDA_FUNCTION_VERSION`
- `AWS_LAMBDA_FUNCTION_NAME`
- `AWS_LAMBDA_FUNCTION_MEMORY_SIZE`

# Test an image with RIE included in the image

The AWS base images for Lambda include the runtime interface emulator. You can also follow these steps after you build the RIE into your alternative base image.

**To test your Lambda function with the emulator**

1. Build your image locally using the `docker build` command.

   ```
   docker build -t myfunction:latest .
   ```

2. Run your container image locally using the `docker run` command.

   ```
   docker run -p 9000:8080  myfunction:latest
   ```

   This command runs the image as a container and starts up an endpoint locally at `localhost:9000/2015-03-31/functions/function/invocations`.

3. From a new terminal window, post an event to the following endpoint using a `curl` command:

   ```
   curl -XPOST "http://localhost:9000/2015-03-31/functions/function/invocations" -d '{}'
   ```

   This command invokes the Lambda function running in the container image and returns a response.

# Build RIE into your base image

You can build RIE into a base image. The following steps show how to download the RIE from GitHub to your local machine and update your Dockerfile to install RIE.

**To build the emulator into your image**

1. Create a script and save it in your project directory. Set execution permissions for the script file.

   The script checks for the presence of the `AWS_LAMBDA_RUNTIME_API` environment variable, which indicates the presence of the runtime API. If the runtime API is present, the script runs the runtime interface client (p. 145). Otherwise, the script runs the runtime interface emulator.

   The following example shows a typical script for a Node.js function.

   ```
   #!/bin/sh
   if [ -z "${AWS_LAMBDA_RUNTIME_API}" ]; then
     exec /usr/local/bin/aws-lambda-rie /usr/local/bin/npx aws-lambda-ric $@
   else
     exec /usr/local/bin/npx aws-lambda-ric $@
   fi
   ```

   The following example shows a typical script for a Python function.

```
#!/bin/sh
if [ -z "${AWS_LAMBDA_RUNTIME_API}" ]; then
  exec /usr/local/bin/aws-lambda-rie /usr/local/bin/python -m awslambdaric $@
else
  exec /usr/local/bin/python -m awslambdaric $@
fi
```

2. Download the runtime interface emulator for your target architecture from GitHub into your project directory. Lambda provides an emulator for each of the instruction set architectures.
   - x86_64 – Download aws-lambda-rie
   - arm64 – Download aws-lambda-rie-arm64
3. Copy the script, install the emulator package, and change `ENTRYPOINT` to run the new script by adding the following lines to your Dockerfile.

   To use the default x86-64 architecture:

```
COPY ./entry_script.sh /entry_script.sh
ADD aws-lambda-rie-x86_64 /usr/local/bin/aws-lambda-rie
ENTRYPOINT [ "/entry_script.sh" ]
```

   To use the arm64 architecture:

```
COPY ./entry_script.sh /entry_script.sh
ADD aws-lambda-rie-arm64 /usr/local/bin/aws-lambda-rie
ENTRYPOINT [ "/entry_script.sh" ]
```

4. Build your image locally using the `docker build` command.

```
docker build -t myfunction:latest .
```

# Test an image without adding RIE to the image

You install the runtime interface emulator to your local machine. When you run the container image, you set the entry point to be the emulator.

**To test an image without adding RIE to the image**

1. From your project directory, run the following command to download the RIE (x86-64 architecture) from GitHub and install it on your local machine.

```
mkdir -p ~/.aws-lambda-rie && curl -Lo ~/.aws-lambda-rie/aws-lambda-rie \
https://github.com/aws/aws-lambda-runtime-interface-emulator/releases/latest/download/
aws-lambda-rie \
&& chmod +x ~/.aws-lambda-rie/aws-lambda-rie
```

   To download the RIE for arm64 architecture, use the previous command with a different GitHub download url.

```
 https://github.com/aws/aws-lambda-runtime-interface-emulator/releases/latest/download/
aws-lambda-rie-arm64 \
```

2. Run your Lambda function using the `docker run` command.

```
docker run -d -v ~/.aws-lambda-rie:/aws-lambda -p 9000:8080 \
  --entrypoint /aws-lambda/aws-lambda-rie hello-world:latest <image entrypoint> \
      <(optional) image command>
```

This runs the image as a container and starts up an endpoint locally at `localhost:9000/2015-03-31/functions/function/invocations`.

3. Post an event to the following endpoint using a `curl` command:

```
curl -XPOST "http://localhost:9000/2015-03-31/functions/function/invocations" -d '{}'
```

This command invokes the function running in the container image and returns a response.

# Prerequisites

To deploy a container image to Lambda, you need the AWS CLI and Docker CLI. Additionally, note the following requirements:

- The container image must implement the Lambda Runtime API (p. 115). The AWS open-source runtime interface clients (p. 145) implement the API. You can add a runtime interface client to your preferred base image to make it compatible with Lambda.
- The container image must be able to run on a read-only file system. Your function code can access a writable `/tmp` directory with between 512 MB and 10,240 MB, in 1-MB increments, of storage.
- The default Lambda user must be able to read all the files required to run your function code. Lambda follows security best practices by defining a default Linux user with least-privileged permissions. Verify that your application code does not rely on files that other Linux users are restricted from running.
- Lambda supports only Linux-based container images.
- Lambda provides multi-architecture base images. However, the image you build for your function must target only one of the architectures. Lambda does not support functions that use multi-architecture container images.

# Image types

You can use an AWS provided base image or an alternative base image, such as Alpine or Debian. Lambda supports any image that conforms to one of the following image manifest formats:

- Docker image manifest V2, schema 2 (used with Docker version 1.10 and newer)
- Open Container Initiative (OCI) Specifications (v1.0.0 and up)

Lambda supports images up to 10 GB in size.

# Container tools

To create your container image, you can use any development tool that supports one of the following container image manifest formats:

- Docker image manifest V2, schema 2 (used with Docker version 1.10 and newer)
- OCI Specifications (v1.0.0 and up)

For example, you can use the Docker CLI to build, test, and deploy your container images.

# Container image settings

Lambda supports the following container image settings in the Dockerfile:

- ENTRYPOINT – Specifies the absolute path to the entry point of the application.
- CMD – Specifies parameters that you want to pass in with ENTRYPOINT.
- WORKDIR – Specifies the absolute path to the working directory.
- ENV – Specifies an environment variable for the Lambda function.

> **Note**
> Lambda ignores the values of any unsupported container image settings in the Dockerfile.

For more information about how Docker uses the container image settings, see ENTRYPOINT in the Dockerfile reference on the Docker Docs website. For more information about using ENTRYPOINT and CMD, see Demystifying ENTRYPOINT and CMD in Docker on the AWS Open Source Blog.

You can specify the container image settings in the Dockerfile when you build your image. You can also override these configurations using the Lambda console or Lambda API. This allows you to deploy multiple functions that deploy the same container image but with different runtime configurations.

> **Warning**
> When you specify ENTRYPOINT or CMD in the Dockerfile or as an override, make sure that you enter the absolute path. Also, do not use symlinks as the entry point to the container.

# Creating images from AWS base images

To build a container image for a new Lambda function, you can start with an AWS base image for Lambda. Lambda provides two types of base images:

- Multi-architecture base image

  Specify one of the main image tags (such as `python:3.9` or `java:11`) to choose this type of image.
- Architecture-specific base image

  Specify an image tag with an architecture suffix. For example, specify `3.9-arm64` to choose the arm64 base image for Python 3.9.

You can also use an alternative base image from another container registry (p. 152). Lambda provides open-source runtime interface clients that you add to an alternative base image to make it compatible with Lambda.

> **Note**
> AWS periodically provides updates to the AWS base images for Lambda. If your Dockerfile includes the image name in the FROM property, your Docker client pulls the latest version of the image from the Amazon ECR repository. To use the updated base image, you must rebuild your container image and update the function code (p. 141).

**To create an image from an AWS base image for Lambda**

1. On your local machine, create a project directory for your new function.

2. Create a directory named **app** in the project directory, and then add your function handler code to the app directory.
3. Use a text editor to create a new Dockerfile.

   The AWS base images provide the following environment variables:

   - LAMBDA_TASK_ROOT=/var/task
   - LAMBDA_RUNTIME_DIR=/var/runtime

   Install any dependencies under the ${LAMBDA_TASK_ROOT} directory alongside the function handler to ensure that the Lambda runtime can locate them when the function is invoked.

   The following shows an example Dockerfile for Node.js, Python, and Ruby:

   Node.js 14

   ```
   FROM public.ecr.aws/lambda/nodejs:14

   # Assumes your function is named "app.js", and there is a package.json file in the
    app directory
   COPY app.js package.json  ${LAMBDA_TASK_ROOT}

   # Install NPM dependencies for function
   RUN npm install

   # Set the CMD to your handler (could also be done as a parameter override outside
    of the Dockerfile)
   CMD [ "app.handler" ]
   ```

   Python 3.8

   ```
   FROM public.ecr.aws/lambda/python:3.8

   # Copy function code
   COPY app.py ${LAMBDA_TASK_ROOT}

   # Install the function's dependencies using file requirements.txt
   # from your project folder.

   COPY requirements.txt  .
   RUN  pip3 install -r requirements.txt --target "${LAMBDA_TASK_ROOT}"

   # Set the CMD to your handler (could also be done as a parameter override outside
    of the Dockerfile)
   CMD [ "app.handler" ]
   ```

   Ruby 2.7

   ```
   FROM public.ecr.aws/lambda/ruby:2.7

   # Copy function code
   COPY app.rb ${LAMBDA_TASK_ROOT}

   # Copy dependency management file
   COPY Gemfile ${LAMBDA_TASK_ROOT}

   # Install dependencies under LAMBDA_TASK_ROOT
   ENV GEM_HOME=${LAMBDA_TASK_ROOT}
   RUN bundle install
   ```

```
# Set the CMD to your handler (could also be done as a parameter override outside
 of the Dockerfile)
CMD [ "app.LambdaFunction::Handler.process" ]
```

4. Build your Docker image with the `docker build` command. Enter a name for the image. The following example names the image `hello-world`.

```
docker build -t hello-world .
```

5. Start the Docker image with the `docker run` command. For this example, enter `hello-world` as the image name.

```
docker run -p 9000:8080 hello-world
```

6. (Optional) Test your application locally using the runtime interface emulator (p. 146). From a new terminal window, post an event to the following endpoint using a `curl` command:

```
curl -XPOST "http://localhost:9000/2015-03-31/functions/function/invocations" -d '{}'
```

This command invokes the function running in the container image and returns a response.

# Creating images from alternative base images

**Prerequisites**

- The AWS CLI
- Docker Desktop
- Your function code

**To create an image using an alternative base image**

1. Choose a base image. Lambda supports all Linux distributions, such as Alpine, Debian, and Ubuntu.
2. On your local machine, create a project directory for your new function.
3. Create a directory named **app** in the project directory, and then add your function handler code to the app directory.
4. Use a text editor to create a new Dockerfile with the following configuration:
   - Set the `FROM` property to the URI of the base image.
   - Add instructions to install the runtime interface client.
   - Set the `ENTRYPOINT` property to invoke the runtime interface client.
   - Set the `CMD` argument to specify the Lambda function handler.

   The following example shows a Dockerfile for Python:

```
# Define function directory
ARG FUNCTION_DIR="/function"

FROM python:buster as build-image

# Install aws-lambda-cpp build dependencies
RUN apt-get update && \
  apt-get install -y \
  g++ \
```

```
  make \
  cmake \
  unzip \
  libcurl4-openssl-dev

# Include global arg in this stage of the build
ARG FUNCTION_DIR
# Create function directory
RUN mkdir -p ${FUNCTION_DIR}

# Copy function code
COPY app/* ${FUNCTION_DIR}

# Install the runtime interface client
RUN pip install \
        --target ${FUNCTION_DIR} \
        awslambdaric

# Multi-stage build: grab a fresh copy of the base image
FROM python:buster

# Include global arg in this stage of the build
ARG FUNCTION_DIR
# Set working directory to function root directory
WORKDIR ${FUNCTION_DIR}

# Copy in the build image dependencies
COPY --from=build-image ${FUNCTION_DIR} ${FUNCTION_DIR}

ENTRYPOINT [ "/usr/local/bin/python", "-m", "awslambdaric" ]
CMD [ "app.handler" ]
```

5. Build your Docker image with the `docker build` command. Enter a name for the image. The following example names the image `hello-world`.

```
docker build -t hello-world .
```

6. (Optional) Test your application locally using the Runtime interface emulator (p. 146).

# Upload the image to the Amazon ECR repository

In the following commands, replace `123456789012` with your AWS account ID and set the region value to the region where you want to create the Amazon ECR repository.

**Note**
In Amazon ECR, if you reassign the image tag to another image, Lambda does not update the image version.

1. Authenticate the Docker CLI to your Amazon ECR registry.

```
aws ecr get-login-password --region us-east-1 | docker login --username AWS --password-stdin 123456789012.dkr.ecr.us-east-1.amazonaws.com
```

2. Create a repository in Amazon ECR using the `create-repository` command.

```
aws ecr create-repository --repository-name hello-world --image-scanning-configuration
 scanOnPush=true --image-tag-mutability MUTABLE
```

3. Tag your image to match your repository name, and deploy the image to Amazon ECR using the `docker push` command.

```
docker tag  hello-world:latest 123456789012.dkr.ecr.us-east-1.amazonaws.com/hello-
world:latest
docker push 123456789012.dkr.ecr.us-east-1.amazonaws.com/hello-world:latest
```

Now that your container image resides in the Amazon ECR container registry, you can create and run (p. 136) the Lambda function.

# Create an image using the AWS SAM toolkit

You can use the AWS Serverless Application Model (AWS SAM) toolkit to create and deploy a function defined as a container image. For a new project, you can use the AWS SAM CLI `init` command to set up the scaffolding for your project in your preferred runtime.

In your AWS SAM template, you set the `Runtime` type to `Image` and provide the URI of the base image.

For more information, see Building applications in the *AWS Serverless Application Model Developer Guide*.

# Configuring AWS Lambda functions

You can use the AWS Lambda API or console to create functions and configure function settings. When you create the function, you chose the type of deployment package for the function. The deployment package type cannot be changed later. The workflow to create a function is different for a function deployed as a container image (p. 136) and for a function deployed as a .zip file archive (p. 132).

After you create the function, you can configure settings for many function capabilities and options (p. 162) such as permissions, environment variables, tags, and layers.

To keep secrets out of your function code, store them in the function's configuration and read them from the execution environment during initialization. Environment variables (p. 166) are always encrypted at rest, and can be encrypted client-side as well. Use environment variables to make your function code portable by removing connection strings, passwords, and endpoints for external resources.

Versions and aliases (p. 173) are secondary resources that you can create to manage function deployment and invocation. Publish versions (p. 173) of your function to store its code and configuration as a separate resource that cannot be changed, and create an alias (p. 175) that points to a specific version. Then you can configure your clients to invoke a function alias, and update the alias when you want to point the client to a new version, instead of updating the client.

As you add libraries and other dependencies to your function, creating and uploading a deployment package can slow down development. Use layers (p. 156) to manage your function's dependencies independently and keep your deployment package small. You can also use layers to share your own libraries with other customers and use publicly available layers with your functions.

# Creating and sharing Lambda layers

Lambda layers (p. 14) provide a convenient way to package libraries and other dependencies that you can use with your Lambda functions. Using layers reduces the size of uploaded deployment archives and makes it faster to deploy your code.

A layer is a .zip file archive that can contain additional code or data. A layer can contain libraries, a custom runtime (p. 90), data, or configuration files. Layers promote code sharing and separation of responsibilities so that you can iterate faster on writing business logic.

You can use layers only with Lambda functions deployed as a .zip file archive (p. 35). For functions defined as a container image (p. 143), you package your preferred runtime and all code dependencies when you create the container image. For more information, see Working with Lambda layers and extensions in container images on the AWS Compute Blog.

You can create layers using the Lambda console, the Lambda API, AWS CloudFormation, or the AWS Serverless Application Model (AWS SAM). For more information about creating layers with AWS SAM, see Working with layers in the *AWS Serverless Application Model Developer Guide*.

> **Note**
> For Node.js runtimes, Lambda doesn't currently support ES module dependencies in layers.

**Sections**


- Creating layer content (p. 156)
- Compiling the .zip file archive for your layer (p. 156)
- Including library dependencies in a layer (p. 157)
- Language-specific instructions (p. 158)
- Creating a layer (p. 158)
- Deleting a layer version (p. 160)
- Configuring layer permissions (p. 160)
- Using AWS CloudFormation with layers (p. 160)


## Creating layer content

When you create a layer, you must bundle all its content into a .zip file archive. You upload the .zip file archive to your layer from Amazon Simple Storage Service (Amazon S3) or your local machine. Lambda extracts the layer contents into the `/opt` directory when setting up the execution environment for the function.

## Compiling the .zip file archive for your layer

You build your layer code into a .zip file archive using the same procedure that you would use for a function deployment package. If your layer includes any native code libraries, you must compile and build these libraries using a Linux development machine so that the binaries are compatible with Amazon Linux (p. 82).

When you create a layer, you can specify whether the layer is compatible with one or both of the instruction set architectures. You may need to set specific compile flags to build a layer that is compatible with the `arm64` architecture.

One way to ensure that you package libraries correctly for Lambda is to use AWS Cloud9. For more information, see Using Lambda layers to simplify your development process on the AWS Compute Blog.

# Including library dependencies in a layer

For each Lambda runtime (p. 82), the PATH variable includes specific folders in the `/opt` directory. If you define the same folder structure in your layer .zip file archive, your function code can access the layer content without the need to specify the path.

The following table lists the folder paths that each runtime supports.

**Layer paths for each Lambda runtime**

| Runtime | Path | | |
|---|---|---|---|
| Node.js | `nodejs/node_modules` | | |
| | `nodejs/node14/node_modules` (`NODE_PATH`) | | |
| Python | `python` | | |
| | `python/lib/python3.9/site-packages`(site directories) | | |
| Java | `java/lib` (`CLASSPATH`) | | |
| Ruby | `ruby/gems/2.7.0` (`GEM_PATH`) | | |
| | `ruby/lib` (`RUBYLIB`) | | |
| All runtimes | `bin` (`PATH`) | | |
| | `lib` (`LD_LIBRARY_PATH`) | | |

The following examples show how you can structure the folders in your layer .zip archive.

Node.js

**Example file structure for the AWS X-Ray SDK for Node.js**

```
xray-sdk.zip
# nodejs/node_modules/aws-xray-sdk
```

Python

**Example file structure for the Pillow library**

```
pillow.zip
# python/PIL
# python/Pillow-5.3.0.dist-info
```

Ruby

**Example file structure for the JSON gem**

```
json.zip
# ruby/gems/2.5.0/
                | build_info
                | cache
                | doc
```

```
                | extensions
                | gems
                | # json-2.1.0
                # specifications
                  # json-2.1.0.gemspec
```

Java

**Example file structure for the Jackson JAR file**

```
jackson.zip
# java/lib/jackson-core-2.2.3.jar
```

All

**Example file structure for the jq library**

```
jq.zip
# bin/jq
```

For more information about path settings in the Lambda execution environment, see Defined runtime environment variables (p. 169).

# Language-specific instructions

For language-specific instructions on how to create a .zip file archive, see the following topics.

Node.js

Deploy Node.js Lambda functions with .zip file archives (p. 288)

Python

Deploy Python Lambda functions with .zip file archives (p. 330)

Ruby

Deploy Ruby Lambda functions with .zip file archives (p. 358)

Java

Deploy Java Lambda functions with .zip or JAR file archives (p. 386)

Go

Deploy Go Lambda functions with .zip file archives (p. 427)

C#

Deploy C# Lambda functions with .zip file archives (p. 458)

PowerShell

Deploy PowerShell Lambda functions with .zip file archives (p. 483)

# Creating a layer

You can create new layers using the Lambda console or the Lambda API.

Layers can have one or more version. When you create a layer, Lambda sets the layer version to version 1. You can configure permissions on an existing layer version, but to update the code or make other configuration changes, you must create a new version of the layer.

### To create a layer (console)

1. Open the Layers page of the Lambda console.
2. Choose **Create layer**.
3. Under **Layer configuration**, for **Name**, enter a name for your layer.
4. (Optional) For **Description**, enter a description for your layer.
5. To upload your layer code, do one of the following:
   - To upload a .zip file from your computer, choose **Upload a .zip file**. Then, choose **Upload** to select your local .zip file.
   - To upload a file from Amazon S3, choose **Upload a file from Amazon S3**. Then, for **Amazon S3 link URL**, enter a link to the file.
6. (Optional) For **Compatible instruction set architectures**, choose one value or both values.
7. (Optional) For **Compatible runtimes**, choose up to 15 runtimes.
8. (Optional) For **License**, enter any necessary license information.
9. Choose **Create**.

### To create a layer (API)

To create a layer, use the **publish-layer-version** command with a name, description, .zip file archive, a list of runtimes (p. 82) and a list of architectures that are compatible with the layer. The runtimes and architecture parameters are optional.

```
aws lambda publish-layer-version --layer-name my-layer --description "My layer"  \
--license-info "MIT" --content S3Bucket=lambda-layers-us-
east-2-123456789012,S3Key=layer.zip \
 --compatible-runtimes python3.6 python3.7 python3.8
  --compatible-architectures "arm64" "x86_64"
```

You should see output similar to the following:

```
{
    "Content": {
        "Location": "https://awslambda-us-east-2-layers.s3.us-east-2.amazonaws.com/
snapshots/123456789012/my-layer-4aaa2fbb-ff77-4b0a-ad92-5b78a716a96a?
versionId=27iWyA73cCAYqyH...",
        "CodeSha256": "tv9jJO+rPbXUUXuRKi7CwHzKtLDkDRJLB3cC3Z/ouXo=",
        "CodeSize": 169
    },
    "LayerArn": "arn:aws:lambda:us-east-2:123456789012:layer:my-layer",
    "LayerVersionArn": "arn:aws:lambda:us-east-2:123456789012:layer:my-layer:1",
    "Description": "My layer",
    "CreatedDate": "2018-11-14T23:03:52.894+0000",
    "Version": 1,
    "CompatibleArchitectures": [
        "arm64",
        "x86_64"
     ],
    "LicenseInfo": "MIT",
    "CompatibleRuntimes": [
        "python3.6",
        "python3.7",
        "python3.8"
    ]
```

```
}
```

**Note**
Each time that you call `publish-layer-version`, you create a new version of the layer.

# Deleting a layer version

To delete a layer version, use the **delete-layer-version** command.

```
aws lambda delete-layer-version --layer-name my-layer --version-number 1
```

When you delete a layer version, you can no longer configure a Lambda function to use it. However, any function that already uses the version continues to have access to it. Version numbers are never reused for a layer name.

# Configuring layer permissions

By default, a layer that you create is private to your AWS account. However, you can optionally share the layer with other accounts or make it public.

To grant layer-usage permission to another account, add a statement to the layer version's permissions policy using the **add-layer-version-permission** command. In each statement, you can grant permission to a single account, all accounts, or an organization.

```
aws lambda add-layer-version-permission --layer-name xray-sdk-nodejs --statement-id
 xaccount \
--action lambda:GetLayerVersion  --principal 111122223333 --version-number 1 --output text
```

You should see output similar to the following:

```
e210ffdc-e901-43b0-824b-5fcd0dd26d16    {"Sid":"xaccount","Effect":"Allow","Principal":
{"AWS":"arn:aws:iam::111122223333:root"},"Action":"lambda:GetLayerVersion","Resource":"arn:aws:lambda:u
east-2:123456789012:layer:xray-sdk-nodejs:1"}
```

Permissions apply only to a single layer version. Repeat the process each time that you create a new layer version.

For more examples, see Granting layer access to other accounts (p. 72).

# Using AWS CloudFormation with layers

You can use AWS CloudFormation to create a layer and associate the layer with your Lambda function. The following example template creates a layer named **blank-nodejs-lib** and attaches the layer to the Lambda function using the **Layers** property.

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: 'AWS::Serverless-2016-10-31'
Description: A Lambda application that calls the Lambda API.
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs12.x
```

```
    CodeUri: function/.
    Description: Call the Lambda API
    Timeout: 10
    # Function's execution role
    Policies:
      - AWSLambdaBasicExecutionRole
      - AWSLambda_ReadOnlyAccess
      - AWSXrayWriteOnlyAccess
    Tracing: Active
    Layers:
      - !Ref libs
libs:
  Type: AWS::Lambda::LayerVersion
  Properties:
    LayerName: blank-nodejs-lib
    Description: Dependencies for the blank sample app.
    Content:
      S3Bucket: my-bucket-region-123456789012
      S3Key: layer.zip
    CompatibleRuntimes:
      - nodejs12.x
```

# Configuring Lambda function options

After you create a function, you can configure additional capabilities for the function, such as triggers, network access, and file system access. You can also adjust resources associated with the function, such as memory and concurrency. These configurations apply to functions defined as .zip file archives and to functions defined as container images.

You can also create and edit test events to test your function using the console.

For function configuration best practices, see Function configuration (p. 793).

**Sections**


- Function versions (p. 162)
- Using the function overview (p. 162)
- Configuring functions (console) (p. 163)
- Configuring functions (API) (p. 134)
- Configuring function memory (console) (p. 164)
- Configuring ephemeral storage (console) (p. 164)
- Accepting function memory recommendations (console) (p. 165)
- Configuring triggers (console) (p. 165)
- Testing functions (console) (p. 165)

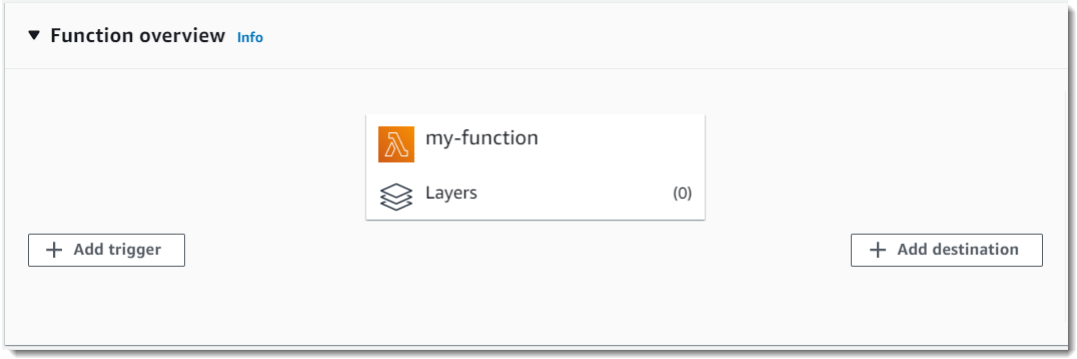

## Function versions

A function has an unpublished version, and can have published versions and aliases. By default, the console displays configuration information for the unpublished version of the function. You change the unpublished version when you update your function's code and configuration.

A published version is a snapshot of your function code and configuration that can't be changed (except for a few configuration items relevant to a function version, such as provisioned concurrency).

## Using the function overview

The **Function overview** shows a visualization of your function and its upstream and downstream resources. You can use it to jump to trigger and destination configuration. You can use it to jump to layer configuration for functions defined as .zip file archives.



# Configuring functions (console)

For the following function configurations, you can change the settings only for the unpublished version of a function. In the console, the function **Configuration** tab provides the following sections:

- **General configuration** – Configure memory (p. 164) or opt in to the AWS Compute Optimizer (p. 165). You can also configure function timeout and the execution role.
- **Permissions** – Configure the execution role and other permissions (p. 51).
- **Environment variables** – Key-value pairs that Lambda sets in the execution environment. To extend your function's configuration outside of code, use environment variables (p. 166).
- **Tags** – Key-value pairs that Lambda attaches to your function resource. Use tags (p. 215) to organize Lambda functions into groups for cost reporting and filtering in the Lambda console.

  Tags apply to the entire function, including all versions and aliases.
- **Virtual private cloud (VPC)** – If your function needs network access to resources that are not available over the internet, configure it to connect to a virtual private cloud (VPC) (p. 191).
- **Monitoring and operations tools** – configure CloudWatch and other monitoring tools.
- **Concurrency** – Reserve concurrency for a function (p. 180) to set the maximum number of simultaneous executions for a function. Provision concurrency to ensure that a function can scale without fluctuations in latency. Reserved concurrency applies to the entire function, including all versions and aliases.
- **Function URL** – Configure a function URL (p. 258) to add a unique HTTP(S) endpoint to your Lambda function. You can configure a function URL on the `$LATEST` unpublished function version, or on any function alias.

You can configure the following options on a function, a function version, or an alias.

- **Triggers** – Configure triggers (p. 165).
- **Destinations** – Configure destinations (p. 230) for asynchronous invocations .
- **Asynchronous invocation** – Configure error handling behavior (p. 228) to reduce the number of retries that Lambda attempts, or the amount of time that unprocessed events stay queued before Lambda discards them. Configure a dead-letter queue (p. 234) to retain discarded events.
- **Code signing** – To use Code signing (p. 211) with your function, configure the function to include a code-signing configuration.
- **Database proxies** – Create a database proxy (p. 201) for functions that use an Amazon RDS DB instance or cluster.
- **File systems** – Connect your function to a file system (p. 206).
- **State machines** – Use a state machine to orchestrate and apply error handling to your function.

The console provides separate tabs to configure aliases and versions:

- **Aliases** – An alias is a named resource that maps to a function version. You can change an alias to map to a different function version.
- **Versions** – Lambda assigns a new version number each time you publish your function. For more information about managing versions, see Lambda function versions (p. 173).

You can configure the following items for a published function version:

- Triggers
- Destinations
- Provisioned concurrency

- Asynchronous invocation
- Database proxies

# Configuring functions (API)

To configure functions with the Lambda API, use the following actions:

- UpdateFunctionCode (p. 1088) – Update the function's code.
- UpdateFunctionConfiguration (p. 1098) – Update version-specific settings.
- TagResource (p. 1067) – Tag a function.
- AddPermission (p. 881) – Modify the resource-based policy (p. 68) of a function, version, or alias.
- PutFunctionConcurrency (p. 1053) – Configure a function's reserved concurrency.
- PublishVersion (p. 1042) – Create an immutable version with the current code and configuration.
- CreateAlias (p. 886) – Create aliases for function versions.
- PutFunctionEventInvokeConfig – Configure error handling for asynchronous invocation.
- CreateFunctionUrlConfig – Create a function URL configuration.
- UpdateFunctionUrlConfig – Update an existing function URL configuration.

# Configuring function memory (console)

Lambda allocates CPU power in proportion to the amount of memory configured. *Memory* is the amount of memory available to your Lambda function at runtime. You can increase or decrease the memory and CPU power allocated to your function using the **Memory (MB)** setting. To configure the memory for your function, set a value between 128 MB and 10,240 MB in 1-MB increments. At 1,769 MB, a function has the equivalent of one vCPU (one vCPU-second of credits per second).

You can configure the memory of your function in the Lambda console.

### To update the memory of a function

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. On the function configuration page, on the **General configuration** pane, choose **Edit**.
4. For **Memory (MB)**, set a value from 128 MB to 10,240 MB.
5. Choose **Save**.

# Configuring ephemeral storage (console)

By default, Lambda allocates 512 MB for a function's /tmp directory. You can increase or decrease this amount using the **Ephemeral storage (MB)** setting. To configure the size of a function's /tmp directory, set a whole number value between 512 MB and 10,240 MB, in 1-MB increments.

> **Note**
> Configuring ephemeral storage past the default 512 MB allocated incurs a cost. For more information, see Lambda pricing.

You can configure the size of a function's /tmp directory in the Lambda console.

### To update the size of a function's /tmp directory

1. Open the Functions page of the Lambda console.

2. Choose a function.
3. On the function configuration page, on the **General configuration** pane, choose **Edit**.
4. For **Ephemeral storage (MB)**, set a value from 512 MB to 10,240 MB.
5. Choose **Save**.

# Accepting function memory recommendations (console)

If you have administrator permissions in AWS Identity and Access Management (IAM), you can opt in to receive Lambda function memory setting recommendations from AWS Compute Optimizer. For instructions on opting in to memory recommendations for your account or organization, see Opting in your account in the *AWS Compute Optimizer User Guide*.

> **Note**
> Compute Optimizer supports only functions that use x86_64 architecture.

When you've opted in and your Lambda function meets Compute Optimizer requirements, you can view and accept function memory recommendations from Compute Optimizer in the Lambda console.

**To accept a function memory recommendation**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. On the function configuration page, on the **General configuration** pane, choose **Edit**.
4. Under **Memory (MB)**, in the memory alert, choose **Update**.
5. Choose **Save**.

# Configuring triggers (console)

You can configure other AWS services to trigger your function each time a specified event occurs.

For details about how services trigger Lambda functions, see Using AWS Lambda with other services (p. 496).

**To add a trigger to your function.**

1. Open the Functions page of the Lambda console.
2. Choose the function to update.
3. Under **Function overview**, choose **Add trigger**.
4. From the drop-down list of triggers, choose a trigger. The console displays additional configuration fields required for this trigger.
5. Choose **Add**.

# Testing functions (console)

You can create test events for your function from the **Test** tab. For more information, see Testing Lambda functions in the console.

You can also invoke your function without saving your test event by choosing **Test** before saving. This creates an unsaved test event that Lambda will preserve for the duration of the session. You can access your unsaved test events from either the **Test** or **Code** tab.

# Using AWS Lambda environment variables

You can use environment variables to adjust your function's behavior without updating code. An environment variable is a pair of strings that is stored in a function's version-specific configuration. The Lambda runtime makes environment variables available to your code and sets additional environment variables that contain information about the function and invocation request.

> **Note**
> To increase database security, we recommend that you use AWS Secrets Manager instead of environment variables to store database credentials. For more information, see Configuring database access for a Lambda function.

Environment variables are not evaluated prior to the function invocation. Any value you define is considered a literal string and not expanded. Perform the variable evaluation in your function code.

**Sections**


- Configuring environment variables (p. 166)
- Configuring environment variables with the API (p. 167)
- Example scenario for environment variables (p. 167)
- Retrieve environment variables (p. 168)
- Defined runtime environment variables (p. 169)
- Securing environment variables (p. 170)
- Sample code and templates (p. 172)


## Configuring environment variables

You define environment variables on the unpublished version of your function. When you publish a version, the environment variables are locked for that version along with other version-specific configuration (p. 162).

You create an environment variable for your function by defining a key and a value. Your function uses the name of the key to retrieve the value of environment variable.

### To set environment variables in the Lambda console

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration**, then choose **Environment variables**.
4. Under **Environment variables**, choose **Edit**.
5. Choose **Add environment variable**.
6. Enter a key and value.

   **Requirements**

   - Keys start with a letter and are at least two characters.
   - Keys only contain letters, numbers, and the underscore character (_).
   - Keys aren't reserved by Lambda (p. 169).
   - The total size of all environment variables doesn't exceed 4 KB.
7. Choose **Save**.

# Configuring environment variables with the API

To manage environment variables with the AWS CLI or AWS SDK, use the following API operations.

- UpdateFunctionConfiguration (p. 1098)
- GetFunctionConfiguration (p. 967)
- CreateFunction (p. 904)

The following example sets two environment variables on a function named `my-function`.

```
aws lambda update-function-configuration --function-name my-function \
    --environment "Variables={BUCKET=my-bucket,KEY=file.txt}"
```

When you apply environment variables with the `update-function-configuration` command, the entire contents of the `Variables` structure is replaced. To retain existing environment variables when you add a new one, include all existing values in your request.

To get the current configuration, use the `get-function-configuration` command.

```
aws lambda get-function-configuration --function-name my-function
```

You should see the following output:

```
{
    "FunctionName": "my-function",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "Runtime": "nodejs16.x",
    "Role": "arn:aws:iam::123456789012:role/lambda-role",
    "Environment": {
        "Variables": {
            "BUCKET": "my-bucket",
            "KEY": "file.txt"
        }
    },
    "RevisionId": "0894d3c1-2a3d-4d48-bf7f-abade99f3c15",
    ...
}
```

To ensure that the values don't change between when you read the configuration and when you update it, you can pass the revision ID from the output of `get-function-configuration` as a parameter to `update-function-configuration`.

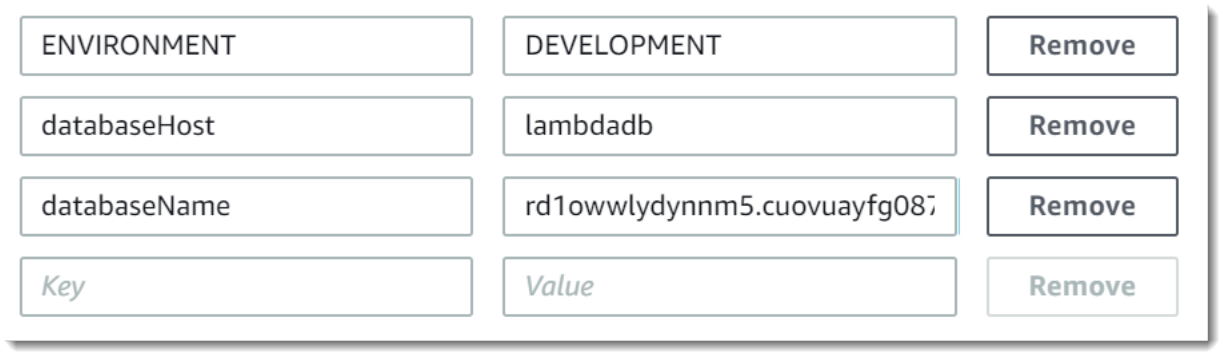
To configure a function's encryption key, set the `KMSKeyARN` option.

```
aws lambda update-function-configuration --function-name my-function \
   --kms-key-arn arn:aws:kms:us-east-2:123456789012:key/055efbb4-xmpl-4336-
ba9c-538c7d31f599
```

# Example scenario for environment variables

You can use environment variables to customize function behavior in your test environment and production environment. For example, you can create two functions with the same code but different configurations. One function connects to a test database, and the other connects to a production database. In this situation, you use environment variables to tell the function the hostname and other connection details for the database.

The following example shows how to define the database host and database name as environment variables.




If you want your test environment to generate more debug information than the production environment, you could set an environment variable to configure your test environment to use more verbose logging or more detailed tracing.

# Retrieve environment variables

To retrieve environment variables in your function code, use the standard method for your programming language.

Node.js

```
let region = process.env.AWS_REGION
```

Python

```
import os
  region = os.environ['AWS_REGION']
```

**Note**
In some cases, you may need to use the following format:

```
region = os.environ.get('AWS_REGION')
```

Ruby

```
region = ENV["AWS_REGION"]
```

Java

```
String region = System.getenv("AWS_REGION");
```

Go

```
var region = os.Getenv("AWS_REGION")
```

C#

```
string region = Environment.GetEnvironmentVariable("AWS_REGION");
```

PowerShell

```
$region = $env:AWS_REGION
```

Lambda stores environment variables securely by encrypting them at rest. You can configure Lambda to use a different encryption key (p. 170), encrypt environment variable values on the client side, or set environment variables in an AWS CloudFormation template with AWS Secrets Manager.

# Defined runtime environment variables

Lambda runtimes (p. 82) set several environment variables during initialization. Most of the environment variables provide information about the function or runtime. The keys for these environment variables are *reserved* and cannot be set in your function configuration.

### Reserved environment variables

- `_HANDLER` – The handler location configured on the function.
- `_X_AMZN_TRACE_ID` – The X-Ray tracing header (p. 715). This environment variable is not defined for custom runtimes (for example, runtimes that use the `provided` or `provided.al2` identifiers). You can set `_X_AMZN_TRACE_ID` for custom runtimes using the `Lambda-Runtime-Trace-Id` response header from the Next invocation (p. 115).
- `AWS_REGION` – The AWS Region where the Lambda function is executed.
- `AWS_EXECUTION_ENV` – The runtime identifier (p. 82), prefixed by `AWS_Lambda_` (for example, `AWS_Lambda_java8`). This environment variable is not defined for custom runtimes (for example, runtimes that use the `provided` or `provided.al2` identifiers).
- `AWS_LAMBDA_FUNCTION_NAME` – The name of the function.
- `AWS_LAMBDA_FUNCTION_MEMORY_SIZE` – The amount of memory available to the function in MB.
- `AWS_LAMBDA_FUNCTION_VERSION` – The version of the function being executed.

  `AWS_LAMBDA_INITIALIZATION_TYPE` – The initialization type of the function, which is either `on-demand` or `provisioned-concurrency`. For information, see Configuring provisioned concurrency (p. 183).
- `AWS_LAMBDA_LOG_GROUP_NAME`, `AWS_LAMBDA_LOG_STREAM_NAME` – The name of the Amazon CloudWatch Logs group and stream for the function.
- `AWS_ACCESS_KEY`, `AWS_ACCESS_KEY_ID`, `AWS_SECRET_ACCESS_KEY`, `AWS_SESSION_TOKEN` – The access keys obtained from the function's execution role (p. 52).
- `AWS_LAMBDA_RUNTIME_API` – (Custom runtime (p. 90)) The host and port of the runtime API (p. 115).
- `LAMBDA_TASK_ROOT` – The path to your Lambda function code.
- `LAMBDA_RUNTIME_DIR` – The path to runtime libraries.

The following additional environment variables aren't reserved and can be extended in your function configuration.

### Unreserved environment variables

- `LANG` – The locale of the runtime (`en_US.UTF-8`).
- `PATH` – The execution path (`/usr/local/bin:/usr/bin/:/bin:/opt/bin`).
- `LD_LIBRARY_PATH` – The system library path (`/lib64:/usr/lib64:$LAMBDA_RUNTIME_DIR:$LAMBDA_RUNTIME_DIR/lib:$LAMBDA_TASK_ROOT:$LAMBDA_TASK_ROOT/lib:/opt/lib`).
- `NODE_PATH` – (Node.js (p. 282)) The Node.js library path (`/opt/nodejs/node12/node_modules/:/opt/nodejs/node_modules:$LAMBDA_RUNTIME_DIR/node_modules`).

- `PYTHONPATH` – (Python 2.7, 3.6, 3.8 (p. 324)) The Python library path (`$LAMBDA_RUNTIME_DIR`).
- `GEM_PATH` – (Ruby (p. 354)) The Ruby library path (`$LAMBDA_TASK_ROOT/vendor/bundle/ruby/2.5.0:/opt/ruby/gems/2.5.0`).
- `AWS_XRAY_CONTEXT_MISSING` – For X-Ray tracing, Lambda sets this to `LOG_ERROR` to avoid throwing runtime errors from the X-Ray SDK.
- `AWS_XRAY_DAEMON_ADDRESS` – For X-Ray tracing, the IP address and port of the X-Ray daemon.
- `AWS_LAMBDA_DOTNET_PREJIT` – For the .NET 3.1 runtime, set this variable to enable or disable .NET 3.1 specific runtime optimizations. Values include `always`, `never`, and `provisioned-concurrency`. For information, see Configuring provisioned concurrency (p. 183).
- `TZ` – The environment's time zone (`UTC`). The execution environment uses NTP to synchronize the system clock.

The sample values shown reflect the latest runtimes. The presence of specific variables or their values can vary on earlier runtimes.

# Securing environment variables

For securing your environment variables, you can use server-side encryption to protect your data at rest and client-side encryption to protect your data in transit.

> **Note**
> To increase database security, we recommend that you use AWS Secrets Manager instead of environment variables to store database credentials. For more information, see Configuring database access for a Lambda function.

**Security at rest**

Lambda always provides server-side encryption at rest with an AWS KMS key. By default, Lambda uses an AWS managed key. If this default behavior suits your workflow, you don't need to set anything else up. Lambda creates the AWS managed key in your account and manages permissions to it for you. AWS doesn't charge you to use this key.

If you prefer, you can provide an AWS KMS customer managed key instead. You might do this to have control over rotation of the KMS key or to meet the requirements of your organization for managing KMS keys. When you use a customer managed key, only users in your account with access to the KMS key can view or manage environment variables on the function.

Customer managed keys incur standard AWS KMS charges. For more information, see AWS Key Management Service pricing, in the *AWS KMS product pages*.

**Security in transit**

For additional security, you can enable helpers for encryption in transit, which ensures that your environment variables are encrypted client-side for protection in transit.

### To configure encryption for your environment variables

1. Use the AWS Key Management Service (AWS KMS) to create any customer managed keys for Lambda to use for server-side and client-side encryption. For more information, see Creating keys in the *AWS Key Management Service Developer Guide*.
2. Using the Lambda console, navigate to the **Edit environment variables** page.
   a. Open the Functions page of the Lambda console.
   b. Choose a function.
   c. Choose **Configuration**, then choose **Environment variables** from the left navigation bar.
   d. In the **Environment variables** section, choose **Edit**.

e. Expand **Encryption configuration**.

3. Optionally, enable console encryption helpers to use client-side encryption to protect your data in transit.

   a. Under **Encryption in transit**, choose **Enable helpers for encryption in transit**.
   b. For each environment variable that you want to enable console encryption helpers for, choose **Encrypt** next to the environment variable.
   c. Under AWS KMS key to encrypt in transit, choose a customer managed key that you created at the beginning of this procedure.
   d. Choose **Execution role policy** and copy the policy. This policy grants permission to your function's execution role to decrypt the environment variables.

      Save this policy to use in the last step of this procedure.
   e. Add code to your function that decrypts the environment variables. Choose **Decrypt secrets snippet** to see an example.

4. Optionally, specify your customer managed key for encryption at rest.

   a. Choose **Use a customer master key**.
   b. Choose a customer managed key that you created at the beginning of this procedure.

5. Choose **Save**.
6. Set up permissions.

   If you're using a customer managed key with server-side encryption, grant permissions to any AWS Identity and Access Management (IAM) users or roles that you want to be able to view or manange environment variables on the function. For more information, see Managing permissions to your server-side encryption KMS key (p. 171).

   If you're enabling client-side encryption for security in transit, your function needs permission to call the `kms:Decrypt` API operation. Add the policy that you saved previously in this procedure to the function's execution role (p. 52).

## Managing permissions to your server-side encryption KMS key

No AWS KMS permissions are required for your user or the function's execution role to use the default encryption key. To use a customer managed key, you need permission to use the key. Lambda uses your permissions to create a grant on the key. This allows Lambda to use it for encryption.

- `kms:ListAliases` – To view keys in the Lambda console.
- `kms:CreateGrant`, `kms:Encrypt` – To configure a customer managed key on a function.
- `kms:Decrypt` – To view and manage environment variables that are encrypted with a customer managed key.

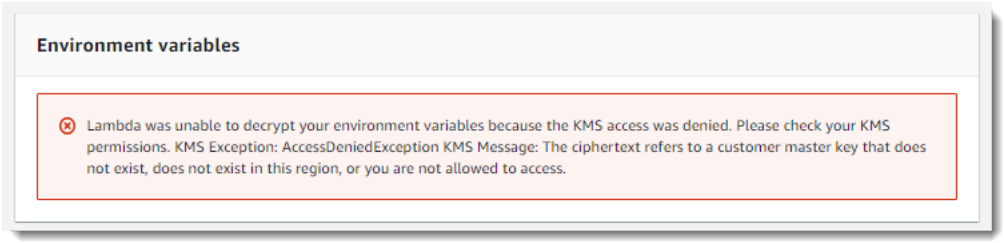
You can get these permissions from your user account or from a key's resource-based permissions policy. `ListAliases` is provided by the managed policies for Lambda (p. 59). Key policies grant the remaining permissions to users in the **Key users** group.

Users without `Decrypt` permissions can still manage functions, but they can't view environment variables or manage them in the Lambda console. To prevent a user from viewing environment variables, add a statement to the user's permissions that denies access to the default key, a customer managed key, or all keys.

### Example IAM policy – Deny access by key ARN

```
{
```

```
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "VisualEditor0",
            "Effect": "Deny",
            "Action": [
                "kms:Decrypt"
            ],
            "Resource": "arn:aws:kms:us-east-2:123456789012:key/3be10e2d-xmpl-4be4-
bc9d-0405a71945cc"
        }
    ]
}
```




For details on managing key permissions, see Using key policies in AWS KMS in the AWS Key Management Service Developer Guide.

# Sample code and templates

Sample applications in this guide's GitHub repository demonstrate the use of environment variables in function code and AWS CloudFormation templates.

### Sample applications

- Blank function (p. 802) – Create a basic function that shows the use of logging, environment variables, AWS X-Ray tracing, layers, unit tests, and the AWS SDK.
- RDS MySQL – Create a VPC and an Amazon RDS DB instance in one template, with a password stored in Secrets Manager. In the application template, import database details from the VPC stack, read the password from Secrets Manager, and pass all connection configuration to the function in environment variables.

# Lambda function versions

You can use versions to manage the deployment of your functions. For example, you can publish a new version of a function for beta testing without affecting users of the stable production version. Lambda creates a new version of your function each time that you publish the function. The new version is a copy of the unpublished version of the function.

> **Note**
> Lambda doesn't create a new version if the code in the unpublished version is the same as the previous published version. You need to deploy code changes in $LATEST before you can create a new version.

A function version includes the following information:

- The function code and all associated dependencies.
- The Lambda runtime that invokes the function.
- All the function settings, including the environment variables.
- A unique Amazon Resource Name (ARN) to identify the specific version of the function.

**Sections**

- Creating function versions (p. 173)
- Managing versions with the Lambda API (p. 173)
- Using versions (p. 174)
- Granting permissions (p. 174)

## Creating function versions

You can change the function code and settings only on the unpublished version of a function. When you publish a version, Lambda locks the code and most of the settings to maintain a consistent experience for users of that version. For more information about configuring function settings, see Configuring Lambda function options (p. 162).

You can create a function version using the Lambda console.

**To create a new function version**

1. Open the Functions page of the Lambda console.
2. Choose a function and then choose **Versions**.
3. On the versions configuration page, choose **Publish new version**.
4. (Optional) Enter a version description.
5. Choose **Publish**.

## Managing versions with the Lambda API

To publish a version of a function, use the PublishVersion (p. 1042) API operation.

The following example publishes a new version of a function. The response returns configuration information about the new version, including the version number and the function ARN with the version suffix.

```
aws lambda publish-version --function-name my-function
```

You should see the following output:

```
{
  "FunctionName": "my-function",
  "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function:1",
  "Version": "1",
  "Role": "arn:aws:iam::123456789012:role/lambda-role",
  "Handler": "function.handler",
  "Runtime": "nodejs16.x",
  ...
}
```

# Using versions

You can reference your Lambda function using either a qualified ARN or an unqualified ARN.

- **Qualified ARN** – The function ARN with a version suffix. The following example refers to version 42 of the `helloworld` function.

```
arn:aws:lambda:aws-region:acct-id:function:helloworld:42
```

- **Unqualified ARN** – The function ARN without a version suffix.

```
arn:aws:lambda:aws-region:acct-id:function:helloworld
```

You can use a qualified or an unqualified ARN in all relevant API operations. However, you can't use an unqualified ARN to create an alias.

If you decide not to publish function versions, you can invoke the function using either the qualified or unqualified ARN in your event source mapping (p. 236). When you invoke a function using an unqualified ARN, Lambda implicitly invokes $LATEST.

Lambda publishes a new function version only if the code has never been published or if the code has changed from the last published version. If there is no change, the function version remains at the last published version.

The qualified ARN for each Lambda function version is unique. After you publish a version, you can't change the ARN or the function code.

# Granting permissions

You can use a resource-based policy (p. 68) or an identity-based policy (p. 59) to grant access to your function. The scope of the permission depends on whether you apply the policy to a function or to one version of a function. For more information about function resource names in policies, see Resources and conditions for Lambda actions (p. 74).

You can simplify the management of event sources and AWS Identity and Access Management (IAM) policies by using function aliases. For more information, see Lambda function aliases (p. 175).

# Lambda function aliases

You can create one or more aliases for your Lambda function. A Lambda alias is like a pointer to a specific function version. Users can access the function version using the alias Amazon Resource Name (ARN).

**Sections**


- Creating a function alias (Console) (p. 175)
- Managing aliases with the Lambda API (p. 175)
- Using aliases (p. 176)
- Resource policies (p. 176)
- Alias routing configuration (p. 176)


## Creating a function alias (Console)

You can create a function alias using the Lambda console.

**To create an alias**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Aliases** and then choose **Create alias**.
4. On the **Create alias** page, do the following:
   a. Enter a **Name** for the alias.
   b. (Optional) Enter a **Description** for the alias.
   c. For **Version**, choose a function version that you want the alias to point to.
   d. (Optional) To configure routing on the alias, expand **Weighted alias**. For more information, see Alias routing configuration (p. 176).
   e. Choose **Save**.

## Managing aliases with the Lambda API

To create an alias using the AWS Command Line Interface (AWS CLI), use the `create-alias` command.

```
aws lambda create-alias --function-name my-function --name alias-name --function-
version version-number --description " "
```

To change an alias to point a new version of the function, use the `update-alias` command.

```
aws lambda update-alias --function-name my-function --name alias-name --function-
version version-number
```

To delete an alias, use the `delete-alias` command.

```
aws lambda delete-alias --function-name my-function --name alias-name
```

The AWS CLI commands in the preceding steps correspond to the following Lambda API operations:

- CreateAlias (p. 886)

- UpdateAlias (p. 1071)
- DeleteAlias (p. 921)

# Using aliases

Each alias has a unique ARN. An alias can point only to a function version, not to another alias. You can update an alias to point to a new version of the function.

Event sources such as Amazon Simple Storage Service (Amazon S3) invoke your Lambda function. These event sources maintain a mapping that identifies the function to invoke when events occur. If you specify a Lambda function alias in the mapping configuration, you don't need to update the mapping when the function version changes. For more information, see Lambda event source mappings (p. 236).

In a resource policy, you can grant permissions for event sources to use your Lambda function. If you specify an alias ARN in the policy, you don't need to update the policy when the function version changes.

# Resource policies

You can use a resource-based policy (p. 68) to give a service, resource, or account access to your function. The scope of that permission depends on whether you apply it to an alias, a version, or the entire function. For example, if you use an alias name (such as `helloworld:PROD`), the permission allows you to invoke the `helloworld` function using the alias ARN (`helloworld:PROD`).

If you attempt to invoke the function without an alias or a specific version, then you get a permission error. This permission error still occurs even if you attempt to directly invoke the function version associated with the alias.

For example, the following AWS CLI command grants Amazon S3 permissions to invoke the PROD alias of the `helloworld` function when Amazon S3 is acting on behalf of `examplebucket`.

```
aws lambda add-permission --function-name helloworld \
--qualifier PROD --statement-id 1 --principal s3.amazonaws.com --action
 lambda:InvokeFunction \
--source-arn arn:aws:s3:::examplebucket --source-account 123456789012
```

For more information about using resource names in policies, see Resources and conditions for Lambda actions (p. 74).

# Alias routing configuration

Use routing configuration on an alias to send a portion of traffic to a second function version. For example, you can reduce the risk of deploying a new version by configuring the alias to send most of the traffic to the existing version, and only a small percentage of traffic to the new version.

Note that Lambda uses a simple probabilistic model to distribute the traffic between the two function versions. At low traffic levels, you might see a high variance between the configured and actual percentage of traffic on each version. If your function uses provisioned concurrency, you can avoid spillover invocations (p. 728) by configuring a higher number of provisioned concurrency instances during the time that alias routing is active.

You can point an alias to a maximum of two Lambda function versions. The versions must meet the following criteria:

- Both versions must have the same execution role (p. 52).

- Both versions must have the same dead-letter queue (p. 234) configuration, or no dead-letter queue configuration.
- Both versions must be published. The alias cannot point to `$LATEST`.

**To configure routing on an alias**

> **Note**
> Verify that the function has at least two published versions. To create additional versions, follow the instructions in Lambda function versions (p. 173).

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Aliases** and then choose **Create alias**.
4. On the **Create alias** page, do the following:
   a. Enter a **Name** for the alias.
   b. (Optional) Enter a **Description** for the alias.
   c. For **Version**, choose the first function version that you want the alias to point to.
   d. Expand **Weighted alias**.
   e. For **Additional version**, choose the second function version that you want the alias to point to.
   f. For **Weight (%)**, enter a weight value for the function. *Weight* is the percentage of traffic that is assigned to that version when the alias is invoked. The first version receives the residual weight. For example, if you specify 10 percent to **Additional version**, the first version is assigned 90 percent automatically.
   g. Choose **Save**.

## Configuring alias routing using CLI

Use the `create-alias` and `update-alias` AWS CLI commands to configure the traffic weights between two function versions. When you create or update the alias, you specify the traffic weight in the `routing-config` parameter.

The following example creates a Lambda function alias named **routing-alias** that points to version 1 of the function. Version 2 of the function receives 3 percent of the traffic. The remaining 97 percent of traffic is routed to version 1.

```
aws lambda create-alias --name routing-alias --function-name my-function --function-version
 1  \
--routing-config AdditionalVersionWeights={"2"=0.03}
```

Use the `update-alias` command to increase the percentage of incoming traffic to version 2. In the following example, you increase the traffic to 5 percent.

```
aws lambda update-alias --name routing-alias --function-name my-function  \
--routing-config AdditionalVersionWeights={"2"=0.05}
```

To route all traffic to version 2, use the `update-alias` command to change the `function-version` property to point the alias to version 2. The command also resets the routing configuration.

```
aws lambda update-alias --name routing-alias --function-name my-function  \
--function-version 2 --routing-config AdditionalVersionWeights={}
```

The AWS CLI commands in the preceding steps correspond to the following Lambda API operations:

- CreateAlias (p. 886)
- UpdateAlias (p. 1071)

## Determining which version has been invoked

When you configure traffic weights between two function versions, there are two ways to determine the Lambda function version that has been invoked:

- **CloudWatch Logs** – Lambda automatically emits a `START` log entry that contains the invoked version ID to Amazon CloudWatch Logs for every function invocation. The following is an example:

  ```
  19:44:37 START RequestId: request id Version: $version
  ```

  For alias invocations, Lambda uses the `Executed Version` dimension to filter the metric data by the invoked version. For more information, see Working with Lambda function metrics (p. 727).
- **Response payload (synchronous invocations)** – Responses to synchronous function invocations include an `x-amz-executed-version` header to indicate which function version has been invoked.

# Managing AWS Lambda functions

*Configuring functions* (p. 155) describes the how to configure the core capabilities and options for a function. Lambda also provides advanced features such as concurrency control, network access, database interworking, file systems, and code signing.

Concurrency (p. 180) is the number of instances of your function that are active. Lambda provides two types of concurrency controls: reserved concurrency and provisioned concurrency.

To use your Lambda function with AWS resources in an Amazon VPC, configure it with security groups and subnets to create a VPC connection (p. 191). Connecting your function to a VPC lets you access resources in a private subnet such as relational databases and caches. You can also create a database proxy (p. 201) for MySQL and Aurora DB instances. A database proxy enables a function to reach high concurrency levels without exhausting database connections.

To use code signing (p. 211) with your Lambda function, configure it with a code-signing configuration. When a user attempts to deploy a code package, Lambda checks that the code package has a valid signature from a trusted publisher. The code-signing configuration includes a set of signing profiles, which define the trusted publishers for this function.

# Managing Lambda reserved concurrency

There are two types of concurrency controls available:

- Reserved concurrency – Reserved concurrency guarantees the maximum number of concurrent instances for the function. When a function has reserved concurrency, no other function can use that concurrency. There is no charge for configuring reserved concurrency for a function.
- Provisioned concurrency – Provisioned concurrency initializes a requested number of execution environments so that they are prepared to respond immediately to your function's invocations. Note that configuring provisioned concurrency incurs charges to your AWS account.

This topic details how to manage and configure reserved concurrency. If you want to decrease latency for your functions, use provisioned concurrency (p. 183).

Concurrency is the number of requests that your function is serving at any given time. When your function is invoked, Lambda allocates an instance of it to process the event. When the function code finishes running, it can handle another request. If the function is invoked again while a request is still being processed, another instance is allocated, which increases the function's concurrency. The total concurrency for all of the functions in your account is subject to a per-region quota.

To learn about how concurrency interacts with scaling, see Lambda function scaling.

**Sections**

- Configuring reserved concurrency (p. 180)
- Configuring concurrency with the Lambda API (p. 182)

## Configuring reserved concurrency

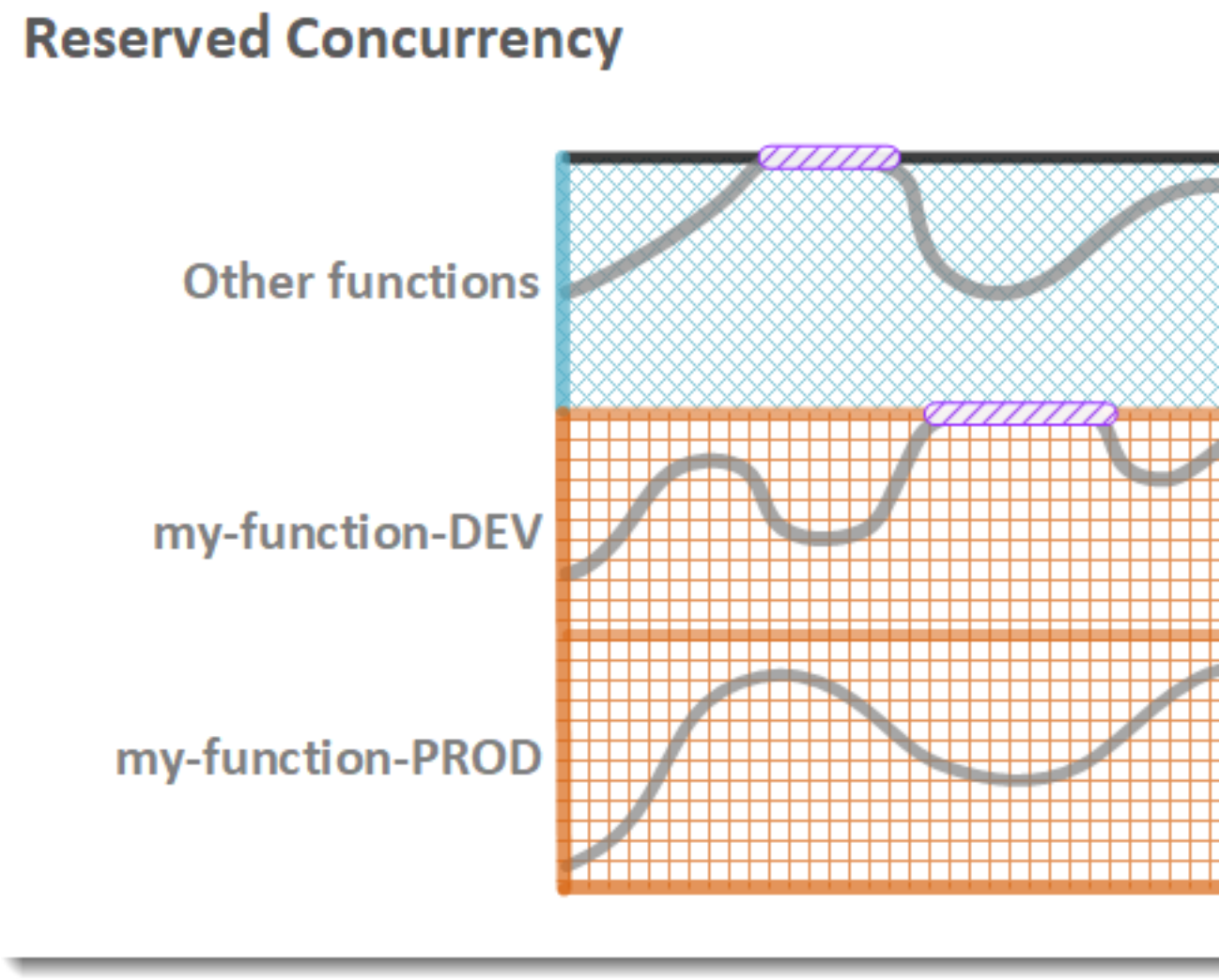
To manage reserved concurrency settings for a function, use the Lambda console.

**To reserve concurrency for a function**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **Concurrency**.
4. Under **Concurrency**, choose **Edit**.
5. Choose **Reserve concurrency**. Enter the amount of concurrency to reserve for the function.
6. Choose **Save**.

You can reserve up to the **Unreserved account concurrency** value that is shown, minus 100 for functions that don't have reserved concurrency. To throttle a function, set the reserved concurrency to zero. This stops any events from being processed until you remove the limit.

The following example shows two functions with pools of reserved concurrency, and the unreserved concurrency pool used by other functions. Throttling errors occur when all of the concurrency in a pool is in use.




**Legend**

- Function concurrency
- Reserved concurrency
- Unreserved concurrency
- Throttling

Reserving concurrency has the following effects.

- **Other functions can't prevent your function from scaling** – All of your account's functions in the same Region without reserved concurrency share the pool of unreserved concurrency. Without reserved concurrency, other functions can use up all of the available concurrency. This prevents your function from scaling up when needed.
- **Your function can't scale out of control** – Reserved concurrency also limits your function from using concurrency from the unreserved pool, which caps its maximum concurrency. You can reserve

concurrency to prevent your function from using all the available concurrency in the Region, or from overloading downstream resources.

Setting per-function concurrency can impact the concurrency pool that is available to other functions. To avoid issues, limit the number of users who can use the `PutFunctionConcurrency` and `DeleteFunctionConcurrency` API operations.

# Configuring concurrency with the Lambda API

To manage concurrency settings the AWS CLI or AWS SDK, use the following API operations.

- PutFunctionConcurrency (p. 1053)
- GetFunctionConcurrency
- DeleteFunctionConcurrency (p. 935)
- GetAccountSettings (p. 945)

To configure reserved concurrency with the AWS CLI, use the `put-function-concurrency` command. The following command reserves a concurrency of 100 for a function named `my-function`:

```
aws lambda put-function-concurrency --function-name my-function --reserved-concurrent-executions 100
```

You should see the following output:

```
{
    "ReservedConcurrentExecutions": 100
}
```

# Managing Lambda provisioned concurrency

There are two types of concurrency controls available:

- Reserved concurrency – Reserved concurrency guarantees the maximum number of concurrent instances for the function. When a function has reserved concurrency, no other function can use that concurrency. There is no charge for configuring reserved concurrency for a function.
- Provisioned concurrency – Provisioned concurrency initializes a requested number of execution environments so that they are prepared to respond immediately to your function's invocations. Note that configuring provisioned concurrency incurs charges to your AWS account.

This topic details how to manage and configure provisioned concurrency. If you want to configure reserved concurrency, see Managing Lambda reserved concurrency (p. 180).

When Lambda allocates an instance of your function, the runtime loads your function's code and runs initialization code that you define outside of the handler. If your code and dependencies are large, or you create SDK clients during initialization, this process can take some time. When your function has not been used for some time, needs to scale up, or when you update a function, Lambda creates new execution environments. This causes the portion of requests that are served by new instances to have higher latency than the rest, otherwise known as a cold start.

By allocating provisioned concurrency before an increase in invocations, you can ensure that all requests are served by initialized instances with low latency. Lambda functions configured with provisioned concurrency run with consistent start-up latency, making them ideal for building interactive mobile or web backends, latency sensitive microservices, and synchronously invoked APIs.

> **Note**
> Provisioned concurrency counts towards a function's reserved concurrency and Regional quotas (p. 796). If the amount of provisioned concurrency on a function's versions and aliases adds up to the function's reserved concurrency, all invocations run on provisioned concurrency. This configuration also has the effect of throttling the unpublished version of the function ($LATEST), which prevents it from executing. You can't allocate more provisioned concurrency than reserved concurrency for a function.

Lambda also integrates with Application Auto Scaling, allowing you to manage provisioned concurrency on a schedule or based on utilization.

**Sections**

- Configuring provisioned concurrency (p. 183)
- Optimizing latency with provisioned concurrency (p. 185)
- Managing provisioned concurrency with Application Auto Scaling (p. 187)

## Configuring provisioned concurrency

To manage provisioned concurrency settings for a version or alias, use the Lambda console. You can configure provisioned concurrency on a version of a function, or on an alias.

Each version of a function can only have one provisioned concurrency configuration. This can be directly on the version itself, or on an alias that points to the version. Two aliases can't allocate provisioned concurrency for the same version.

If you change the version that an alias points to, Lambda deallocates the provisioned concurrency from the old version and allocates it to the new version. You can add a routing configuration to an alias that

has provisioned concurrency. For more information, see Lambda function aliases (p. 175). Note that you can't manage provisioned concurrency settings on the alias while the routing configuration is in place.

> **Note**
> Provisioned Concurrency is not supported on the unpublished version of the function ($LATEST). Ensure your client application is not pointing to $LATEST before configuring provisioned concurrency.

### To allocate provisioned concurrency for an alias or version

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **Concurrency**.
4. Under **Provisioned concurrency configurations**, choose **Add configuration**.
5. Choose an alias or version.
6. Enter the amount of provisioned concurrency to allocate.
7. Choose **Save**.

You can also configure provisioned concurrency using the Lambda API with the following operations:

- PutProvisionedConcurrencyConfig
- GetProvisionedConcurrencyConfig
- ListProvisionedConcurrencyConfigs
- DeleteProvisionedConcurrencyConfig

To allocate provisioned concurrency for a function, use `put-provisioned-concurrency-config`. The following command allocates a concurrency of 100 for the `BLUE` alias of a function named `my-function`:

```
aws lambda put-provisioned-concurrency-config --function-name my-function \
--qualifier BLUE --provisioned-concurrent-executions 100
```

You should see the following output:

```
{
    "Requested ProvisionedConcurrentExecutions": 100,
    "Allocated ProvisionedConcurrentExecutions": 0,
    "Status": "IN_PROGRESS",
    "LastModified": "2019-11-21T19:32:12+0000"
}
```

To view your account's concurrency quotas in a Region, use `get-account-settings`.

```
aws lambda get-account-settings
```

You should see the following output:

```
{
    "AccountLimit": {
        "TotalCodeSize": 80530636800,
        "CodeSizeUnzipped": 262144000,
```

```
        "CodeSizeZipped": 52428800,
        "ConcurrentExecutions": 1000,
        "UnreservedConcurrentExecutions": 900
    },
    "AccountUsage": {
        "TotalCodeSize": 174913095,
        "FunctionCount": 52
    }
}
```

You can manage provisioned concurrency for all aliases and versions from the function configuration page. The list of provisioned concurrency configurations shows the allocation progress of each configuration. Provisioned concurrency settings are also available on the configuration page for each version and alias.

Lambda emits the following metrics for provisioned concurrency:

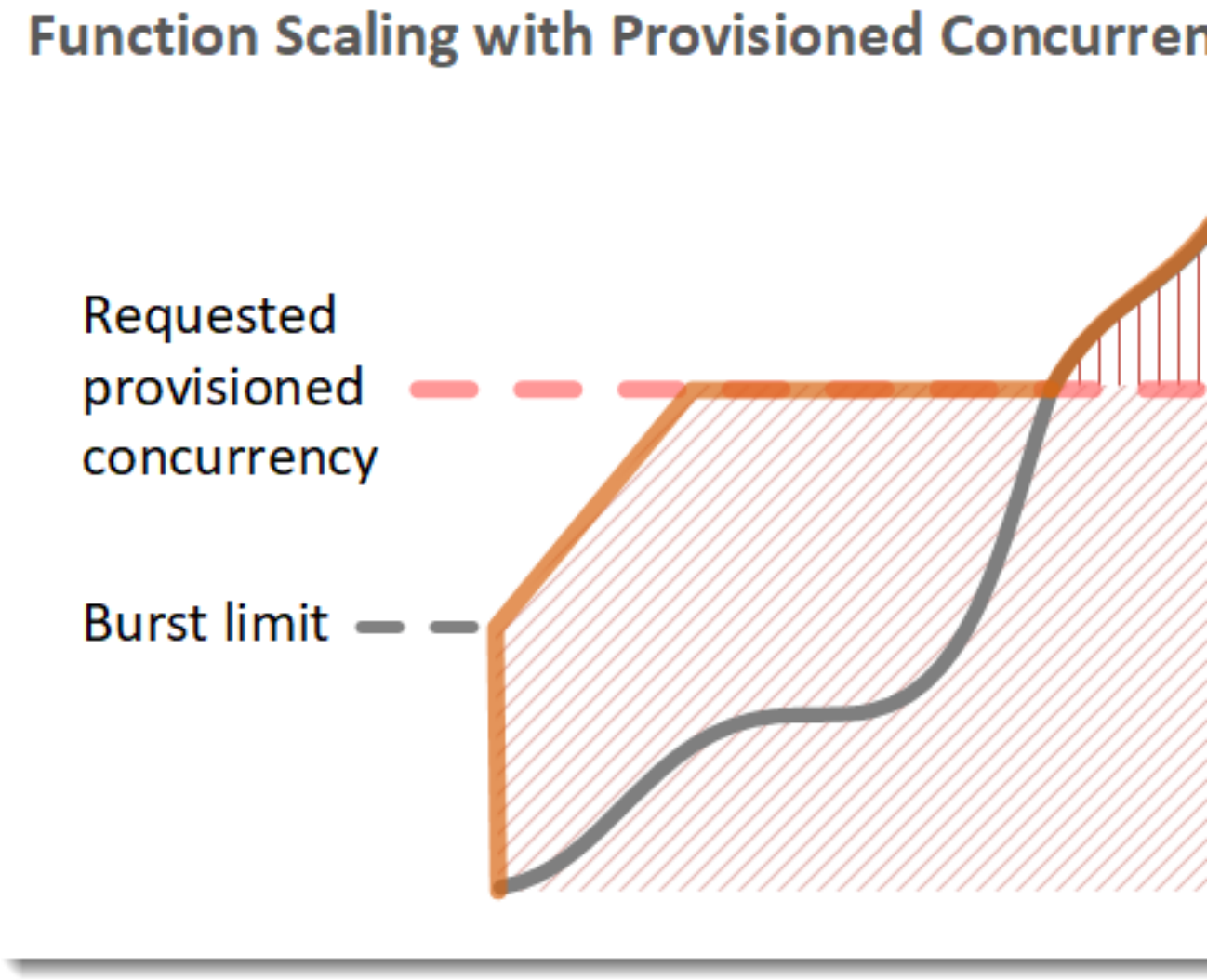
### Provisioned concurrency metrics

- `ProvisionedConcurrentExecutions` – The number of function instances that are processing events on provisioned concurrency. For each invocation of an alias or version with provisioned concurrency, Lambda emits the current count.
- `ProvisionedConcurrencyInvocations` – The number of times your function code is executed on provisioned concurrency.
- `ProvisionedConcurrencySpilloverInvocations` – The number of times your function code is executed on standard concurrency when all provisioned concurrency is in use.
- `ProvisionedConcurrencyUtilization` – For a version or alias, the value of `ProvisionedConcurrentExecutions` divided by the total amount of provisioned concurrency allocated. For example, .5 indicates that 50 percent of allocated provisioned concurrency is in use.

For more details, see Working with Lambda function metrics (p. 727).

# Optimizing latency with provisioned concurrency

Provisioned concurrency does not come online immediately after you configure it. Lambda starts allocating provisioned concurrency after a minute or two of preparation. Similar to how functions scale under load (p. 30), up to 3000 instances of the function can be initialized at once, depending on the Region. After the initial burst, instances are allocated at a steady rate of 500 per minute until the request is fulfilled. When you request provisioned concurrency for multiple functions or versions of a function in the same Region, scaling quotas apply across all requests.




**Legend**

- Function instances
- Open requests
- Provisioned concurrency
- Standard concurrency

To optimize latency, you can customize the initialization behavior for functions that use provisioned concurrency . You can run initialization code for provisioned concurrency instances without impacting latency, because the initialization code runs at allocation time. However, the initialization code for an on-demand instance directly impacts the latency of the first invocation. For an on-demand instance, you may choose to defer initialization for a specific capability until the function needs that capability.

To determine the type of initialization, check the value of AWS_LAMBDA_INITIALIZATION_TYPE. Lambda sets this environment variable to `provisioned-concurrency` or `on-demand`. The value

of AWS_LAMBDA_INITIALIZATION_TYPE is immutable and does not change over the lifetime of the execution environment.

If you use the .NET 3.1 runtime, you can configure the AWS_LAMBDA_DOTNET_PREJIT environment variable to improve the latency for functions that use provisioned concurrency. The .NET runtime lazily compiles and initializes each library that your code calls for the first time. As a result, the first invocation of a Lambda function can take longer than subsequent invocations. When you set AWS_LAMBDA_DOTNET_PREJIT to `ProvisionedConcurrency`, Lambda performs ahead-of-time JIT compilation for common system dependencies. Lambda performs this initialization optimization for provisioned concurrency instances only, which results in faster performance for the first invocation. If you set the environment variable to `Always`, Lambda performs ahead-of-time JIT compilation for every initialization. If you set the environment variable to `Never`, ahead-of-time JIT compilation is disabled. The default value for AWS_LAMBDA_DOTNET_PREJIT is `ProvisionedConcurrency`.

For provisioned concurrency instances, your function's initialization code (p. 22) runs during allocation and every few hours, as running instances of your function are recycled. You can see the initialization time in logs and traces (p. 715) after an instance processes a request. However, initialization is billed even if the instance never processes a request. Provisioned concurrency runs continually and is billed separately from initialization and invocation costs. For details, see AWS Lambda pricing.

For more information on optimizing functions using provisioned concurrency, see the Lambda Operator Guide.

# Managing provisioned concurrency with Application Auto Scaling

Application Auto Scaling allows you to manage provisioned concurrency on a schedule or based on utilization. Use a target tracking scaling policy if want your function to maintain a specified utilization percentage, and scheduled scaling to increase provisioned concurrency in anticipation of peak traffic.

## Target tracking

With target tracking, Application Auto Scaling creates and manages the CloudWatch alarms that trigger a scaling policy and calculates the scaling adjustment based on a metric and target value that you define. This is ideal for applications that don't have a scheduled time of increased traffic, but have certain traffic patterns.

To increase provisioned concurrency automatically as needed, use the `RegisterScalableTarget` and `PutScalingPolicy` Application Auto Scaling API operations to register a target and create a scaling policy:

1. Register a function's alias as a scaling target. The following example registers the BLUE alias of a function named `my-function`:

```
aws application-autoscaling register-scalable-target --service-namespace lambda \
                        --resource-id function:my-function:BLUE --min-capacity 1 --max-
capacity 100 \
                        --scalable-dimension lambda:function:ProvisionedConcurrency
```

2. Apply a scaling policy to the target. The following example configures Application Auto Scaling to adjust the provisioned concurrency configuration for an alias to keep utilization near 70 percent.

```
aws application-autoscaling put-scaling-policy --service-namespace lambda \
                        --scalable-dimension lambda:function:ProvisionedConcurrency --
resource-id function:my-function:BLUE \
                        --policy-name my-policy --policy-type TargetTrackingScaling \
```

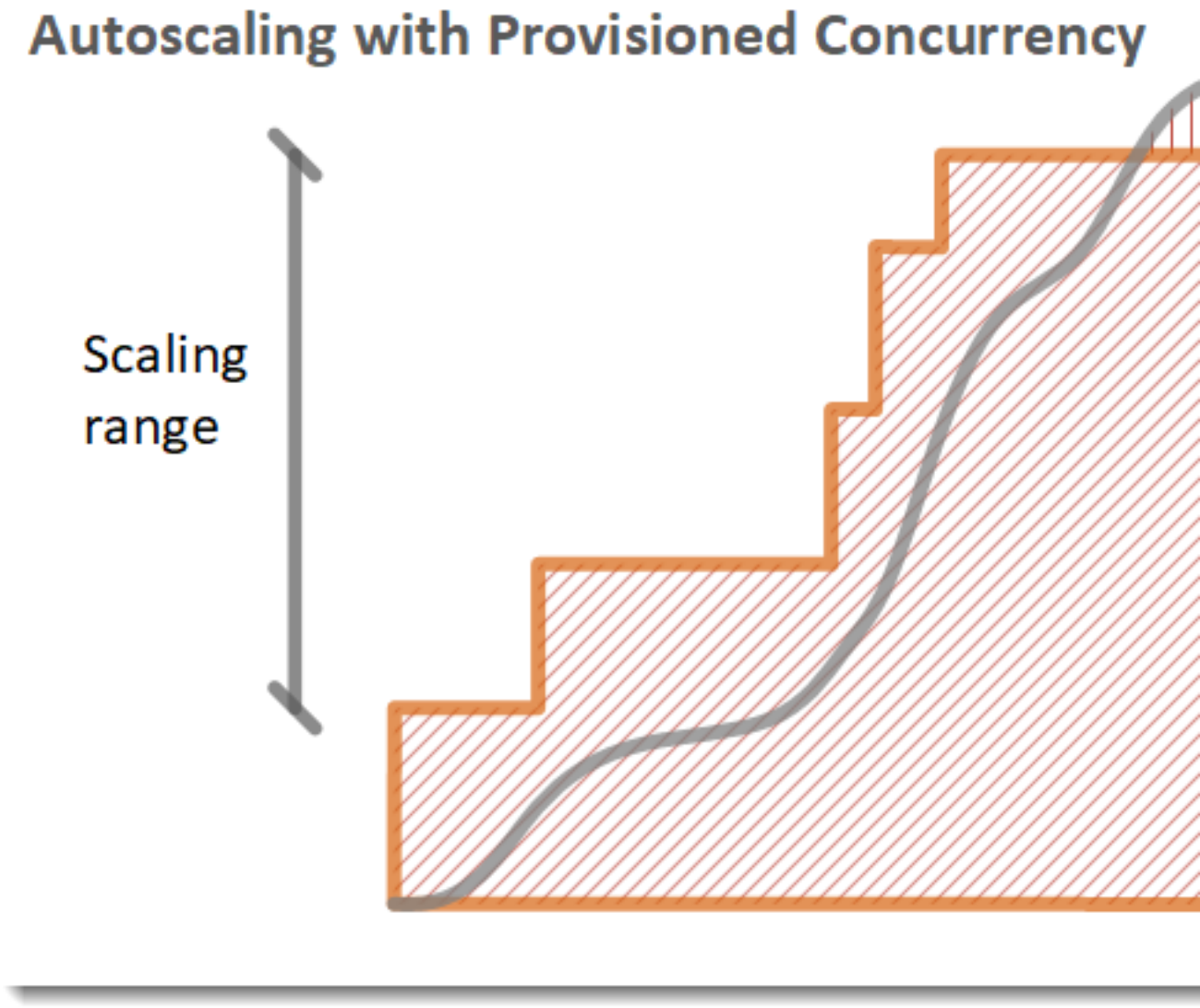
```
                        --target-tracking-scaling-policy-configuration
 '{ "TargetValue": 0.7, "PredefinedMetricSpecification": { "PredefinedMetricType":
 "LambdaProvisionedConcurrencyUtilization" }}'
```

You should see the following output:

```
{
    "PolicyARN": "arn:aws:autoscaling:us-
east-2:123456789012:scalingPolicy:12266dbb-1524-xmpl-a64e-9a0a34b996fa:resource/lambda/
function:my-function:BLUE:policyName/my-policy",
    "Alarms": [
        {
            "AlarmName": "TargetTracking-function:my-function:BLUE-AlarmHigh-aed0e274-
xmpl-40fe-8cba-2e78f000c0a7",
            "AlarmARN": "arn:aws:cloudwatch:us-
east-2:123456789012:alarm:TargetTracking-function:my-function:BLUE-AlarmHigh-aed0e274-
xmpl-40fe-8cba-2e78f000c0a7"
        },
        {
            "AlarmName": "TargetTracking-function:my-function:BLUE-AlarmLow-7e1a928e-
xmpl-4d2b-8c01-782321bc6f66",
            "AlarmARN": "arn:aws:cloudwatch:us-
east-2:123456789012:alarm:TargetTracking-function:my-function:BLUE-AlarmLow-7e1a928e-
xmpl-4d2b-8c01-782321bc6f66"
        }
    ]
}
```

Application Auto Scaling creates two alarms in CloudWatch. The first alarm triggers when the utilization of provisioned concurrency consistently exceeds 70 percent. When this happens, Application Auto Scaling allocates more provisioned concurrency to reduce utilization. The second alarm triggers when utilization is consistently less than 63 percent (90 percent of the 70 percent target). When this happens, Application Auto Scaling reduces the alias's provisioned concurrency.

In the following example, a function scales between a minimum and maximum amount of provisioned concurrency based on utilization. When the number of open requests increases, Application Auto Scaling increases provisioned concurrency in large steps until it reaches the configured maximum. The function continues to scale on standard concurrency until utilization starts to drop. When utilization is consistently low, Application Auto Scaling decreases provisioned concurrency in smaller periodic steps.




**Legend**

- Function instances
- Open requests
- Provisioned concurrency
- Standard concurrency

Both of these alarms use the *average* statistic by default. Functions that have traffic patterns of quick bursts may not trigger your provisioned concurrency to scale up. For example, if your Lambda function executes quickly (20–100 ms) and your traffic pattern comes in quick bursts, this may cause incoming requests to exceed your allocated provisioned concurrency during the burst, but if the burst doesn't last 3 minutes, auto scaling will not trigger. Additionally, if CloudWatch doesn't get three data points that hit the target average, the auto scaling policy will not trigger.

For more information on target tracking scaling policies, see Target tracking scaling policies for Application Auto Scaling.

## Scheduled scaling

Scaling based on a schedule allows you to set your own scaling schedule according to predictable load changes. For more information and examples, see Scheduling AWS Lambda Provisioned Concurrency for recurring peak usage.

# Configuring a Lambda function to access resources in a VPC

You can configure a Lambda function to connect to private subnets in a virtual private cloud (VPC) in your AWS account. Use Amazon Virtual Private Cloud (Amazon VPC) to create a private network for resources such as databases, cache instances, or internal services. Connect your function to the VPC to access private resources while the function is running.

When you connect a function to a VPC, Lambda assigns your function to a Hyperplane ENI (elastic network interface) for each subnet in your function's VPC configuration. Lambda creates a Hyperplane ENI the first time a unique subnet and security group combination is defined for a VPC-enabled function in an account.

While Lambda creates a Hyperplane ENI, you can't perform additional operations that target the function, such as creating versions (p. 173) or updating the function's code. For new functions, you can't invoke the function until its state changes from `Pending` to `Active`. For existing functions, you can still invoke an earlier version while the update is in progress. For details about the Hyperplane ENI lifecycle, see the section called “Lambda Hyperplane ENIs” (p. 27).

Lambda functions can't connect directly to a VPC with dedicated instance tenancy. To connect to resources in a dedicated VPC, peer it to a second VPC with default tenancy.

**Sections**

- Managing VPC connections (p. 191)
- Execution role and user permissions (p. 192)
- Configuring VPC access (console) (p. 192)
- Configuring VPC access (API) (p. 193)
- Using IAM condition keys for VPC settings (p. 194)
- Internet and service access for VPC-connected functions (p. 197)
- VPC tutorials (p. 197)
- Sample VPC configurations (p. 197)

## Managing VPC connections

This section provides a summary of Lambda VPC connections. For details about VPC networking in Lambda, see the section called “Networking” (p. 26).

Multiple functions can share a network interface, if the functions share the same subnet and security group. Connecting additional functions to the same VPC configuration (subnet and security group) that has an existing Lambda-managed network interface is much quicker than creating a new network interface.

If your functions aren't active for a long period of time, Lambda reclaims its network interfaces, and the functions become `Idle`. To reactivate an idle function, invoke it. This invocation fails, and the function enters a `Pending` state again until a network interface is available.

If you update your function to access a different VPC, it terminates connectivity from the Hyperplane ENI to the previous VPC. The process to update the connectivity to a new VPC can take several minutes. During this time, Lambda connects function invocations to the previous VPC. After the update is complete, new invocations start using the the new VPC and the Lambda function is no longer connected to the older VPC.

For short-lived operations, such as DynamoDB queries, the latency overhead of setting up a TCP connection might be greater than the operation itself. To ensure connection reuse for short-lived/infrequently invoked functions, we recommend that you use *TCP keep-alive* for connections that were created during your function initialization, to avoid creating new connections for subsequent invokes. For more information on reusing connections using keep-alive, refer to Lambda documentation on reusing connections.

# Execution role and user permissions

Lambda uses your function's permissions to create and manage network interfaces. To connect to a VPC, your function's execution role (p. 52) must have the following permissions:

### Execution role permissions

- **ec2:CreateNetworkInterface**
- **ec2:DescribeNetworkInterfaces** – This action only works if it's allowed on all resources (`"Resource": "*"`).
- **ec2:DeleteNetworkInterface** – If you don't specify a resource ID for **DeleteNetworkInterface** in the execution role, your function may not be able to access the VPC. Either specify a unique resource ID, or include all resource IDs, for example, `"Resource": "arn:aws:ec2:us-west-2:123456789012:*/*"`.

These permissions are included in the AWS managed policy **AWSLambdaVPCAccessExecutionRole**. Note that these permissions are required only to create ENIs, not to invoke your VPC function. In other words, you are still able to invoke your VPC function successfully even if you remove these permissions from your execution role. To completely disassociate your Lambda function from the VPC, update the function's VPC configuration settings using the console or the UpdateFunctionConfiguration (p. 1098) API.

When you configure VPC connectivity, Lambda uses your permissions to verify network resources. To configure a function to connect to a VPC, your AWS Identity and Access Management (IAM) user needs the following permissions:

### User permissions

- **ec2:DescribeSecurityGroups**
- **ec2:DescribeSubnets**
- **ec2:DescribeVpcs**

# Configuring VPC access (console)

If your IAM permissions (p. 194) allow you only to create Lambda functions that connect to your VPC, you must configure the VPC when you create the function. If your IAM permissions allow you to create functions that aren't connected to your VPC, you can add the VPC configuration after you create the function.

### To configure a VPC when you create a function

1. Open the Functions page of the Lambda console.
2. Choose **Create function**.
3. Under **Basic information**, for **Function name**, enter a name for your function.
4. Expand **Advanced settings**.

5. Under **Network**, choose a **VPC** for your function to access.
6. Choose subnets and security groups. When you choose a security group, the console displays the inbound and outbound rules for that security group.

   **Note**
   To access private resources, connect your function to private subnets. If your function needs internet access, use network address translation (NAT) (p. 197). Connecting a function to a public subnet doesn't give it internet access or a public IP address.
7. Choose **Create function**.

### To configure a VPC for an existing function

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **VPC**.
4. Under **VPC**, choose **Edit**.
5. Choose a VPC, subnets, and security groups.

   **Note**
   To access private resources, connect your function to private subnets. If your function needs internet access, use network address translation (NAT) (p. 197). Connecting a function to a public subnet doesn't give it internet access or a public IP address.
6. Choose **Save**.

# Configuring VPC access (API)

To connect a Lambda function to a VPC, you can use the following API operations:

- CreateFunction (p. 904)
- UpdateFunctionConfiguration (p. 1098)

To create a function and connect it to a VPC using the AWS Command Line Interface (AWS CLI), you can use the `create-function` command with the `vpc-config` option. The following example creates a function with a connection to a VPC with two subnets and one security group.

```
aws lambda create-function --function-name my-function \
--runtime nodejs16.x --handler index.js --zip-file fileb://function.zip \
--role arn:aws:iam::123456789012:role/lambda-role \
--vpc-config
 SubnetIds=subnet-071f712345678e7c8,subnet-07fd123456788a036,SecurityGroupIds=sg-085912345678492fb
```

To connect an existing function to a VPC, use the `update-function-configuration` command with the `vpc-config` option.

```
aws lambda update-function-configuration --function-name my-function \
--vpc-config
 SubnetIds=subnet-071f712345678e7c8,subnet-07fd123456788a036,SecurityGroupIds=sg-085912345678492fb
```

To disconnect your function from a VPC, update the function configuration with an empty list of subnets and security groups.

```
aws lambda update-function-configuration --function-name my-function \
```

```
--vpc-config SubnetIds=[],SecurityGroupIds=[]
```

# Using IAM condition keys for VPC settings

You can use Lambda-specific condition keys for VPC settings to provide additional permission controls for your Lambda functions. For example, you can require that all functions in your organization are connected to a VPC. You can also specify the subnets and security groups that the function's users can and can't use.

Lambda supports the following condition keys in IAM policies:

- **lambda:VpcIds** – Allow or deny one or more VPCs.
- **lambda:SubnetIds** – Allow or deny one or more subnets.
- **lambda:SecurityGroupIds** – Allow or deny one or more security groups.

The Lambda API operations CreateFunction (p. 904) and UpdateFunctionConfiguration (p. 1098) support these condition keys. For more information about using condition keys in IAM policies, see IAM JSON Policy Elements: Condition in the *IAM User Guide*.

> **Tip**
> If your function already includes a VPC configuration from a previous API request, you can send an `UpdateFunctionConfiguration` request without the VPC configuration.

## Example policies with condition keys for VPC settings

The following examples demonstrate how to use condition keys for VPC settings. After you create a policy statement with the desired restrictions, append the policy statement for the target IAM user or role.

### Ensure that users deploy only VPC-connected functions

To ensure that all users deploy only VPC-connected functions, you can deny function create and update operations that don't include a valid VPC ID.

Note that VPC ID is not an input parameter to the `CreateFunction` or `UpdateFunctionConfiguration` request. Lambda retrieves the VPC ID value based on the subnet and security group parameters.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "EnforceVPCFunction",
      "Action": [
          "lambda:CreateFunction",
          "lambda:UpdateFunctionConfiguration"
       ],
      "Effect": "Deny",
      "Resource": "*",
      "Condition": {
        "Null": {
           "lambda:VpcIds": "true"
        }
      }
    }
  ]
}
```

## Deny users access to specific VPCs, subnets, or security groups

To deny users access to specific VPCs, use `StringEquals` to check the value of the `lambda:VpcIds` condition. The following example denies users access to `vpc-1` and `vpc-2`.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "EnforceOutOfVPC",
      "Action": [
          "lambda:CreateFunction",
          "lambda:UpdateFunctionConfiguration"
       ],
      "Effect": "Deny",
      "Resource": "*",
      "Condition": {
        "StringEquals": {
            "lambda:VpcIds": ["vpc-1", "vpc-2"]
        }
      }
    }
```

To deny users access to specific subnets, use `StringEquals` to check the value of the `lambda:SubnetIds` condition. The following example denies users access to `subnet-1` and `subnet-2`.

```
{
      "Sid": "EnforceOutOfSubnet",
      "Action": [
          "lambda:CreateFunction",
          "lambda:UpdateFunctionConfiguration"
       ],
      "Effect": "Deny",
      "Resource": "*",
      "Condition": {
        "ForAnyValue:StringEquals": {
            "lambda:SubnetIds": ["subnet-1", "subnet-2"]
        }
      }
    }
```

To deny users access to specific security groups, use `StringEquals` to check the value of the `lambda:SecurityGroupIds` condition. The following example denies users access to `sg-1` and `sg-2`.

```
{
      "Sid": "EnforceOutOfSecurityGroups",
      "Action": [
          "lambda:CreateFunction",
          "lambda:UpdateFunctionConfiguration"
       ],
      "Effect": "Deny",
      "Resource": "*",
      "Condition": {
        "ForAnyValue:StringEquals": {
            "lambda:SecurityGroupIds": ["sg-1", "sg-2"]
        }
      }
    }
  ]
}
```

## Allow users to create and update functions with specific VPC settings

To allow users to access specific VPCs, use `StringEquals` to check the value of the `lambda:VpcIds` condition. The following example allows users to access `vpc-1` and `vpc-2`.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "EnforceStayInSpecificVpc",
      "Action": [
          "lambda:CreateFunction",
          "lambda:UpdateFunctionConfiguration"
       ],
      "Effect": "Allow",
      "Resource": "*",
      "Condition": {
        "StringEquals": {
            "lambda:VpcIds": ["vpc-1", "vpc-2"]
        }
      }
    }
```

To allow users to access specific subnets, use `StringEquals` to check the value of the `lambda:SubnetIds` condition. The following example allows users to access `subnet-1` and `subnet-2`.

```
{
      "Sid": "EnforceStayInSpecificSubnets",
      "Action": [
          "lambda:CreateFunction",
          "lambda:UpdateFunctionConfiguration"
       ],
      "Effect": "Allow",
      "Resource": "*",
      "Condition": {
        "ForAllValues:StringEquals": {
            "lambda:SubnetIds": ["subnet-1", "subnet-2"]
        }
      }
    }
```

To allow users to access specific security groups, use `StringEquals` to check the value of the `lambda:SecurityGroupIds` condition. The following example allows users to access `sg-1` and `sg-2`.

```
{
      "Sid": "EnforceStayInSpecificSecurityGroup",
      "Action": [
          "lambda:CreateFunction",
          "lambda:UpdateFunctionConfiguration"
       ],
      "Effect": "Allow",
      "Resource": "*",
      "Condition": {
        "ForAllValues:StringEquals": {
            "lambda:SecurityGroupIds": ["sg-1", "sg-2"]
        }
      }
```

```
    }
  ]
}
```

# Internet and service access for VPC-connected functions

By default, Lambda runs your functions in a secure VPC with access to AWS services and the internet. Lambda owns this VPC, which isn't connected to your account's default VPC. When you connect a function to a VPC in your account, the function can't access the internet unless your VPC provides access.

> **Note**
> Several AWS services offer VPC endpoints. You can use VPC endpoints to connect to AWS services from within a VPC without internet access.

Internet access from a private subnet requires network address translation (NAT). To give your function access to the internet, route outbound traffic to a NAT gateway in a public subnet. The NAT gateway has a public IP address and can connect to the internet through the VPC's internet gateway. An idle NAT gateway connection will time out after 350 seconds. For more information, see How do I give internet access to my Lambda function in a VPC?

# VPC tutorials

In the following tutorials, you connect a Lambda function to resources in your VPC.

- Tutorial: Configuring a Lambda function to access Amazon RDS in an Amazon VPC (p. 657)
- Tutorial: Configuring a Lambda function to access Amazon ElastiCache in an Amazon VPC (p. 589)

# Sample VPC configurations

You can use the following sample AWS CloudFormation templates to create VPC configurations to use with Lambda functions. There are two templates available in this guide's GitHub repository:

- vpc-private.yaml – A VPC with two private subnets and VPC endpoints for Amazon Simple Storage Service (Amazon S3) and Amazon DynamoDB. Use this template to create a VPC for functions that don't need internet access. This configuration supports use of Amazon S3 and DynamoDB with the AWS SDKs, and access to database resources in the same VPC over a local network connection.
- vpc-privatepublic.yaml – A VPC with two private subnets, VPC endpoints, a public subnet with a NAT gateway, and an internet gateway. Internet-bound traffic from functions in the private subnets is routed to the NAT gateway using a route table.

To create a VPC using a template, on the AWS CloudFormation console Stacks page, choose **Create stack**, and then follow the instructions in the **Create stack** wizard.

# Configuring interface VPC endpoints for Lambda

If you use Amazon Virtual Private Cloud (Amazon VPC) to host your AWS resources, you can establish a connection between your VPC and Lambda. You can use this connection to invoke your Lambda function without crossing the public internet.

To establish a private connection between your VPC and Lambda, create an interface VPC endpoint. Interface endpoints are powered by AWS PrivateLink, which enables you to privately access Lambda APIs without an internet gateway, NAT device, VPN connection, or AWS Direct Connect connection. Instances in your VPC don't need public IP addresses to communicate with Lambda APIs. Traffic between your VPC and Lambda does not leave the AWS network.

Each interface endpoint is represented by one or more elastic network interfaces in your subnets. A network interface provides a private IP address that serves as an entry point for traffic to Lambda.

**Sections**

- Considerations for Lambda interface endpoints (p. 198)
- Creating an interface endpoint for Lambda (p. 199)
- Creating an interface endpoint policy for Lambda (p. 199)

## Considerations for Lambda interface endpoints

Before you set up an interface endpoint for Lambda, be sure to review Interface endpoint properties and limitations in the *Amazon VPC User Guide*.

You can call any of the Lambda API operations from your VPC. For example, you can invoke the Lambda function by calling the `Invoke` API from within your VPC. For the full list of Lambda APIs, see Actions in the Lambda API reference.

### Keep-alive for persistent connections

Lambda purges idle connections over time, so you must use a keep-alive directive to maintain persistent connections. Attempting to reuse an idle connection when invoking a function results in a connection error. To maintain your persistent connection, use the keep-alive directive associated with your runtime. For an example, see Reusing Connections with Keep-Alive in Node.js in the *AWS SDK for JavaScript Developer Guide*.

### Billing Considerations

There is no additional cost to access a Lambda function through an interface endpoint. For more Lambda pricing information, see AWS Lambda Pricing.

Standard pricing for AWS PrivateLink applies to interface endpoints for Lambda. Your AWS account is billed for every hour an interface endpoint is provisioned in each Availability Zone and for data processed through the interface endpoint. For more interface endpoint pricing information, see AWS PrivateLink pricing.

### VPC Peering Considerations

You can connect other VPCs to the VPC with interface endpoints using VPC peering. VPC peering is a networking connection between two VPCs. You can establish a VPC peering connection between your own two VPCs, or with a VPC in another AWS account. The VPCs can also be in two different AWS Regions.

Traffic between peered VPCs stays on the AWS network and does not traverse the public internet. Once VPCs are peered, resources like Amazon Elastic Compute Cloud (Amazon EC2) instances, Amazon Relational Database Service (Amazon RDS) instances, or VPC-enabled Lambda functions in both VPCs can access the Lambda API through interface endpoints created in the one of the VPCs.

# Creating an interface endpoint for Lambda

You can create an interface endpoint for Lambda using either the Amazon VPC console or the AWS Command Line Interface (AWS CLI). For more information, see Creating an interface endpoint in the *Amazon VPC User Guide*.

**To create an interface endpoint for Lambda (console)**

1. Open the Endpoints page of the Amazon VPC console.
2. Choose **Create Endpoint**.
3. For **Service category**, verify that **AWS services** is selected.
4. For **Service Name**, choose **com.amazonaws.*region*.lambda**. Verify that the **Type** is **Interface**.
5. Choose a VPC and subnets.
6. To enable private DNS for the interface endpoint, select the **Enable DNS Name** check box.
7. For **Security group**, choose one or more security groups.
8. Choose **Create endpoint**.

To use the private DNS option, you must set the `enableDnsHostnames` and `enableDnsSupportattributes` of your VPC. For more information, see Viewing and updating DNS support for your VPC in the *Amazon VPC User Guide*. If you enable private DNS for the interface endpoint, you can make API requests to Lambda using its default DNS name for the Region, for example, `lambda.us-east-1.amazonaws.com`. For more service endpoints, see Service endpoints and quotas in the *AWS General Reference*.

For more information, see Accessing a service through an interface endpoint in the *Amazon VPC User Guide*.

For information about creating and configuring an endpoint using AWS CloudFormation, see the AWS::EC2::VPCEndpoint resource in the *AWS CloudFormation User Guide*.

**To create an interface endpoint for Lambda (AWS CLI)**

Use the `create-vpc-endpoint` command and specify the VPC ID, VPC endpoint type (interface), service name, subnets that will use the endpoint, and security groups to associate with the endpoint's network interfaces. For example:

```
aws ec2 create-vpc-endpoint --vpc-id vpc-ec43eb89 --vpc-endpoint-type Interface --service-
name \
   com.amazonaws.us-east-1.lambda --subnet-id subnet-abababab --security-group-id
 sg-1a2b3c4d
```

# Creating an interface endpoint policy for Lambda

To control who can use your interface endpoint and which Lambda functions the user can access, you can attach an endpoint policy to your endpoint. The policy specifies the following information:

- The principal that can perform actions.

- The actions that the principal can perform.
- The resources on which the principal can perform actions.

For more information, see Controlling access to services with VPC endpoints in the *Amazon VPC User Guide*.

**Example: Interface endpoint policy for Lambda actions**

The following is an example of an endpoint policy for Lambda. When attached to an endpoint, this policy allows user `MyUser` to invoke the function `my-function`.

> **Note**
> You need to include both the qualified and the unqualified function ARN in the resource.

```
{
   "Statement":[
      {
         "Principal":
         {
             "AWS": "arn:aws:iam::111122223333:user/MyUser"
         },
         "Effect":"Allow",
         "Action":[
            "lambda:InvokeFunction"
         ],
         "Resource": [
               "arn:aws:lambda:us-east-2:123456789012:function:my-function",
               "arn:aws:lambda:us-east-2:123456789012:function:my-function:*"
            ]
      }
   ]
}
```

# Configuring database access for a Lambda function

You can create an Amazon RDS Proxy database proxy for your function. A database proxy manages a pool of database connections and relays queries from a function. This enables a function to reach high concurrency (p. 14) levels without exhausting database connections.

**Sections**


- Creating a database proxy (console) (p. 201)
- Using the function's permissions for authentication (p. 202)
- Sample application (p. 202)


## Creating a database proxy (console)

You can use the Lambda console to create an Amazon RDS Proxy database proxy.

**To create a database proxy**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **Database proxies**.
4. Choose **Add database proxy**.
5. Configure the following options.
   - **Proxy identifier** – The name of the proxy.
   - **RDS DB instance** – A supported MySQL or PostgreSQL DB instance or cluster.
   - **Secret** – A Secrets Manager secret with the database user name and password.

     **Example secret**

     ```
     {
         "username": "admin",
         "password": "e2abcecxmpldc897"
       }
     ```
   - **IAM role** – An IAM role with permission to use the secret, and a trust policy that allows Amazon RDS to assume the role.
   - **Authentication** – The authentication and authorization method for connecting to the proxy from your function code.
6. Choose **Add**.

**Pricing**
Amazon RDS charges a hourly price for proxies that is determined by the instance size of your database. For details, see RDS Proxy pricing.

Proxy creation takes a few minutes. When the proxy is available, configure your function to connect to the proxy endpoint instead of the database endpoint.

Standard Amazon RDS Proxy pricing applies. For more information, see Managing connections with the Amazon RDS Proxy in the Amazon Aurora User Guide.

# Using the function's permissions for authentication

By default, you can connect to a proxy with the same username and password that it uses to connect to the database. The only difference in your function code is the endpoint that the database client connects to. The drawback of this method is that you must expose the password to your function code, either by configuring it in a secure environment variable or by retrieving it from Secrets Manager.

You can create a database proxy that uses the function's IAM credentials for authentication and authorization instead of a password. To use the function's permissions to connect to the proxy, set **Authentication** to **Execution role**.

The Lambda console adds the required permission (`rds-db:connect`) to the execution role. You can then use the AWS SDK to generate a token that allows it to connect to the proxy. The following example shows how to configure a database connection with the `mysql2` library in Node.js.

**Example dbadmin/index-iam.js – AWS SDK signer**

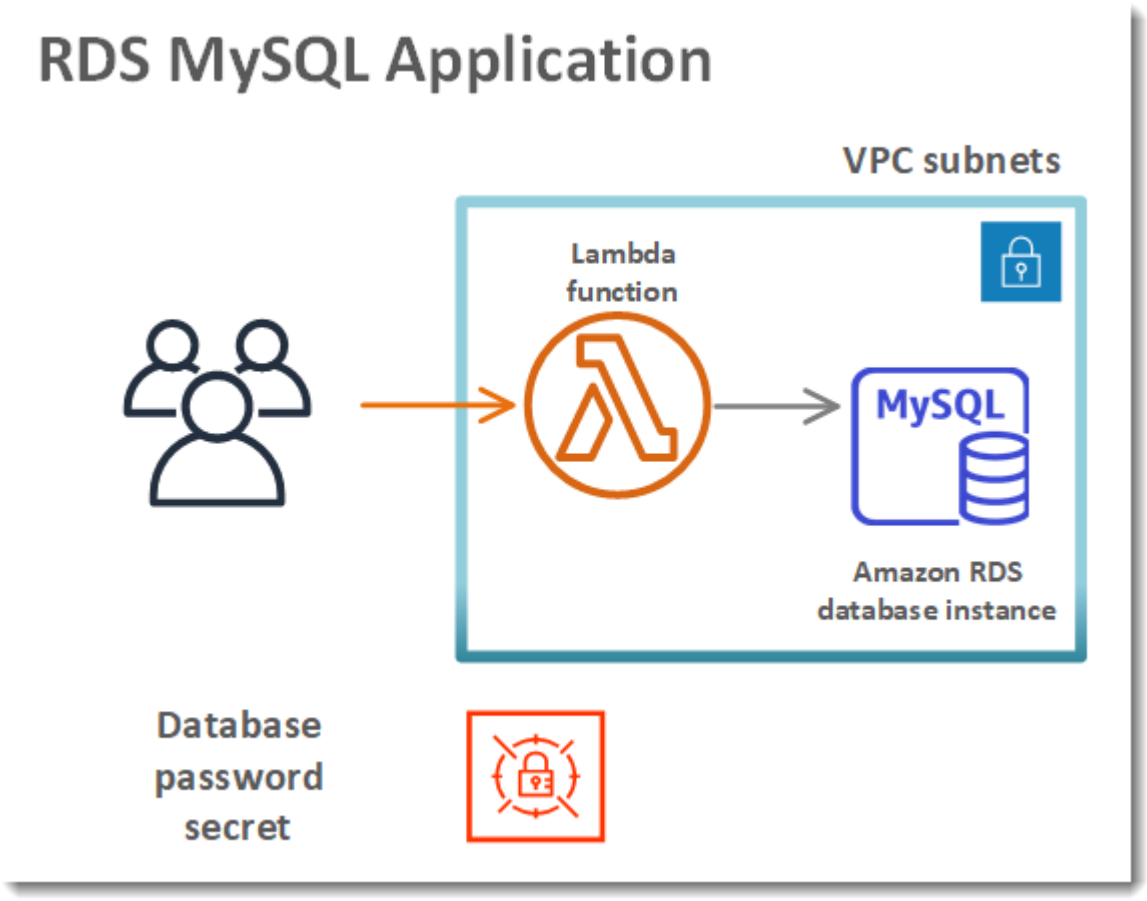
```
const signer = new AWS.RDS.Signer({
  region: region,
  hostname: host,
  port: sqlport,
  username: username
})

exports.handler = async (event) => {
  let connectionConfig = {
    host     : host,
    user     : username,
    database : database,
    ssl: 'Amazon RDS',
    authPlugins: { mysql_clear_password: () => () => signer.getAuthToken() }
  }
  var connection = mysql.createConnection(connectionConfig)
  var query = event.query
  var result
  connection.connect()
}
```

For more information, see IAM database authentication in the Amazon RDS User Guide.

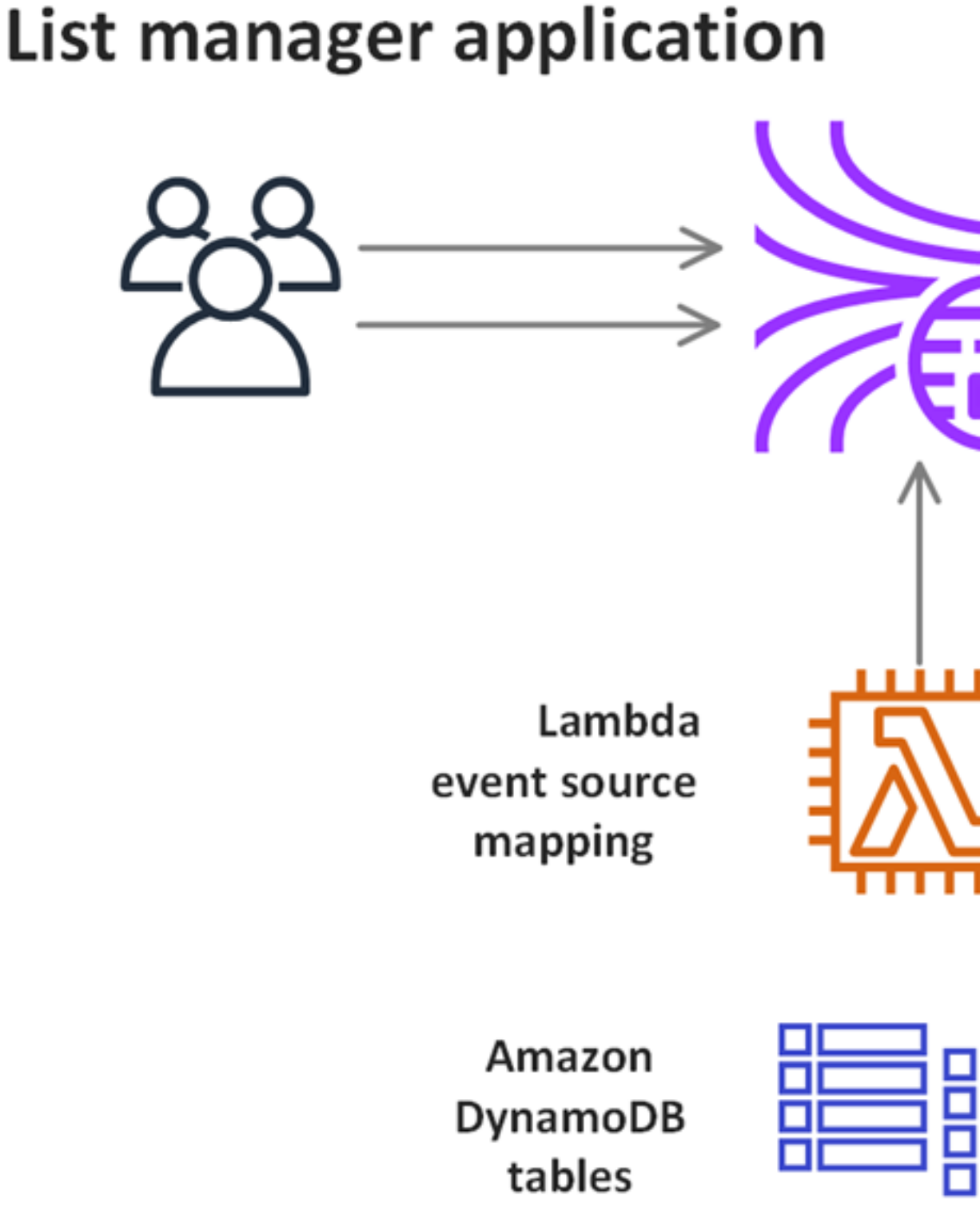
# Sample application

Sample applications that demonstrate the use of Lambda with an Amazon RDS database are available in this guide's GitHub repository. There are two applications:

- RDS MySQL – The AWS CloudFormation template `template-vpcrds.yml` creates a MySQL 5.7 database in a private VPC. In the sample application, a Lambda function proxies queries to the database. The function and database templates both use Secrets Manager to access database credentials.




- List Manager – A processor function reads events from a Kinesis stream. It uses the data from the events to update DynamoDB tables, and stores a copy of the event in a MySQL database.


List manager application
Lambda
event source
mapping
Amazon
DynamoDB
tables

To use the sample applications, follow the instructions in the GitHub repository: RDS MySQL, List Manager.

# Configuring file system access for Lambda functions

You can configure a function to mount an Amazon Elastic File System (Amazon EFS) file system to a local directory. With Amazon EFS, your function code can access and modify shared resources safely and at high concurrency.

**Sections**


- Execution role and user permissions (p. 206)
- Configuring a file system and access point (p. 206)
- Connecting to a file system (console) (p. 207)
- Configuring file system access with the Lambda API (p. 208)
- AWS CloudFormation and AWS SAM (p. 208)
- Sample applications (p. 210)


## Execution role and user permissions

If the file system doesn't have a user-configured IAM policy, EFS uses a default policy that grants full access to any client that can connect to the file system using a file system mount target. If the file system has a user-configured IAM policy, your function's execution role must have the correct `elasticfilesystem` permissions.

### Execution role permissions

- **elasticfilesystem:ClientMount**
- **elasticfilesystem:ClientWrite (not required for read-only connections)**

These permissions are included in the **AmazonElasticFileSystemClientReadWriteAccess** managed policy. Additionally, your execution role must have the permissions required to connect to the file system's VPC (p. 192).

When you configure a file system, Lambda uses your permissions to verify mount targets. To configure a function to connect to a file system, your IAM user needs the following permissions:

### User permissions

- **elasticfilesystem:DescribeMountTargets**

## Configuring a file system and access point

Create a file system in Amazon EFS with a mount target in every Availability Zone that your function connects to. For performance and resilience, use at least two Availability Zones. For example, in a simple configuration you could have a VPC with two private subnets in separate Availability Zones. The function connects to both subnets and a mount target is available in each. Ensure that NFS traffic (port 2049) is allowed by the security groups used by the function and mount targets.

> **Note**
> When you create a file system, you choose a performance mode that can't be changed later. **General purpose** mode has lower latency, and **Max I/O** mode supports a higher maximum throughput and IOPS. For help choosing, see Amazon EFS performance in the *Amazon Elastic File System User Guide*.

An access point connects each instance of the function to the right mount target for the Availability Zone it connects to. For best performance, create an access point with a non-root path, and limit the number of files that you create in each directory. The following example creates a directory named `my-function` on the file system and sets the owner ID to 1001 with standard directory permissions (755).

**Example access point configuration**

- **Name** – `files`
- **User ID** – `1001`
- **Group ID** – `1001`
- **Path** – `/my-function`
- **Permissions** – `755`
- **Owner user ID** – `1001`
- **Group user ID** – `1001`

When a function uses the access point, it is given user ID 1001 and has full access to the directory.

For more information, see the following topics in the *Amazon Elastic File System User Guide*:

- Creating resources for Amazon EFS
- Working with users, groups, and permissions

# Connecting to a file system (console)

A function connects to a file system over the local network in a VPC. The subnets that your function connects to can be the same subnets that contain mount points for your file system, or subnets in the same Availability Zone that can route NFS traffic (port 2049) to the file system.

> **Note**
> If your function is not already connected to a VPC, see Configuring a Lambda function to access resources in a VPC (p. 191).

**To configure file system access**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **File systems**.
4. Under **File system**, choose **Add file system**.
5. Configure the following properties:
   - **EFS file system** – The access point for a file system in the same VPC.
   - **Local mount path** – The location where the file system is mounted on the Lambda function, starting with `/mnt/`.

> **Pricing**
> Amazon EFS charges for storage and throughput, with rates that vary by storage class. For details, see Amazon EFS pricing.
> Lambda charges for data transfer between VPCs. This only applies if your function's VPC is peered to another VPC with a file system. The rates are the same as for Amazon EC2 data transfer between VPCs in the same Region. For details, see Lambda pricing.

For more information about Lambda's integration with Amazon EFS, see Using Amazon EFS with Lambda (p. 595).

# Configuring file system access with the Lambda API

Use the following API operations to connect your Lambda function to a file system:

- CreateFunction (p. 904)
- UpdateFunctionConfiguration (p. 1098)

To connect a function to a file system, use the `update-function-configuration` command. The following example connects a function named `my-function` to a file system with ARN of an access point.

```
ARN=arn:aws:elasticfilesystem:us-east-2:123456789012:access-point/fsap-015cxmplb72b405fd
aws lambda update-function-configuration --function-name my-function \
      --file-system-configs Arn=$ARN,LocalMountPath=/mnt/efs0
```

You can get the ARN of a file system's access point with the `describe-access-points` command.

```
aws efs describe-access-points
```

You should see the following output:

```
{
    "AccessPoints": [
        {
            "ClientToken": "console-aa50c1fd-xmpl-48b5-91ce-57b27a3b1017",
            "Name": "lambda-ap",
            "Tags": [
                {
                    "Key": "Name",
                    "Value": "lambda-ap"
                }
            ],
            "AccessPointId": "fsap-015cxmplb72b405fd",
            "AccessPointArn": "arn:aws:elasticfilesystem:us-east-2:123456789012:access-
point/fsap-015cxmplb72b405fd",
            "FileSystemId": "fs-aea3xmpl",
            "RootDirectory": {
                "Path": "/"
            },
            "OwnerId": "123456789012",
            "LifeCycleState": "available"
        }
    ]
}
```

# AWS CloudFormation and AWS SAM

You can use AWS CloudFormation and the AWS Serverless Application Model (AWS SAM) to automate the creation of Lambda applications. To enable a file system connection on an AWS SAM `AWS::Serverless::Function` resource, use the `FileSystemConfigs` property.

**Example template.yml – File system configuration**

```
Transform: AWS::Serverless-2016-10-31
Resources:
```

```
VPC:
  Type: AWS::EC2::VPC
  Properties:
    CidrBlock: 10.0.0.0/16
Subnet1:
  Type: AWS::EC2::Subnet
  Properties:
    VpcId:
      Ref: VPC
    CidrBlock: 10.0.1.0/24
    AvailabilityZone: "us-west-2a"
EfsSecurityGroup:
  Type: AWS::EC2::SecurityGroup
  Properties:
    VpcId:
      Ref: VPC
    GroupDescription: "mnt target sg"
    SecurityGroupIngress:
    - IpProtocol: -1
      CidrIp: "0.0.0.0/0"
FileSystem:
  Type: AWS::EFS::FileSystem
  Properties:
    PerformanceMode: generalPurpose
AccessPoint:
  Type: AWS::EFS::AccessPoint
  Properties:
    FileSystemId:
      Ref: FileSystem
    PosixUser:
      Uid: "1001"
      Gid: "1001"
    RootDirectory:
      CreationInfo:
        OwnerGid: "1001"
        OwnerUid: "1001"
        Permissions: "755"
MountTarget1:
  Type: AWS::EFS::MountTarget
  Properties:
    FileSystemId:
      Ref: FileSystem
    SubnetId:
      Ref: Subnet1
    SecurityGroups:
    - Ref: EfsSecurityGroup
MyFunctionWithEfs:
  Type: AWS::Serverless::Function
  Properties:
    Handler: index.handler
    Runtime: python3.9
    VpcConfig:
      SecurityGroupIds:
      - Ref: EfsSecurityGroup
      SubnetIds:
      - Ref: Subnet1
    FileSystemConfigs:
    - Arn: !GetAtt AccessPoint.Arn
      LocalMountPath: "/mnt/efs"
    Description: Use a file system.
  DependsOn: "MountTarget1"
```

You must add the `DependsOn` to ensure that the mount targets are fully created before the Lambda runs for the first time.

For the AWS CloudFormation `AWS::Lambda::Function` type, the property name and fields are the same. For more information, see Using AWS Lambda with AWS CloudFormation (p. 542).

# Sample applications

The GitHub repository for this guide includes a sample application that demonstrates the use of Amazon EFS with a Lambda function.

- efs-nodejs – A function that uses an Amazon EFS file system in a Amazon VPC. This sample includes a VPC, file system, mount targets, and access point configured for use with Lambda.

# Configuring code signing for AWS Lambda

Code signing for AWS Lambda helps to ensure that only trusted code runs in your Lambda functions. When you enable code signing for a function, Lambda checks every code deployment and verifies that the code package is signed by a trusted source.

> **Note**
> Functions defined as container images do not support code signing.

To verify code integrity, use AWS Signer to create digitally signed code packages for functions and layers. When a user attempts to deploy a code package, Lambda performs validation checks on the code package before accepting the deployment. Because code signing validation checks run at deployment time, there is no performance impact on function execution.

You also use AWS Signer to create *signing profiles*. You use a signing profile to create the signed code package. Use AWS Identity and Access Management (IAM) to control who can sign code packages and create signing profiles. For more information, see Authentication and Access Control in the *AWS Signer Developer Guide*.

To enable code signing for a function, you create a *code signing configuration* and attach it to the function. A code signing configuration defines a list of allowed signing profiles and the policy action to take if any of the validation checks fail.

Lambda layers follow the same signed code package format as function code packages. When you add a layer to a function that has code signing enabled, Lambda checks that the layer is signed by an allowed signing profile. When you enable code signing for a function, all layers that are added to the function must also be signed by one of the allowed signing profiles.

Use IAM to control who can create code signing configurations. Typically, you allow only specific administrative users to have this ability. Additionally, you can set up IAM policies to enforce that developers only create functions that have code signing enabled.

You can configure code signing to log changes to AWS CloudTrail. Successful and blocked deployments to functions are logged to CloudTrail with information about the signature and validation checks.

You can configure code signing for your functions using the Lambda console, the AWS Command Line Interface (AWS CLI), AWS CloudFormation, and the AWS Serverless Application Model (AWS SAM).

There is no additional charge for using AWS Signer or code signing for AWS Lambda.

**Sections**


- Signature validation (p. 211)
- Configuration prerequisites (p. 212)
- Creating code signing configurations (p. 212)
- Updating a code signing configuration (p. 212)
- Deleting a code signing configuration (p. 213)
- Enabling code signing for a function (p. 213)
- Configuring IAM policies (p. 213)
- Configuring code signing with the Lambda API (p. 214)


## Signature validation

Lambda performs the following validation checks when you deploy a signed code package to your function:

1. Integrity – Validates that the code package has not been modified since it was signed. Lambda compares the hash of the package with the hash from the signature.
2. Expiry – Validates that the signature of the code package has not expired.
3. Mismatch – Validates that the code package is signed with one of the allowed signing profiles for the Lambda function. A mismatch also occurs if a signature is not present.
4. Revocation – Validates that the signature of the code package has not been revoked.

The signature validation policy defined in the code signing configuration determines which of the following actions Lambda takes if any of the validation checks fail:

- Warn – Lambda allows the deployment of the code package, but issues a warning. Lambda issues a new Amazon CloudWatch metric and also stores the warning in the CloudTrail log.
- Enforce – Lambda issues a warning (the same as for the Warn action) and blocks the deployment of the code package.

You can configure the policy for the expiry, mismatch, and revocation validation checks. Note that you cannot configure a policy for the integrity check. If the integrity check fails, Lambda blocks deployment.

# Configuration prerequisites

Before you can configure code signing for a Lambda function, use AWS Signer to do the following:

- Create one or more signing profiles.
- Use a signing profile to create a signed code package for your function.

For more information, see Creating Signing Profiles (Console) in the *AWS Signer Developer Guide*.

# Creating code signing configurations

A code signing configuration defines a list of allowed signing profiles and the signature validation policy.

**To create a code signing configuration (console)**

1. Open the Code signing configurations page of the Lambda console.
2. Choose **Create configuration**.
3. For **Description**, enter a descriptive name for the configuration.
4. Under **Signing profiles**, add up to 20 signing profiles to the configuration.
    a. For **Signing profile version ARN**, choose a profile version's Amazon Resource Name (ARN), or enter the ARN.
    b. To add an additional signing profile, choose **Add signing profiles**.
5. Under **Signature validation policy**, choose **Warn** or **Enforce**.
6. Choose **Create configuration**.

# Updating a code signing configuration

When you update a code signing configuration, the changes impact the future deployments of functions that have the code signing configuration attached.

**To update a code signing configuration (console)**

1. Open the Code signing configurations page of the Lambda console.
2. Select a code signing configuration to update, and then choose **Edit**.
3. For **Description**, enter a descriptive name for the configuration.
4. Under **Signing profiles**, add up to 20 signing profiles to the configuration.
   a. For **Signing profile version ARN**, choose a profile version's Amazon Resource Name (ARN), or enter the ARN.
   b. To add an additional signing profile, choose **Add signing profiles**.
5. Under **Signature validation policy**, choose **Warn** or **Enforce**.
6. Choose **Save changes**.

# Deleting a code signing configuration

You can delete a code signing configuration only if no functions are using it.

**To delete a code signing configuration (console)**

1. Open the Code signing configurations page of the Lambda console.
2. Select a code signing configuration to delete, and then choose **Delete**.
3. To confirm, choose **Delete** again.

# Enabling code signing for a function

To enable code signing for a function, you associate a code signing configuration with the function.

**To associate a code signing configuration with a function (console)**

1. Open the Functions page of the Lambda console.
2. Choose the function for which you want to enable code signing.
3. Under **Code signing configuration**, choose **Edit**.
4. In **Edit code signing**, choose a code signing configuration for this function.
5. Choose **Save**.

# Configuring IAM policies

To grant permission for a user to access the code signing API operations (p. 214), attach one or more policy statements to the user policy. For more information about user policies, see Identity-based IAM policies for Lambda (p. 59).

The following example policy statement grants permission to create, update, and retrieve code signing configurations.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
          "lambda:CreateCodeSigningConfig",
```

```
          "lambda:UpdateCodeSigningConfig",
          "lambda:GetCodeSigningConfig"
        ],
      "Resource": "*"
    }
  ]
}
```

Administrators can use the `CodeSigningConfigArn` condition key to specify the code signing configurations that developers must use to create or update your functions.

The following example policy statement grants permission to create a function. The policy statement includes a `lambda:CodeSigningConfigArn` condition to specify the allowed code signing configuration. Lambda blocks any `CreateFunction` API request if its `CodeSigningConfigArn` parameter is missing or does not match the value in the condition.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "AllowReferencingCodeSigningConfig",
      "Effect": "Allow",
      "Action": [
          "lambda:CreateFunction",
        ],
      "Resource": "*",
      "Condition": {
          "StringEquals": {
              "lambda:CodeSigningConfigArn":
                  “arn:aws:lambda:us-west-2:123456789012:code-signing-
config:csc-0d4518bd353a0a7c6”
          }
      }
    }
  ]
}
```

# Configuring code signing with the Lambda API

To manage code signing configurations with the AWS CLI or AWS SDK, use the following API operations:

- ListCodeSigningConfigs
- CreateCodeSigningConfig
- GetCodeSigningConfig
- UpdateCodeSigningConfig
- DeleteCodeSigningConfig

To manage the code signing configuration for a function, use the following API operations:

- CreateFunction (p. 904)
- GetFunctionCodeSigningConfig
- PutFunctionCodeSigningConfig
- DeleteFunctionCodeSigningConfig
- ListFunctionsByCodeSigningConfig

# Using tags on Lambda functions

You can tag AWS Lambda functions to activate attribute-based access control (ABAC) (p. 64) and to organize them by owner, project, or department. Tags are free-form key-value pairs that are supported across AWS services for use in ABAC, filtering resources, and adding detail to billing reports.

Tags apply at the function level, not to versions or aliases. Tags are not part of the version-specific configuration that Lambda creates a snapshot of when you publish a version.

**Sections**


- Permissions required for working with tags (p. 215)
- Using tags with the Lambda console (p. 215)
- Using tags with the AWS CLI (p. 217)
- Requirements for tags (p. 218)


## Permissions required for working with tags

Grant appropriate permissions to the AWS Identity and Access Management (IAM) identity (user, group, or role) for the person working with the function:

- **lambda:ListTags** – When a function has tags, grant this permission to anyone who needs to call `GetFunction` or `ListTags` on it.
- **lambda:TagResource** – Grant this permission to anyone who needs to call `CreateFunction` or `TagResource`.

For more information, see Identity-based IAM policies for Lambda (p. 59).

## Using tags with the Lambda console

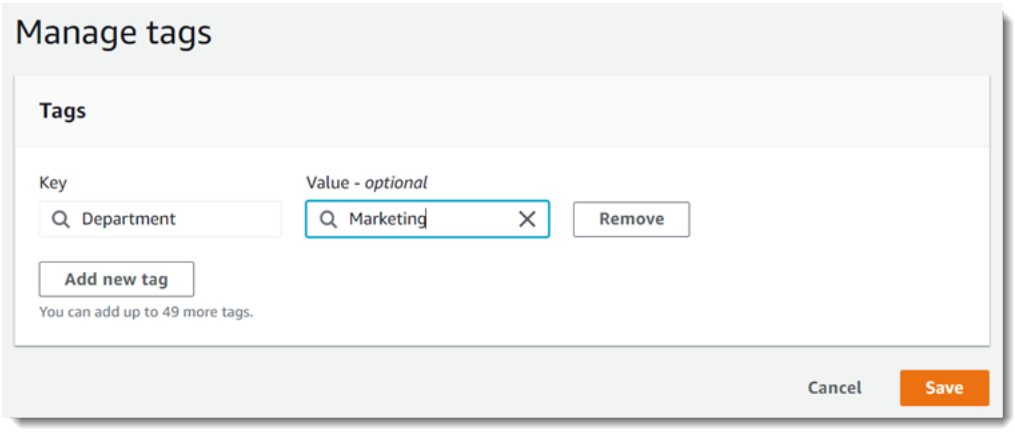
You can use the Lambda console to create functions that have tags, add tags to existing functions, and filter functions by tags that you add.

### To add tags when you create a function

1. Open the Functions page of the Lambda console.
2. Choose **Create function**.
3. Choose **Author from scratch** or **Container image**.
4. Under **Basic information**, do the following:
    a. For **Function name**, enter the function name. Function names are limited to 64 characters in length.
    b. For **Runtime**, choose the language version to use for your function.
    c. (Optional) For **Architecture**, choose the instruction set architecture (p. 23) to use for your function. The default architecture is x86_64. When you build the deployment package for your function, make sure that it is compatible with the instruction set architecture that you choose.
5. Expand **Advanced settings**, and then select **Enable tags**.
6. Choose **Add new tag**, and then enter a **Key** and an optional **Value**. To add more tags, repeat this step.
7. Choose **Create function**.

### To add tags to an existing function

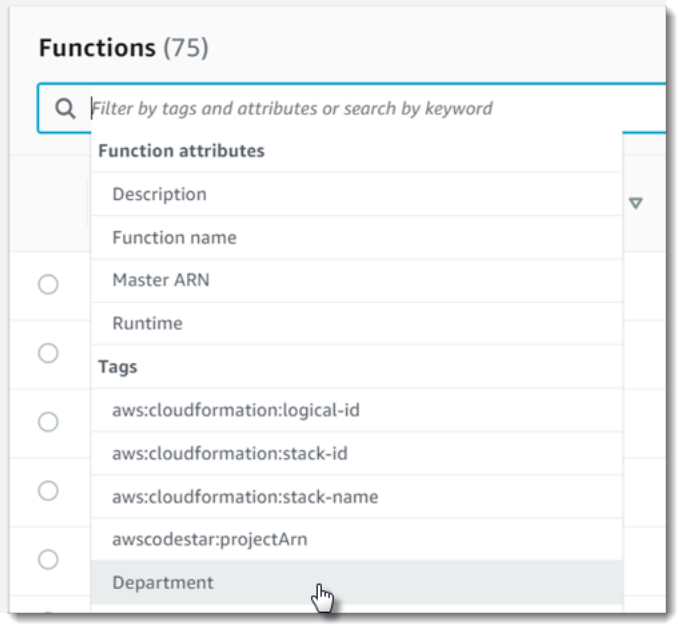
1. Open the Functions page of the Lambda console.
2. Choose the name of a function.
3. Choose **Configuration**, and then choose **Tags**.
4. Under **Tags**, choose **Manage tags**.
5. Choose **Add new tag**, and then enter a **Key** and an optional **Value**. To add more tags, repeat this step.



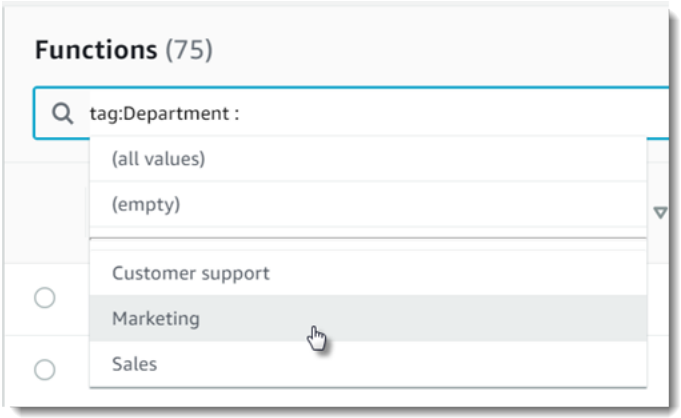

6. Choose **Save**.

### To filter functions with tags

1. Open the Functions page of the Lambda console.
2. Choose the search bar to see a list of function attributes and tag keys.




3. Choose a tag key to see a list of values that are in use in the current AWS Region.
4. Choose a value to see functions with that value, or choose **(all values)** to see all functions that have a tag with that key.




The search bar also supports searching for tag keys. Enter `tag` to see only a list of tag keys, or enter the name of a key to find it in the list.

# Using tags with the AWS CLI

## Adding and removing tags

To create a new Lambda function with tags, use the **create-function** command with the --tags option.

```
aws lambda create-function --function-name my-function
--handler index.js --runtime nodejs16.x \
--role arn:aws:iam::123456789012:role/lambda-role \
--tags Department=Marketing,CostCenter=1234ABCD
```

To add tags to an existing function, use the **tag-resource** command.

```
aws lambda tag-resource \
--resource arn:aws:lambda:us-east-2:123456789012:function:my-function \
--tags Department=Marketing,CostCenter=1234ABCD
```

To remove tags, use the **untag-resource** command.

```
aws lambda untag-resource --resource arn:aws:lambda:us-east-1:123456789012:function:my-
function \
--tag-keys Department
```

## Viewing tags on a function

If you want to view the tags that are applied to a specific Lambda function, you can use either of the following AWS CLI commands:

- ListTags (p. 1031) – To view a list of the tags associated with this function, include your Lambda function ARN (Amazon Resource Name):

  ```
  aws lambda list-tags --resource arn:aws:lambda:us-east-1:123456789012:function:my-
  function
  ```

- GetFunction (p. 958) – To view a list of the tags associated with this function, include your Lambda function name:

```
aws lambda get-function --function-name my-function
```

### Filtering functions by tag

You can use the AWS Resource Groups Tagging API GetResources API operation to filter your resources by tags. The `GetResources` operation receives up to 10 filters, with each filter containing a tag key and up to 10 tag values. You provide `GetResources` with a `ResourceType` to filter by specific resource types.

For more information about AWS Resource Groups, see What are resource groups? in the *AWS Resource Groups and Tags User Guide*.

## Requirements for tags

The following requirements apply to tags:

- Maximum number of tags per resource: 50
- Maximum key length: 128 Unicode characters in UTF-8
- Maximum value length: 256 Unicode characters in UTF-8
- Tag keys and values are case sensitive.
- Do not use the `aws:` prefix in your tag names or values because it is reserved for AWS use. You can't edit or delete tag names or values with this prefix. Tags with this prefix do not count against your tags per resource limit.
- If you plan to use your tagging schema across multiple services and resources, remember that other services may have restrictions on allowed characters. Generally allowed characters are: letters, spaces, and numbers representable in UTF-8, plus the following special characters: + - = . _ : / @.

# Using layers with your Lambda function

A Lambda layer is a .zip file archive that can contain additional code or other content. A layer can contain libraries, a custom runtime, data, or configuration files. Use layers to reduce deployment package size and to promote code sharing and separation of responsibilities so that you can iterate faster on writing business logic.

You can use layers only with Lambda functions deployed as a .zip file archive (p. 35). For a function defined as a container image (p. 143), you can package your preferred runtime and all code dependencies when you create the container image. For more information, see Working with Lambda layers and extensions in container images on the AWS Compute Blog.

**Sections**


- Configuring functions to use layers (p. 219)
- Accessing layer content from your function (p. 222)
- Finding layer information (p. 222)
- Adding layer permissions (p. 222)
- Using AWS SAM to add a layer to a function (p. 160)
- Sample applications (p. 223)


## Configuring functions to use layers

You can add up to five layers to a Lambda function. The total unzipped size of the function and all layers cannot exceed the unzipped deployment package size quota of 250 MB. For more information, see Lambda quotas (p. 796).

If your functions consume a layer that a different AWS account publishes, your functions can continue to use the layer version after it has been deleted, or after your permission to access the layer is revoked. However, you cannot create a new function that uses a deleted layer version.

> **Note**
> Make sure that the layers that you add to a function are compatible with the runtime and instruction set architecture of the function.

### Configuring layers with the console

#### Adding a layer to a function

1. Open the Functions page of the Lambda console.
2. Choose the function to configure.
3. Under **Layers**, choose **Add a layer**
4. Under **Choose a layer**, choose a layer source.
5. For the **AWS layers** or **Custom layers** layer source:
   a. Choose a layer from the pull-down menu.
   b. Under **Version**, choose a layer version from the pull-down menu. Each layer version entry lists its compatible runtimes and architectures.
   c. Choose **Add**.
6. For the **Specify an ARN** layer source:
   a. Enter an ARN in the text box and choose **Verify**.

b. Choose **Add**.

The order in which you add the layers is the order in which Lambda later merges the layer content into the execution environment. You can change the layer merge order using the console.

### Update layer order for your function

1. Open the Functions page of the Lambda console.
2. Choose the function to configure.
3. Under **Layers**, choose **Edit**
4. Choose one of the layers.
5. Choose **Merge earlier** or **Merge later** to adjust the order of the layers.
6. Choose **Save**.

Layers are versioned, and the content of each layer version is immutable. The layer owner can release a new layer version to provide updated content. You can use the console to update your functions' layer versions.

### Update layer versions for your function

1. Open the Functions page of the Lambda console.
2. Under **Additional resources**, choose **Layers**.
3. Choose the layer to modify.
4. Under **Functions using this version**, select the functions you want to modify, then choose **Edit**.
5. From **Layer version**, select the layer version to change to.
6. Choose **Update functions**.

You cannot update functions' layer versions across AWS accounts.

## Configuring layers with the API

To add layers to your function, use the **update-function-configuration** command. The following example adds two layers: one from the same AWS account as the function, and one from a different account.

```
aws lambda update-function-configuration --function-name my-function \
--layers arn:aws:lambda:us-east-2:123456789012:layer:my-layer:3
 \
arn:aws:lambda:us-east-2:111122223333:layer:their-layer:2
```

You should see output similar to the following:

```
{
    "FunctionName": "test-layers",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "Runtime": "nodejs16.x",
    "Role": "arn:aws:iam::123456789012:role/service-role/lambda-role",
    "Layers": [
        {
            "Arn": "arn:aws:lambda:us-east-2:123456789012:layer:my-layer:3",
            "CodeSize": 169
        },
        {
            "Arn": "arn:aws:lambda:us-east-2:111122223333:layer:their-layer:2",
```

```
            "CodeSize": 169
        }
    ],
    "RevisionId": "81cc64f5-5772-449a-b63e-12330476bcc4",
    ...
}
```

To specify the layer versions to use, you must provide the full Amazon Resource Name (ARN) of each layer version. When you add layers to a function that already has layers, you overwrite the previous list of layers. Be sure to include all layers every time that you update the layer configuration. The order in which you add the layers is the order in which Lambda later extracts the layer content into the execution environment.

To remove all layers, specify an empty list.

```
aws lambda update-function-configuration --function-name my-function --layers []
```

The creator of a layer can delete a version of the layer. If you're using that layer version in a function, your function continues to run as though the layer version still exists. However, when you update the layer configuration, you must remove the reference to the deleted version.

Layers are versioned, and the content of each layer version is immutable. The layer owner can release a new layer version to provide updated content. You can use the API to update the layer versions that your function uses.

### Update layer versions for your function

To update one or more layer versions for your function, use the **update-function-configuration** command. Use the `--layers` option with this command to include all of the layer versions for the function, even if you are updating one of the layer versions. If the function already has layers, the new list overwrites the previous list.

The following procedure steps assume that you have packaged the updated layer code into a local file named `layer.zip`.

1. (Optional) If the new layer version is not published yet, publish the new version.

   ```
    aws lambda publish-layer-version --layer-name my-layer --description "My layer" --
   license-info "MIT" \
   --zip-file  "fileb://layer.zip"  --compatible-runtimes python3.6 python3.7
   ```

2. (Optional) If the function has more than one layer, get the current layer versions associated with the function.

   ```
   aws lambda get-function-configuration --function-name my-function  --query
    'Layers[*].Arn' --output yaml
   ```

3. Add the new layer version to the function. In the following example command, the function also has a layer version named `other-layer:5`:

   ```
   aws lambda update-function-configuration --function-name my-function \
   --layers arn:aws:lambda:us-east-2:123456789012:layer:my-layer:2 \
               arn:aws:lambda:us-east-2:123456789012:layer:other-layer:5
   ```

# Accessing layer content from your function

If your Lambda function includes layers, Lambda extracts the layer contents into the `/opt` directory in the function execution environment. Lambda extracts the layers in the order (low to high) listed by the function. Lambda merges folders with the same name, so if the same file appears in multiple layers, the function uses the version in the last extracted layer.

Each Lambda runtime (p. 82) adds specific `/opt` directory folders to the PATH variable. Your function code can access the layer content without the need to specify the path. For more information about path settings in the Lambda execution environment, see Defined runtime environment variables (p. 169).

# Finding layer information

To find layers in your AWS account that are compatible with your Lambda function's runtime, use the **list-layers** command.

```
aws lambda list-layers --compatible-runtime python3.8
```

You should see output similar to the following:

```
{
    "Layers": [
        {
            "LayerName": "my-layer",
            "LayerArn": "arn:aws:lambda:us-east-2:123456789012:layer:my-layer",
            "LatestMatchingVersion": {
                "LayerVersionArn": "arn:aws:lambda:us-east-2:123456789012:layer:my-
layer:2",
                "Version": 2,
                "Description": "My layer",
                "CreatedDate": "2018-11-15T00:37:46.592+0000",
                "CompatibleRuntimes": [
                    "python3.6",
                    "python3.7",
                    "python3.8",
                ]
            }
        }
    ]
}
```

To list all layers in your account, you can omit the `--compatible-runtime` option. The details in the response reflect the latest version of the layer.

You can also get the latest version of a layer using the **list-layer-versions** command.

```
aws lambda list-layer-versions --layer-name my-layer --query
 'LayerVersions[0].LayerVersionArn
```

# Adding layer permissions

To use a Lambda function with a layer, you need permission to call the GetLayerVersion (p. 980) API operation on the layer version. For functions in your AWS account, you can add this permission from your user policy (p. 59).

To use a layer in another account, the owner of that account must grant your account permission in a resource-based policy (p. 68).

For examples, see Granting layer access to other accounts (p. 72).

# Using AWS SAM to add a layer to a function

To automate the creation and mapping of layers in your application, use the AWS Serverless Application Model (AWS SAM). The `AWS::Serverless::LayerVersion` resource type creates a layer version that you can reference from your Lambda function configuration.

**Example blank-nodejs/template.yml – Serverless resources**

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: 'AWS::Serverless-2016-10-31'
Description: An AWS Lambda application that calls the Lambda API.
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs12.x
      CodeUri: function/.
      Description: Call the AWS Lambda API
      Timeout: 10
      # Function's execution role
      Policies:
        - AWSLambdaBasicExecutionRole
        - AWSLambda_ReadOnlyAccess
        - AWSXrayWriteOnlyAccess
      Tracing: Active
      Layers:
        - !Ref libs
  libs:
    Type: AWS::Serverless::LayerVersion
    Properties:
      LayerName: blank-nodejs-lib
      Description: Dependencies for the blank sample app.
      ContentUri: lib/.
      CompatibleRuntimes:
        - nodejs12.x
```

When you update your dependencies and deploy, AWS SAM creates a new version of the layer and updates the mapping.

# Sample applications

The GitHub repository for this guide provides blank sample applications that demonstrate the use of layers for dependency management.

- **Node.js** – blank-nodejs
- **Python** – blank-python
- **Ruby** – blank-ruby
- **Java** – blank-java

For more information about the blank sample app, see Blank function sample application for AWS Lambda (p. 802). For other samples, see *Samples* (p. 800).

# Invoking Lambda functions

You can invoke Lambda functions directly using the Lambda console (p. 9), a function URL (p. 258) HTTP(S) endpoint, the Lambda API, an AWS SDK, the AWS Command Line Interface (AWS CLI), and AWS toolkits. You can also configure other AWS services to invoke your function, or you can configure Lambda to read from a stream or queue and invoke your function.

When you invoke a function, you can choose to invoke it synchronously or asynchronously. With synchronous invocation (p. 225), you wait for the function to process the event and return a response. With asynchronous (p. 228) invocation, Lambda queues the event for processing and returns a response immediately. For asynchronous invocation, Lambda handles retries and can send invocation records to a destination (p. 230).

To use your function to process data automatically, add one or more triggers. A trigger is a Lambda resource or a resource in another service that you configure to invoke your function in response to lifecycle events, external requests, or on a schedule. Your function can have multiple triggers. Each trigger acts as a client invoking your function independently. Each event that Lambda passes to your function has data from only one client or trigger.

To process items from a stream or queue, you can create an event source mapping (p. 236). An event source mapping is a resource in Lambda that reads items from an Amazon Simple Queue Service (Amazon SQS) queue, an Amazon Kinesis stream, or an Amazon DynamoDB stream, and sends them to your function in batches. Each event that your function processes can contain hundreds or thousands of items.

Other AWS services and resources invoke your function directly. For example, you can configure Amazon EventBridge (CloudWatch Events) to invoke your function on a timer, or you can configure Amazon Simple Storage Service (Amazon S3) to invoke your function when an object is created. Each service varies in the method that it uses to invoke your function, the structure of the event, and how you configure it. For more information, see Using AWS Lambda with other services (p. 496).

Depending on who invokes your function and how it's invoked, scaling behavior and the types of errors that occur can vary. When you invoke a function synchronously, you receive errors in the response and can retry. When you invoke asynchronously, use an event source mapping, or configure another service to invoke your function, the retry requirements and the way that your function scales to handle large numbers of events can vary. For more information, see Lambda function scaling (p. 30) and Error handling and automatic retries in AWS Lambda (p. 250).

**Topics**


- Synchronous invocation (p. 225)
- Asynchronous invocation (p. 228)
- Lambda event source mappings (p. 236)
- Lambda event filtering (p. 241)
- Lambda function states (p. 248)
- Error handling and automatic retries in AWS Lambda (p. 250)
- Testing Lambda functions in the console (p. 252)
- Using Lambda extensions (p. 254)
- Invoking functions defined as container images (p. 257)

# Synchronous invocation

When you invoke a function synchronously, Lambda runs the function and waits for a response. When the function completes, Lambda returns the response from the function's code with additional data, such as the version of the function that was invoked. To invoke a function synchronously with the AWS CLI, use the `invoke` command.

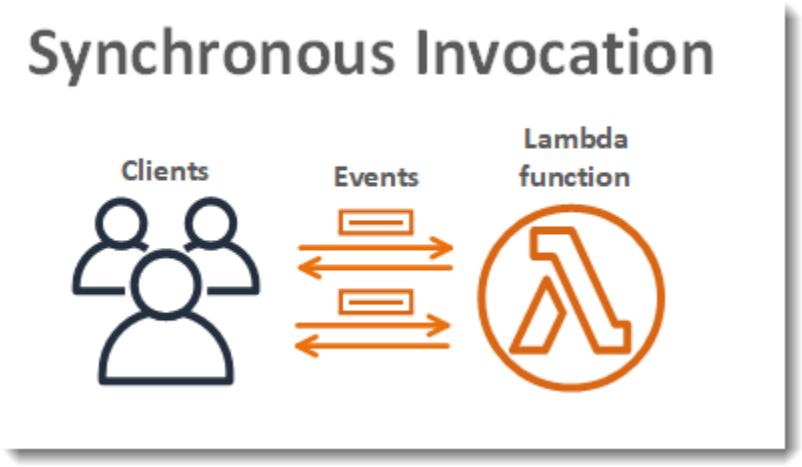
```
aws lambda invoke --function-name my-function --cli-binary-format raw-in-base64-out --
payload '{ "key": "value" }' response.json
```

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

You should see the following output:

```
{
    "ExecutedVersion": "$LATEST",
    "StatusCode": 200
}
```

The following diagram shows clients invoking a Lambda function synchronously. Lambda sends the events directly to the function and sends the function's response back to the invoker.




The `payload` is a string that contains an event in JSON format. The name of the file where the AWS CLI writes the response from the function is `response.json`. If the function returns an object or error, the response is the object or error in JSON format. If the function exits without error, the response is `null`.

The output from the command, which is displayed in the terminal, includes information from headers in the response from Lambda. This includes the version that processed the event (useful when you use aliases (p. 175)), and the status code returned by Lambda. If Lambda was able to run the function, the status code is 200, even if the function returned an error.

> **Note**
> For functions with a long timeout, your client might be disconnected during synchronous invocation while it waits for a response. Configure your HTTP client, SDK, firewall, proxy, or operating system to allow for long connections with timeout or keep-alive settings.

If Lambda isn't able to run the function, the error is displayed in the output.

```
aws lambda invoke --function-name my-function --cli-binary-format raw-in-base64-out --
payload value response.json
```

You should see the following output:

```
An error occurred (InvalidRequestContentException) when calling the Invoke operation: Could
 not parse request body into json: Unrecognized token 'value': was expecting ('true',
 'false' or 'null')
 at [Source: (byte[])"value"; line: 1, column: 11]
```

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

You can use the AWS CLI to retrieve logs for an invocation using the `--log-type` command option. The response contains a `LogResult` field that contains up to 4 KB of base64-encoded logs from the invocation.

### Example retrieve a log ID

The following example shows how to retrieve a *log ID* from the `LogResult` field for a function named `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail
```

You should see the following output:

```
{
    "StatusCode": 200,
    "LogResult":
 "U1RBUlQgUmVxdWVzdElkOiA4N2QwNDRiOC1mMTU0LTExZTgtOGNkYS0yOTc0YzVlNGZiMjEgVmVyc2lvb...",
    "ExecutedVersion": "$LATEST"
}
```

### Example decode the logs

In the same command prompt, use the `base64` utility to decode the logs. The following example shows how to retrieve base64-encoded logs for `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail \
--query 'LogResult' --output text |  base64 -d
```

You should see the following output:

```
START RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8 Version: $LATEST
"AWS_SESSION_TOKEN": "AgoJb3JpZ2luX2VjELj...", "_X_AMZN_TRACE_ID": "Root=1-5d02e5ca-
f5792818b6fe8368e5b51d50;Parent=191db58857df8395;Sampled=0"",ask/lib:/opt/lib",
END RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8
REPORT RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8  Duration: 79.67 ms      Billed
 Duration: 80 ms         Memory Size: 128 MB     Max Memory Used: 73 MB
```

The `base64` utility is available on Linux, macOS, and Ubuntu on Windows. macOS users may need to use `base64 -D`.

For more information about the `Invoke` API, including a full list of parameters, headers, and errors, see Invoke (p. 993).

When you invoke a function directly, you can check the response for errors and retry. The AWS CLI and AWS SDK also automatically retry on client timeouts, throttling, and service errors. For more information, see Error handling and automatic retries in AWS Lambda (p. 250).

# Asynchronous invocation

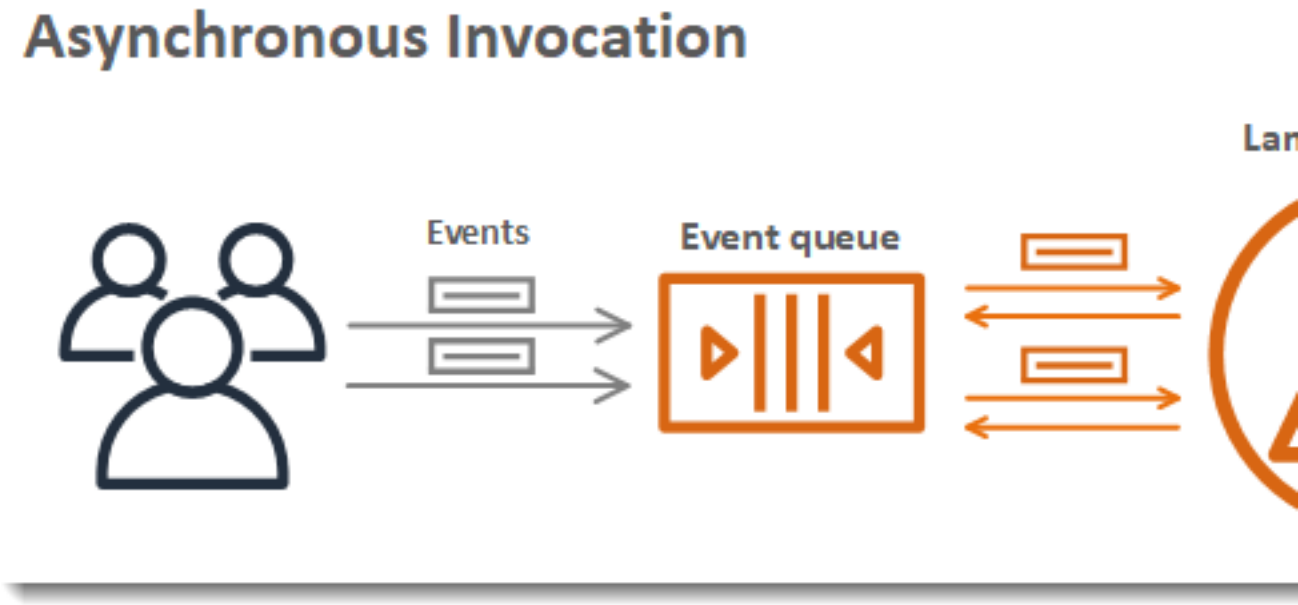
Several AWS services, such as Amazon Simple Storage Service (Amazon S3) and Amazon Simple Notification Service (Amazon SNS), invoke functions asynchronously to process events. When you invoke a function asynchronously, you don't wait for a response from the function code. You hand off the event to Lambda and Lambda handles the rest. You can configure how Lambda handles errors, and can send invocation records to a downstream resource to chain together components of your application.

**Sections**


- How Lambda handles asynchronous invocations (p. 228)
- Configuring error handling for asynchronous invocation (p. 230)
- Configuring destinations for asynchronous invocation (p. 230)
- Asynchronous invocation configuration API (p. 233)
- Dead-letter queues (p. 234)


## How Lambda handles asynchronous invocations

The following diagram shows clients invoking a Lambda function asynchronously. Lambda queues the events before sending them to the function.




For asynchronous invocation, Lambda places the event in a queue and returns a success response without additional information. A separate process reads events from the queue and sends them to your function. To invoke a function asynchronously, set the invocation type parameter to `Event`.

```
aws lambda invoke \
  --function-name my-function  \
      --invocation-type Event \
          --cli-binary-format raw-in-base64-out \
              --payload '{ "key": "value" }' response.json
```

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

```
{
    "StatusCode": 202
}
```

The output file (`response.json`) doesn't contain any information, but is still created when you run this command. If Lambda isn't able to add the event to the queue, the error message appears in the command output.

Lambda manages the function's asynchronous event queue and attempts to retry on errors. If the function returns an error, Lambda attempts to run it two more times, with a one-minute wait between the first two attempts, and two minutes between the second and third attempts. Function errors include errors returned by the function's code and errors returned by the function's runtime, such as timeouts.

If the function doesn't have enough concurrency available to process all events, additional requests are throttled. For throttling errors (429) and system errors (500-series), Lambda returns the event to the queue and attempts to run the function again for up to 6 hours. The retry interval increases exponentially from 1 second after the first attempt to a maximum of 5 minutes. If the queue contains many entries, Lambda increases the retry interval and reduces the rate at which it reads events from the queue.

Even if your function doesn't return an error, it's possible for it to receive the same event from Lambda multiple times because the queue itself is eventually consistent. If the function can't keep up with incoming events, events might also be deleted from the queue without being sent to the function. Ensure that your function code gracefully handles duplicate events, and that you have enough concurrency available to handle all invocations.

When the queue is very long, new events might age out before Lambda has a chance to send them to your function. When an event expires or fails all processing attempts, Lambda discards it. You can configure error handling (p. 230) for a function to reduce the number of retries that Lambda performs, or to discard unprocessed events more quickly.

You can also configure Lambda to send an invocation record to another service. Lambda supports the following destinations (p. 230) for asynchronous invocation.

- **Amazon SQS** – A standard SQS queue.
- **Amazon SNS** – An SNS topic.
- **AWS Lambda** – A Lambda function.
- **Amazon EventBridge** – An EventBridge event bus.

The invocation record contains details about the request and response in JSON format. You can configure separate destinations for events that are processed successfully, and events that fail all processing attempts. Alternatively, you can configure an Amazon SQS queue or Amazon SNS topic as a dead-letter queue (p. 234) for discarded events. For dead-letter queues, Lambda only sends the content of the event, without details about the response.

> **Note**
> To prevent a function from triggering, you can set the function's reserved concurrency to zero. When you set reserved concurrency to zero for an asynchronously-invoked function, Lambda begins sending new events to the configured dead-letter queue (p. 234) or the on-failure event destination (p. 230), without any retries. To process events that were sent while reserved concurrency was set to zero, you need to consume the events from the dead-letter queue or the on-failure event destination.

# Configuring error handling for asynchronous invocation

Use the Lambda console to configure error handling settings on a function, a version, or an alias.

**To configure error handling**

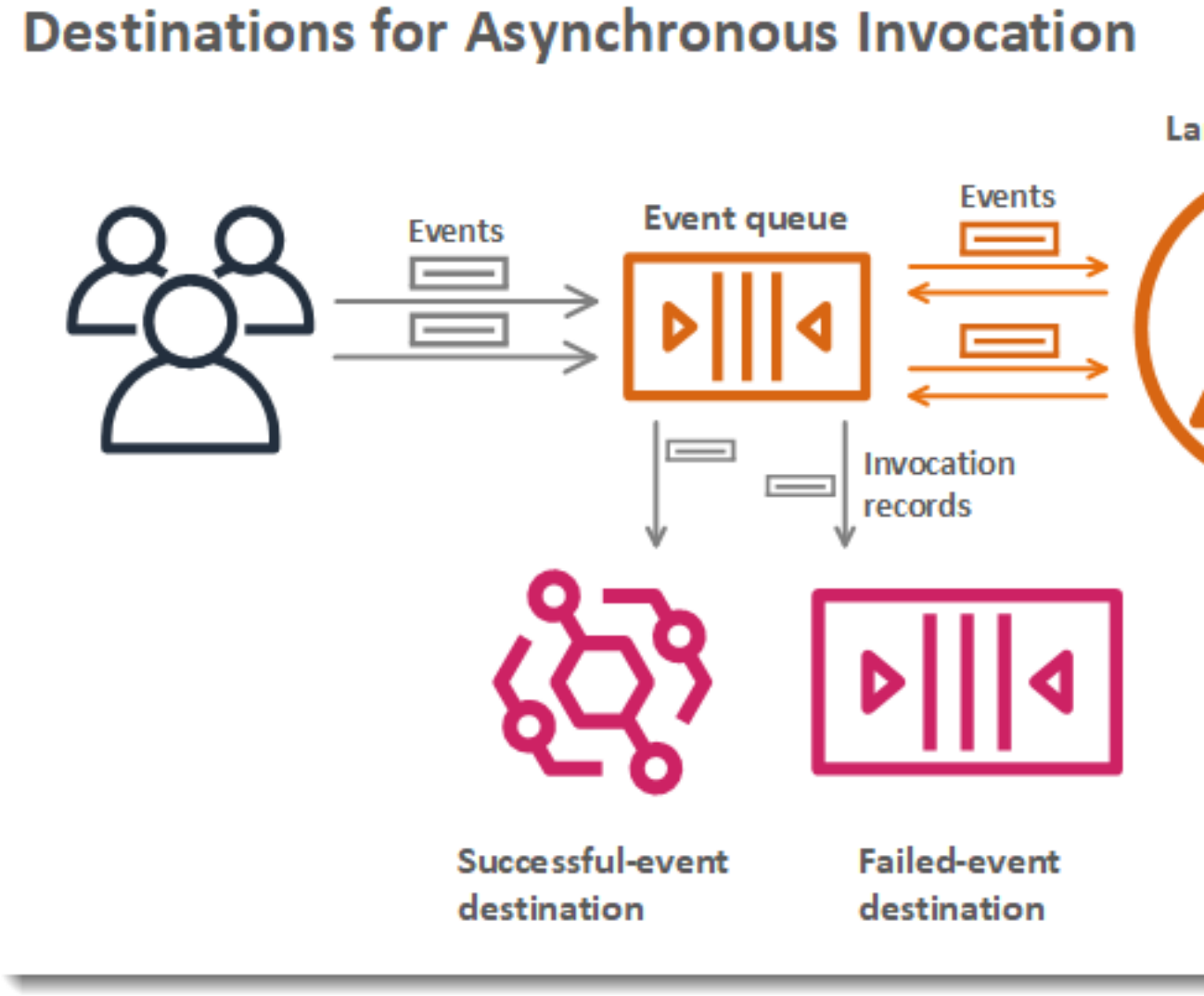
1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **Asynchronous invocation**.
4. Under **Asynchronous invocation**, choose **Edit**.
5. Configure the following settings.
   - **Maximum age of event** – The maximum amount of time Lambda retains an event in the asynchronous event queue, up to 6 hours.
   - **Retry attempts** – The number of times Lambda retries when the function returns an error, between 0 and 2.
6. Choose **Save**.

When an invocation event exceeds the maximum age or fails all retry attempts, Lambda discards it. To retain a copy of discarded events, configure a failed-event destination.

# Configuring destinations for asynchronous invocation

To send records of asynchronous invocations to another service, add a destination to your function. You can configure separate destinations for events that fail processing and events that are successfully processed. Like error handling settings, you can configure destinations on a function, a version, or an alias.

The following example shows a function that is processing asynchronous invocations. When the function returns a success response or exits without throwing an error, Lambda sends a record of the invocation to an EventBridge event bus. When an event fails all processing attempts, Lambda sends an invocation record to an Amazon SQS queue.




To send events to a destination, your function needs additional permissions. Add a policy with the required permissions to your function's execution role (p. 52). Each destination service requires a different permission, as follows:

- **Amazon SQS** – sqs:SendMessage
- **Amazon SNS** – sns:Publish
- **Lambda** – InvokeFunction (p. 993)
- **EventBridge** – events:PutEvents

Add destinations to your function in the Lambda console's function visualization.

### To configure a destination for asynchronous invocation records

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Under **Function overview**, choose **Add destination**.

4. For **Source**, choose **Asynchronous invocation**.
5. For **Condition**, choose from the following options:
   - **On failure** – Send a record when the event fails all processing attempts or exceeds the maximum age.
   - **On success** – Send a record when the function successfully processes an asynchronous invocation.
6. For **Destination type**, choose the type of resource that receives the invocation record.
7. For **Destination**, choose a resource.
8. Choose **Save**.

When an invocation matches the condition, Lambda sends a JSON document with details about the invocation to the destination.

### Destination-specific JSON format

- For Amazon SQS and Amazon SNS (`SnsDestination` and `SqsDestination`), the invocation record is passed as the `Message` to the destination.
- For Lambda (`LambdaDestination`), the invocation record is passed as the payload to the function.
- For EventBridge (`EventBridgeDestination`), the invocation record is passed as the `detail` in the PutEvents call. The value for the `source` event field is `lambda`. The value for the `detail-type` event field is either *Lambda Function Invocation Result – Success* or *Lambda Function Invocation Result – Failure*. The `resource` event field contains the function and destination Amazon Resource Names (ARNs). For other event fields, see Amazon EventBridge events.

The following example shows an invocation record for an event that failed three processing attempts due to a function error.

### Example invocation record

```
{
    "version": "1.0",
    "timestamp": "2019-11-14T18:16:05.568Z",
    "requestContext": {
        "requestId": "e4b46cbf-b738-xmpl-8880-a18cdf61200e",
        "functionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function:
$LATEST",
        "condition": "RetriesExhausted",
        "approximateInvokeCount": 3
    },
    "requestPayload": {
        "ORDER_IDS": [
            "9e07af03-ce31-4ff3-xmpl-36dce652cb4f",
            "637de236-e7b2-464e-xmpl-baf57f86bb53",
            "a81ddca6-2c35-45c7-xmpl-c3a03a31ed15"
        ]
    },
    "responseContext": {
        "statusCode": 200,
        "executedVersion": "$LATEST",
        "functionError": "Unhandled"
    },
    "responsePayload": {
        "errorMessage": "RequestId: e4b46cbf-b738-xmpl-8880-a18cdf61200e Process exited
 before completing request"
    }
}
```

The invocation record contains details about the event, the response, and the reason that the record was sent.

# Asynchronous invocation configuration API

To manage asynchronous invocation settings with the AWS CLI or AWS SDK, use the following API operations.

- PutFunctionEventInvokeConfig
- GetFunctionEventInvokeConfig
- UpdateFunctionEventInvokeConfig
- ListFunctionEventInvokeConfigs
- DeleteFunctionEventInvokeConfig

To configure asynchronous invocation with the AWS CLI, use the `put-function-event-invoke-config` command. The following example configures a function with a maximum event age of 1 hour and no retries.

```
aws lambda put-function-event-invoke-config --function-name error \
--maximum-event-age-in-seconds 3600 --maximum-retry-attempts 0
```

You should see the following output:

```
{
    "LastModified": 1573686021.479,
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:error:$LATEST",
    "MaximumRetryAttempts": 0,
    "MaximumEventAgeInSeconds": 3600,
    "DestinationConfig": {
        "OnSuccess": {},
        "OnFailure": {}
    }
}
```

The `put-function-event-invoke-config` command overwrites any existing configuration on the function, version, or alias. To configure an option without resetting others, use `update-function-event-invoke-config`. The following example configures Lambda to send a record to an SQS queue named `destination` when an event can't be processed.

```
aws lambda update-function-event-invoke-config --function-name error \
--destination-config '{"OnFailure":{"Destination": "arn:aws:sqs:us-
east-2:123456789012:destination"}}'
```

You should see the following output:

```
{
    "LastModified": 1573687896.493,
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:error:$LATEST",
    "MaximumRetryAttempts": 0,
    "MaximumEventAgeInSeconds": 3600,
    "DestinationConfig": {
        "OnSuccess": {},
        "OnFailure": {
            "Destination": "arn:aws:sqs:us-east-2:123456789012:destination"
        }
    }
```

```
}
```

# Dead-letter queues

As an alternative to an on-failure destination (p. 230), you can configure your function with a dead-letter queue to save discarded events for further processing. A dead-letter queue acts the same as an on-failure destination in that it is used when an event fails all processing attempts or expires without being processed. However, a dead-letter queue is part of a function's version-specific configuration, so it is locked in when you publish a version. On-failure destinations also support additional targets and include details about the function's response in the invocation record.

To reprocess events in a dead-letter queue, you can set it as an event source for your Lambda function. Alternatively, you can manually retrieve the events.

You can choose an Amazon SQS queue or Amazon SNS topic for your dead-letter queue. If you don't have a queue or topic, create one. Choose the target type that matches your use case.

- Amazon SQS queue – A queue holds failed events until they're retrieved. Choose an Amazon SQS queue if you expect a single entity, such as a Lambda function or CloudWatch alarm, to process the failed event. For more information, see Using Lambda with Amazon SQS (p. 697).

  Create a queue in the Amazon SQS console.
- Amazon SNS topic – A topic relays failed events to one or more destinations. Choose an Amazon SNS topic if you expect multiple entities to act on a failed event. For example, you can configure a topic to send events to an email address, a Lambda function, and/or an HTTP endpoint. For more information, see Using AWS Lambda with Amazon SNS (p. 689).

  Create a topic in the Amazon SNS console.

To send events to a queue or topic, your function needs additional permissions. Add a policy with the required permissions to your function's execution role (p. 52).

- **Amazon SQS** – sqs:SendMessage
- **Amazon SNS** – sns:Publish

If the target queue or topic is encrypted with a customer managed key, the execution role must also be a user in the key's resource-based policy.

After creating the target and updating your function's execution role, add the dead-letter queue to your function. You can configure multiple functions to send events to the same target.

### To configure a dead-letter queue

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **Asynchronous invocation**.
4. Under **Asynchronous invocation**, choose **Edit**.
5. Set **DLQ resource** to **Amazon SQS** or **Amazon SNS**.
6. Choose the target queue or topic.
7. Choose **Save**.

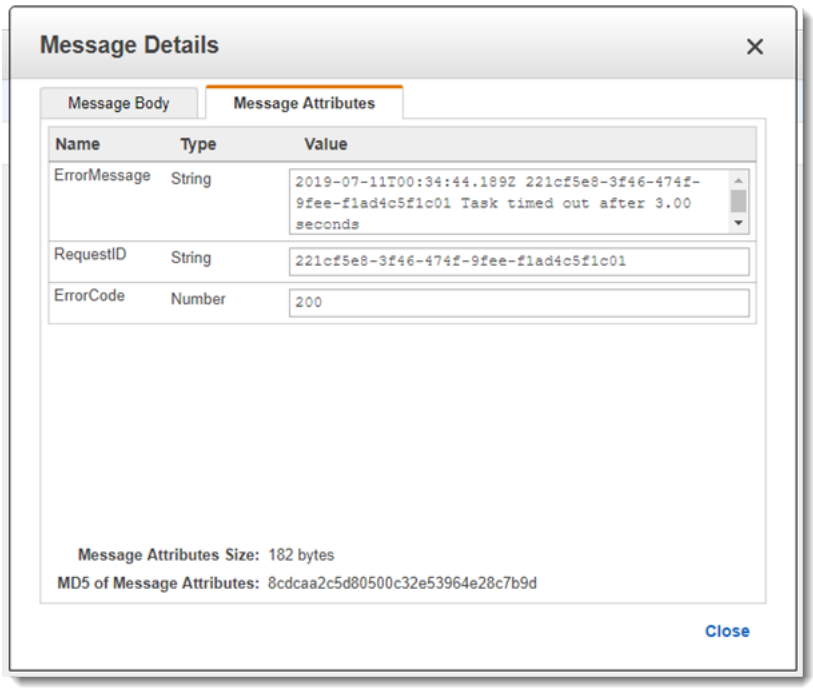
To configure a dead-letter queue with the AWS CLI, use the `update-function-configuration` command.

```
aws lambda update-function-configuration --function-name my-function \
--dead-letter-config TargetArn=arn:aws:sns:us-east-2:123456789012:my-topic
```

Lambda sends the event to the dead-letter queue as-is, with additional information in attributes. You can use this information to identify the error that the function returned, or to correlate the event with logs or an AWS X-Ray trace.

### Dead-letter queue message attributes

- **RequestID** (String) – The ID of the invocation request. Request IDs appear in function logs. You can also use the X-Ray SDK to record the request ID on an attribute in the trace. You can then search for traces by request ID in the X-Ray console. For an example, see the error processor sample (p. 807).
- **ErrorCode** (Number) – The HTTP status code.
- **ErrorMessage** (String) – The first 1 KB of the error message.




If Lambda can't send a message to the dead-letter queue, it deletes the event and emits the DeadLetterErrors (p. 727) metric. This can happen because of lack of permissions, or if the total size of the message exceeds the limit for the target queue or topic. For example, if an Amazon SNS notification with a body close to 256 KB triggers a function that results in an error, the additional event data added by Amazon SNS, combined with the attributes added by Lambda, can cause the message to exceed the maximum size allowed in the dead-letter queue.

If you're using Amazon SQS as an event source, configure a dead-letter queue on the Amazon SQS queue itself and not on the Lambda function. For more information, see Using Lambda with Amazon SQS (p. 697).

# Lambda event source mappings

An event source mapping is a Lambda resource that reads from an event source and invokes a Lambda function. You can use event source mappings to process items from a stream or queue in services that don't invoke Lambda functions directly. Lambda provides event source mappings for the following services.

**Services that Lambda reads events from**

- Amazon DynamoDB (p. 559)
- Amazon Kinesis (p. 613)
- Amazon MQ (p. 638)
- Amazon Managed Streaming for Apache Kafka (Amazon MSK) (p. 646)
- Self-managed Apache Kafka (p. 600)
- Amazon Simple Queue Service (Amazon SQS) (p. 697)

An event source mapping uses permissions in the function's execution role (p. 52) to read and manage items in the event source. Permissions, event structure, settings, and polling behavior vary by event source. For more information, see the linked topic for the service that you use as an event source.

To manage an event source with the AWS Command Line Interface (AWS CLI) or an AWS SDK, you can use the following API operations:

- CreateEventSourceMapping (p. 893)
- ListEventSourceMappings (p. 1006)
- GetEventSourceMapping (p. 952)
- UpdateEventSourceMapping (p. 1078)
- DeleteEventSourceMapping (p. 925)

The following example uses the AWS CLI to map a function named `my-function` to a DynamoDB stream that its Amazon Resource Name (ARN) specifies, with a batch size of 500.

```
aws lambda create-event-source-mapping --function-name my-function --batch-size 500 --
maximum-batching-window-in-seconds 5 --starting-position LATEST \
--event-source-arn arn:aws:dynamodb:us-east-2:123456789012:table/my-table/
stream/2019-06-10T19:26:16.525
```

You should see the following output:

```
{
    "UUID": "14e0db71-5d35-4eb5-b481-8945cf9d10c2",
    "BatchSize": 500,
    "MaximumBatchingWindowInSeconds": 5,
    "ParallelizationFactor": 1,
    "EventSourceArn": "arn:aws:dynamodb:us-east-2:123456789012:table/my-table/
stream/2019-06-10T19:26:16.525",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "LastModified": 1560209851.963,
    "LastProcessingResult": "No records processed",
    "State": "Creating",
    "StateTransitionReason": "User action",
    "DestinationConfig": {},
```

```
    "MaximumRecordAgeInSeconds": 604800,
    "BisectBatchOnFunctionError": false,
    "MaximumRetryAttempts": 10000
}
```

Lambda event source mappings process events at least once due to the distributed nature of its pollers. As a result, your Lambda function may receive duplicate events in rare situations. Follow Best practices for working with AWS Lambda functions (p. 792) and build idempotent functions to avoid issues related to duplicate events.

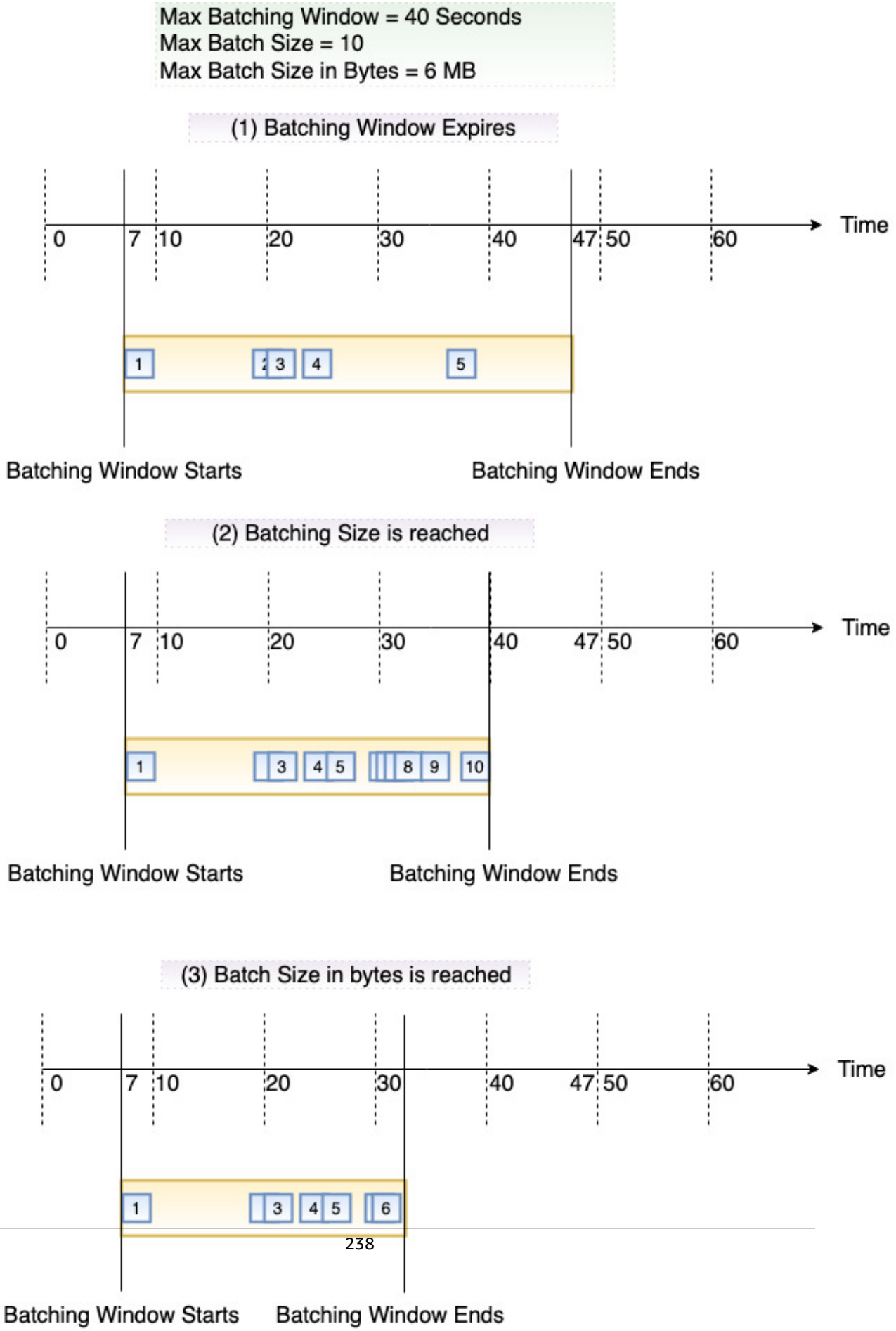
# Batching behavior

Event source mappings read items from a target event source. By default, an event source mapping batches records together into a single payload that Lambda sends to your function. To fine-tune batching behavior, you can configure a batching window (`MaximumBatchingWindowInSeconds`) and a batch size (`BatchSize`). A batching window is the maximum amount of time to gather records into a single payload. A batch size is the maximum number of records in a single batch. Lambda invokes your function when one of the following three criteria is met:

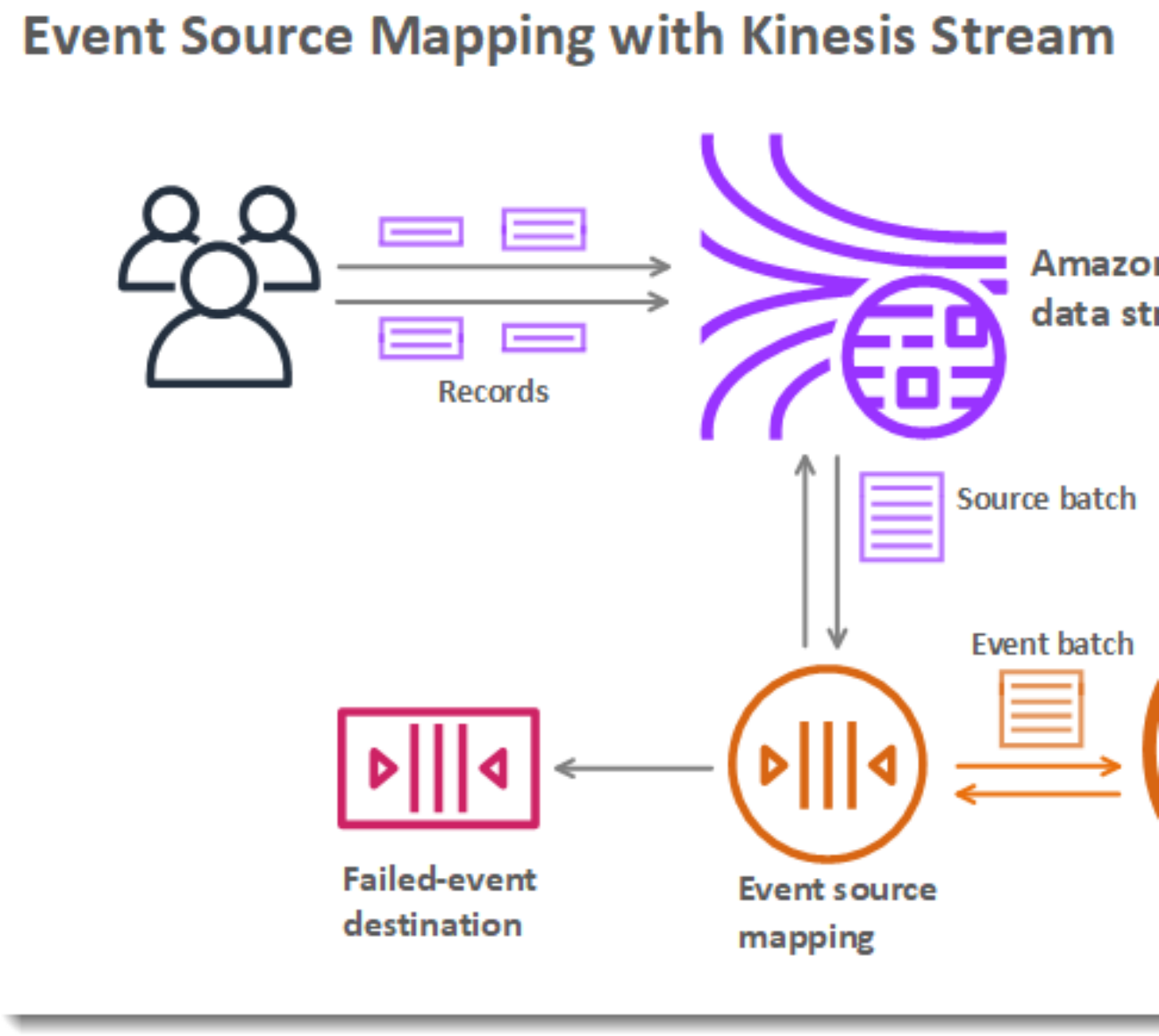
- **The batching window reaches its maximum value.** Batching window behavior varies depending on the specific event source.
  - **For Kinesis, DynamoDB, and Amazon SQS event sources:** The default batching window is 0 seconds. This means that Lambda sends batches to your function as quickly as possible. If you configure a `MaximumBatchingWindowInSeconds`, the next batching window begins as soon as the previous function invocation completes.
  - **For Amazon MSK, self-managed Apache Kafka, and Amazon MQ event sources:** The default batching window is 500 ms. You can configure `MaximumBatchingWindowInSeconds` to any value from 0 seconds to 300 seconds in increments of seconds. A batching window begins as soon as the first record arrives.

    **Note**
    Because you can only change `MaximumBatchingWindowInSeconds` in increments of seconds, you cannot revert back to the 500 ms default batching window after you have changed it. To restore the default batching window, you must create a new event source mapping.
- **The batch size is met.** The minimum batch size is 1. The default and maximum batch size depend on the event source. For details about these values, see the `BatchSize` specification for the `CreateEventSourceMapping` API operation.
- **The payload size reaches 6 MB.** You cannot modify this limit.

The following diagram illustrates these three conditions. Suppose a batching window begins at `t = 7` seconds. In the first scenario, the batching window reaches its 40 second maximum at `t = 47` seconds after accumulating 5 records. In the second scenario, the batch size reaches 10 before the batching window expires, so the batching window ends early. In the third scenario, the maximum payload size is reached before the batching window expires, so the batching window ends early.


Max Batching Window = 40 Seconds
Max Batch Size = 10
Max Batch Size in Bytes = 6 MB
(1) Batching Window Expires
0
7
10
20
30
40
47
50
60
Time
1
3
4
5
Batching Window Starts
Batching Window Ends
(2) Batching Size is reached
0
7
10
20
30
40
47
50
60
Time
1
3
4
5
8
9
10
Batching Window Starts
Batching Window Ends
(3) Batch Size in bytes is reached
0
7
10
20
30
40
47
50
60
Time
1
3
4
5
6
Batching Window Starts
Batching Window Ends

The following example shows an event source mapping that reads from a Kinesis stream. If a batch of events fails all processing attempts, the event source mapping sends details about the batch to an SQS queue.




The event batch is the event that Lambda sends to the function. It is a batch of records or messages compiled from the items that the event source mapping reads up until the current batching window expires.

For streams, an event source mapping creates an iterator for each shard in the stream and processes items in each shard in order. You can configure the event source mapping to read only new items that appear in the stream, or to start with older items. Processed items aren't removed from the stream, and other functions or consumers can process them.

By default, if your function returns an error, the event source mapping reprocesses the entire batch until the function succeeds, or the items in the batch expire. To ensure in-order processing, the event source mapping pauses processing for the affected shard until the error is resolved. You can configure the

event source mapping to discard old events, restrict the number of retries, or process multiple batches in parallel. If you process multiple batches in parallel, in-order processing is still guaranteed for each partition key, but the event source mapping simultaneously processes multiple partition keys in the same shard.

You can also configure the event source mapping to send an invocation record to another service when it discards an event batch. Lambda supports the following destinations (p. 230) for event source mappings.

- **Amazon SQS** – An SQS queue.
- **Amazon SNS** – An SNS topic.

The invocation record contains details about the failed event batch in JSON format.

The following example shows an invocation record for a Kinesis stream.

### Example invocation record

```
{
    "requestContext": {
        "requestId": "c9b8fa9f-5a7f-xmpl-af9c-0c604cde93a5",
        "functionArn": "arn:aws:lambda:us-east-2:123456789012:function:myfunction",
        "condition": "RetryAttemptsExhausted",
        "approximateInvokeCount": 1
    },
    "responseContext": {
        "statusCode": 200,
        "executedVersion": "$LATEST",
        "functionError": "Unhandled"
    },
    "version": "1.0",
    "timestamp": "2019-11-14T00:38:06.021Z",
    "KinesisBatchInfo": {
        "shardId": "shardId-000000000001",
        "startSequenceNumber": "49601189658422359378836298521827638475320189012309704722",
        "endSequenceNumber": "49601189658422359378836298522902373528957594348623495186",
        "approximateArrivalOfFirstRecord": "2019-11-14T00:38:04.835Z",
        "approximateArrivalOfLastRecord": "2019-11-14T00:38:05.580Z",
        "batchSize": 500,
        "streamArn": "arn:aws:kinesis:us-east-2:123456789012:stream/mystream"
    }
}
```

Lambda also supports in-order processing for FIFO (first-in, first-out) queues (p. 697), scaling up to the number of active message groups. For standard queues, items aren't necessarily processed in order. Lambda scales up to process a standard queue as quickly as possible. When an error occurs, Lambda returns batches to the queue as individual items and might process them in a different grouping than the original batch. Occasionally, the event source mapping might receive the same item from the queue twice, even if no function error occurred. Lambda deletes items from the queue after they're processed successfully. You can configure the source queue to send items to a dead-letter queue if Lambda can't process them.

For information about services that invoke Lambda functions directly, see Using AWS Lambda with other services (p. 496).

# Lambda event filtering

For Amazon Kinesis, Amazon DynamoDB, and Amazon Simple Queue Service (Amazon SQS) event sources, you can use event filtering to control which events Lambda sends to your function for processing. For example, you can define filter criteria so that you process only the records from a Kinesis stream that have the status code `ERROR`.

You can define up to five different filters for a single event source. If an event satisfies any one of these five filters, Lambda sends the event to your function. Otherwise, Lambda discards the event. An event either satisfies the filter criteria or it doesn't. If you're using batching windows, Lambda applies your filter criteria to each new event to determine whether to add it to the current batch.

**Topics**


- Event filtering basics (p. 241)
- Filter rule syntax (p. 242)
- Filtering examples (p. 243)
- Attaching filter criteria to an event source mapping (console) (p. 244)
- Attaching filter criteria to an event source mapping (AWS CLI) (p. 245)
- Properly filtering Amazon SQS messages (p. 246)
- Properly filtering Kinesis and DynamoDB messages (p. 247)


## Event filtering basics

A filter criteria (`FilterCriteria`) object is a structure that consists of a list of filters (`Filters`). Each filter (`Filter`) is a structure that defines an event filtering pattern (`Pattern`). A `Pattern` is a string representation of a JSON filter rule. A `FilterCriteria` object looks like the following example:

```
{
   "Filters": [
        {
            "Pattern": "{ \"Metadata1\": [ rule1 ], \"data\": { \"Data1\": [ rule2 ] }}"
        }
    ]
}
```

For added clarity, here is the value of the filter's `Pattern` expanded in plain JSON:

```
{
    "Metadata1": [ pattern1 ],
    "data": {
        "Data1": [ pattern2 ]
    }
}
```

There are three main parts to a `FilterCriteria` object: metadata properties, data properties, and filter patterns. For example, suppose you receive a Kinesis event from your event source that looks like the following:

```
"kinesis": {
    "partitionKey": "1",
    "sequenceNumber": "49590338271490256608559692538361571095921575989136588898",
    "data": {
        "City": "Seattle",
        "State": "WA",
        "Temperature": "46",
```

```
        "Month": "December"
    },
    "approximateArrivalTimestamp": 1545084650.987
}
```

- **Metadata properties** are the fields of the event object. In the example `FilterCriteria`, `Metadata1` refers to a metadata property. In the Kinesis event example, `Metadata1` could refer to a field such as `partitionKey`.
- **Data properties** are the fields of the event body. In the example `FilterCriteria`, `Data1` refers to a data property. In the Kinesis event example, `Data1` could refer to fields such as `City` and `Temperature`.

  **Note**
  To filter on data properties, make sure to contain them in `FilterCriteria` within the proper key. This key depends on the event source. For Kinesis event sources, the data key is `data`. For Amazon SQS event sources, the data key is `body`. For DynamoDB event sources, the data key is `dynamodb`.
- **Filter rules** define the filter that you want to apply to a specific property. In the example `FilterCriteria`, `rule1` applies to `Metadata1`, and `rule2` applies to `Data1`. The syntax of your filter rule depends on the comparison operator that you use. For more information, see Filter rule syntax (p. 242).

When you create a `FilterCriteria` object, specify only the metadata properties and data properties that you want the filter to match on. For Lambda to consider the event a match, the event must contain all the field names included in a filter. Lambda ignores the fields that aren't included in a filter.

# Filter rule syntax

For filter rules, Lambda supports the same set of syntax and rules as Amazon EventBridge. For more information, see Amazon EventBridge event patterns in the *Amazon EventBridge User Guide*.

The following is a summary of all the comparison operators available for Lambda event filtering.

| Comparison operator | Example | Rule syntax |
|---|---|---|
| Null | UserID is null | "UserID": [ null ] |
| Empty | LastName is empty | "LastName": [""] |
| Equals | Name is "Alice" | "Name": [ "Alice" ] |
| And | Location is "New York" and Day is "Monday" | "Location": [ "New York" ], "Day": ["Monday"] |
| Or | PaymentType is "Credit" or "Debit" | "PaymentType": [ "Credit", "Debit"] |
| Not | Weather is anything but "Raining" | "Weather": [ { "anything-but": [ "Raining" ] } ] |
| Numeric (equals) | Price is 100 | "Price": [ { "numeric": [ "=", 100 ] } ] |
| Numeric (range) | Price is more than 10, and less than or equal to 20 | "Price": [ { "numeric": [ ">", 10, "<=", 20 ] } ] |
| Exists | ProductName exists | "ProductName": [ { "exists": true } ] |

| Comparison operator | Example | Rule syntax |
|---|---|---|
| Does not exist | ProductName does not exist | "ProductName": [ { "exists": false } ] |
| Begins with | Region is in the US | "Region": [ {"prefix": "us-" } ] |

**Note**
Like EventBridge, for strings, Lambda uses exact character-by-character matching without case-folding or any other string normalization. For numbers, Lambda also uses string representation. For example, 300, 300.0, and 3.0e2 are not considered equal.

# Filtering examples

Suppose you have a Kinesis event source, and you want your function to handle only events with a specific `partitionKey` (a metadata property). In addition, you want to process only events with the `Location` field (a data property) equal to "Los Angeles". In this case, your `FilterCriteria` object would look like this:

```
{
   "Filters": [
        {
            "Pattern": "{ \"partitionKey\": [ \"1\" ], \"data\": { \"Location\": [ \"Los
 Angeles\" ] }}"
        }
    ]
}
```

For added clarity, here is the value of the filter's `Pattern` expanded in plain JSON.

```
{
    "partitionKey": [ "1" ],
    "data": {
        "Location": [ "Los Angeles" ]
    }
}
```

The previous example uses the **Equals** comparison operator for both `partitionKey` and `Location`.

As another example, suppose that you want to handle only events where the `Temperature` data property is greater than 50 but less than or equal to 60. In this case, your `FilterCriteria` object would look like this:

```
{
   "Filters": [
        {
            "Pattern": "{ \"data\": { \"Temperature\": [ {\"numeric\": [ \">\", 50, \"<=\",
 60 ] }]}"
        }
    ]
}
```

For added clarity, here is the value of the filter's `Pattern` expanded in plain JSON.

```
{
    "data": {
        "Temperature": [ {"numeric": [ ">", 50, "<=", 60 ] } ]
    }
```

```
}
```

The previous example uses the **Numeric (range)** comparison operator for `Temperature`.

## Multi-level filtering

You can also use event filtering to handle multi-level JSON filtering. For example, suppose you receive a DynamoDB stream event with a data object that looks like the following:

```
"dynamodb": {
    "Keys": {
        "Id": {
            "N": "101"
        }
    },
    "NewImage": {
        "Message": {
            "S": "New item!"
        },
        "Id": {
            "N": "101"
        }
    },
    "SequenceNumber": "111",
    "SizeBytes": 26,
    "StreamViewType": "NEW_AND_OLD_IMAGES"
}
```

Suppose you only wanted to handle events where the Key ID value, `N`, is 101. In this case, your `FilterCriteria` object would look like this:

```
{
   "Filters": [
        {
            "Pattern": "{ \"dynamodb\": { \"Keys\": { \"Id\": { \"N\": [ "101" ] } } } }"
        }
    ]
}
```

For added clarity, here is the value of the filter's `Pattern` expanded in plain JSON.

```
{
    "dynamodb": {
        "Keys": {
            "Id": {
                "N": [ "101" ]
            }
        }
    }
}
```

The previous example uses the **Equals** comparison operator for `N`, which is nested multiple layers within the `dynamodb` data field.

# Attaching filter criteria to an event source mapping (console)

Follow these steps to create a new event source mapping with filter criteria using the Lambda console.

**To create a new event source mapping with filter criteria (console)**

1. Open the Functions page of the Lambda console.
2. Choose the name of a function to create an event source mapping for.
3. Under **Function overview**, choose **Add trigger**.
4. For **Trigger configuration**, choose a trigger type that supports event filtering. These include **SQS**, **DynamoDB**, and **Kinesis**.
5. Expand **Additional settings**.
6. Under **Filter criteria**, define and enter your filters. For example, you can enter the following:

```
{ "a" : [ 1, 2 ] }
```

   This instructs Lambda to process only the records where field `a` is equal to 1 or 2.
7. Choose **Add**.

When you enter filter criteria using the console, you provide only the filter pattern. In step 6 of the preceding instructions, `{ "a" : [ 1, 2 ] }` corresponds to the following `FilterCriteria`:

```
{
   "Filters": [
      {
          "Pattern": "{ \"a\" : [ 1, 2 ] }"
      }
   ]
}
```

After creating your event source mapping in the console, you can see the formatted `FilterCriteria` in the trigger details. Note that when entering filters using the console, you don't need to provide the `Pattern` key or escape quotes.

> **Note**
> By default, you can have five different filters per event source. You can request a quota increase for up to 10 filters per event source. The Lambda console lets you add up to 10 filters depending on the current quota for your account. If you attempt to add more filters than your current quota allows, Lambda throws an error when you try to create the event source.

# Attaching filter criteria to an event source mapping (AWS CLI)

Suppose you want an event source mapping to have the following `FilterCriteria`:

```
{
   "Filters": [
      {
          "Pattern": "{ \"a\" : [ 1, 2 ] }"
      }
   ]
}
```

To create a new event source mapping with these filter criteria using the AWS Command Line Interface (AWS CLI), run the following command:

```
aws lambda create-event-source-mapping \
    --function-name my-function \
```

```
    --event-source-arn arn:aws:sqs:us-east-2:123456789012:my-queue \
    --filter-criteria "{\"Filters\": [{\"Pattern\": \"{ \"a\" : [ 1, 2 ]}\"}]}"
```

This CreateEventSourceMapping (p. 893) command creates a new Amazon SQS event source mapping for function `my-function` with the specified `FilterCriteria`.

To add these filter criteria to an existing event source mapping, run the following command:

```
aws lambda update-event-source-mapping \
    --uuid "a1b2c3d4-5678-90ab-cdef-11111EXAMPLE" \
    --filter-criteria "{\"Filters\": [{\"Pattern\": \"{ \"a\" : [ 1, 2 ]}\"}]}"
```

Note that to update an event source mapping, you need its UUID. You can get the UUID from a ListEventSourceMappings (p. 1006) call. Lambda also returns the UUID in the CreateEventSourceMapping (p. 893) API response.

To remove filter criteria from an event source, you can run the following UpdateEventSourceMapping (p. 1078) command with an empty `FilterCriteria` object:

```
aws lambda update-event-source-mapping \
    --uuid "a1b2c3d4-5678-90ab-cdef-11111EXAMPLE" \
    --filter-criteria "{}"
```

# Properly filtering Amazon SQS messages

If an Amazon SQS message doesn't satisfy your filter criteria, Lambda automatically removes the message from the queue. You don't have to manually delete these messages in Amazon SQS.

For Amazon SQS, the message `body` can be any string. However, this can be problematic if your `FilterCriteria` expects `body` to be in a valid JSON format. The reverse scenario is also true—if the incoming message `body` is in a valid JSON format, this can lead to unintended behavior if your filter criteria expects `body` to be a plain string.

To avoid this issue, ensure that the format of `body` in your `FilterCriteria` matches the expected format of `body` in messages that you receive from your queue. Before filtering your messages, Lambda automatically evaluates the format of the incoming message `body` and of your filter pattern for `body`. If there is a mismatch, Lambda drops the message. The following table summarizes this evaluation:

| Incoming message `body` format | Filter pattern `body` format | Resulting action |
|---|---|---|
| Plain string | Plain string | Lambda filters based on your filter criteria. |
| Plain string | No filter pattern for data properties | Lambda filters (on the other metadata properties only) based on your filter criteria. |
| Plain string | Valid JSON | Lambda drops the message. |
| Valid JSON | Plain string | Lambda drops the message. |
| Valid JSON | No filter pattern for data properties | Lambda filters (on the other metadata properties only) based on your filter criteria. |
| Valid JSON | Valid JSON | Lambda filters based on your filter criteria. |

If you don't include `body` as part of your `FilterCriteria`, Lambda skips this check.

# Properly filtering Kinesis and DynamoDB messages

Once your filter criteria processes an Kinesis or DynamoDB record, the streams iterator advances past this record. If the record doesn't satisfy your filter criteria, you don't have to manually delete the record from your event source. After the retention period, Kinesis and DynamoDB automatically delete these old records. If you want records to be deleted sooner, see Changing the Data Retention Period.

To properly filter events from stream event sources, both the data field and your filter criteria for the data field must be in valid JSON format. (For Kinesis, the data field is `data`. For DynamoDB, the data field is `dynamodb`.) If either field isn't in a valid JSON format, Lambda drops the message or throws an exception. The following table summarizes the specific behavior:

| **Incoming data format (`data` or `dynamodb`)** | **Filter pattern format for data properties** | **Resulting action** |
|---|---|---|
| Valid JSON | Valid JSON | Lambda filters based on your filter criteria. |
| Valid JSON | No filter pattern for data properties | Lambda filters (on the other metadata properties only) based on your filter criteria. |
| Valid JSON | Non-JSON | Lambda throws an exception at the time of the event source mapping creation or update. The filter pattern for data properties must be in a valid JSON format. |
| Non-JSON | Valid JSON | Lambda drops the record. |
| Non-JSON | No filter pattern for data properties | Lambda filters (on the other metadata properties only) based on your filter criteria. |
| Non-JSON | Non-JSON | Lambda throws an exception at the time of the event source mapping creation or update. The filter pattern for data properties must be in a valid JSON format. |

# Lambda function states

Lambda includes a state field in the function configuration for all functions to indicate when your function is ready to invoke. `State` provides information about the current status of the function, including whether you can successfully invoke the function. Function states do not change the behavior of function invocations or how your function runs the code. Function states include:

- `Pending` – After Lambda creates the function, it sets the state to pending. While in pending state, Lambda attempts to create or configure resources for the function, such as VPC or EFS resources. Lambda does not invoke a function during pending state. Any invocations or other API actions that operate on the function will fail.
- `Active` – Your function transitions to active state after Lambda completes resource configuration and provisioning. Functions can only be successfully invoked while active.
- `Failed` – Indicates that resource configuration or provisioning encountered an error.
- `Inactive` – A function becomes inactive when it has been idle long enough for Lambda to reclaim the external resources that were configured for it. When you try to invoke a function that is inactive, the invocation fails and Lambda sets the function to pending state until the function resources are recreated. If Lambda fails to recreate the resources, the function is set to the inactive state.

If you are using SDK-based automation workflows or calling Lambda's service APIs directly, ensure that you check a function's state before invocation to verify that it is active. You can do this with the Lambda API action GetFunction (p. 958), or by configuring a waiter using the AWS SDK for Java 2.0.

```
aws lambda get-function --function-name my-function --query 'Configuration.[State,
 LastUpdateStatus]'
```

You should see the following output:

```
[
 "Active",
 "Successful"
]
```

Functions have two other attributes, `StateReason` and `StateReasonCode`. These provide information and context about the function's state when it is not active for troubleshooting issues.

The following operations fail while function creation is pending:

- Invoke (p. 993)
- UpdateFunctionCode (p. 1088)
- UpdateFunctionConfiguration (p. 1098)
- PublishVersion (p. 1042)

## Function states while updating

Lambda provides additional context for functions undergoing updates with the `LastUpdateStatus` attribute, which can have the following statuses:

- `InProgress` – An update is happening on an existing function. While a function update is in progress, invocations go to the function's previous code and configuration.
- `Successful` – The update has completed. Once Lambda finishes the update, this stays set until a further update.

- `Failed` – The function update has failed. Lambda aborts the update and the function's previous code and configuration remain available.

### Example

The following is the result of `get-function-configuration` on a function undergoing an update.

```
{
    "FunctionName": "my-function",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "Runtime": "nodejs16.x",
    "VpcConfig": {
        "SubnetIds": [
            "subnet-071f712345678e7c8",
            "subnet-07fd123456788a036",
            "subnet-0804f77612345cacf"
        ],
        "SecurityGroupIds": [
            "sg-085912345678492fb"
        ],
        "VpcId": "vpc-08e1234569e011e83"
    },
    "State": "Active",
    "LastUpdateStatus": "InProgress",
    ...
}
```

FunctionConfiguration (p. 1148) has two other attributes, `LastUpdateStatusReason` and `LastUpdateStatusReasonCode`, to help troubleshoot issues with updating.

The following operations fail while an asynchronous update is in progress:

- UpdateFunctionCode (p. 1088)
- UpdateFunctionConfiguration (p. 1098)
- PublishVersion (p. 1042)

# Error handling and automatic retries in AWS Lambda

When you invoke a function, two types of error can occur. Invocation errors occur when the invocation request is rejected before your function receives it. Function errors occur when your function's code or runtime (p. 82) returns an error. Depending on the type of error, the type of invocation, and the client or service that invokes the function, the retry behavior and the strategy for managing errors varies.

Issues with the request, caller, or account can cause invocation errors. Invocation errors include an error type and status code in the response that indicate the cause of the error.

### Common invocation errors

- **Request** – The request event is too large or isn't valid JSON, the function doesn't exist, or a parameter value is the wrong type.
- **Caller** – The user or service doesn't have permission to invoke the function.
- **Account** – The maximum number of function instances are already running, or requests are being made too quickly.

Clients such as the AWS CLI and the AWS SDK retry on client timeouts, throttling errors (429), and other errors that aren't caused by a bad request. For a full list of invocation errors, see Invoke (p. 993).

Function errors occur when your function code or the runtime that it uses return an error.

### Common function errors

- **Function** – Your function's code throws an exception or returns an error object.
- **Runtime** – The runtime terminated your function because it ran out of time, detected a syntax error, or failed to marshal the response object into JSON. The function exited with an error code.

Unlike invocation errors, function errors don't cause Lambda to return a 400-series or 500-series status code. If the function returns an error, Lambda indicates this by including a header named `X-Amz-Function-Error`, and a JSON-formatted response with the error message and other details. For examples of function errors in each language, see the following topics.

- AWS Lambda function errors in Node.js (p. 300)
- AWS Lambda function errors in Python (p. 345)
- AWS Lambda function errors in Ruby (p. 370)
- AWS Lambda function errors in Java (p. 405)
- AWS Lambda function errors in Go (p. 440)
- AWS Lambda function errors in C# (p. 471)
- AWS Lambda function errors in PowerShell (p. 492)

When you invoke a function directly, you determine the strategy for handling errors. You can retry, send the event to a queue for debugging, or ignore the error. Your function's code might have run completely, partially, or not at all. If you retry, ensure that your function's code can handle the same event multiple times without causing duplicate transactions or other unwanted side effects.

When you invoke a function indirectly, you need to be aware of the retry behavior of the invoker and any service that the request encounters along the way. This includes the following scenarios.

- **Asynchronous invocation** – Lambda retries function errors twice. If the function doesn't have enough capacity to handle all incoming requests, events might wait in the queue for hours or days to be sent to the function. You can configure a dead-letter queue on the function to capture events that weren't successfully processed. For more information, see Asynchronous invocation (p. 228).
- **Event source mappings** – Event source mappings that read from streams retry the entire batch of items. Repeated errors block processing of the affected shard until the error is resolved or the items expire. To detect stalled shards, you can monitor the Iterator Age (p. 727) metric.

  For event source mappings that read from a queue, you determine the length of time between retries and destination for failed events by configuring the visibility timeout and redrive policy on the source queue. For more information, see Lambda event source mappings (p. 236) and the service-specific topics under Using AWS Lambda with other services (p. 496).
- **AWS services** – AWS services can invoke your function synchronously (p. 225) or asynchronously. For synchronous invocation, the service decides whether to retry. For example, Amazon S3 batch operations retries the operation if the Lambda function returns a `TemporaryFailure` response code. Services that proxy requests from an upstream user or client may have a retry strategy or may relay the error response back to the requestor. For example, API Gateway always relays the error response back to the requestor.

  For asynchronous invocation, the behavior is the same as when you invoke the function synchronously. For more information, see the service-specific topics under Using AWS Lambda with other services (p. 496) and the invoking service's documentation.
- **Other accounts and clients** – When you grant access to other accounts, you can use resource-based policies (p. 68) to restrict the services or resources they can configure to invoke your function. To protect your function from being overloaded, consider putting an API layer in front of your function with Amazon API Gateway (p. 502).

To help you deal with errors in Lambda applications, Lambda integrates with services like Amazon CloudWatch and AWS X-Ray. You can use a combination of logs, metrics, alarms, and tracing to quickly detect and identify issues in your function code, API, or other resources that support your application. For more information, see Monitoring and troubleshooting Lambda applications (p. 718).

For a sample application that uses a CloudWatch Logs subscription, X-Ray tracing, and a Lambda function to detect and process errors, see Error processor sample application for AWS Lambda (p. 807).

# Testing Lambda functions in the console

You can test your Lambda function in the console by invoking your function with a test event. A *test event* is a JSON input to your function. If your function doesn't require input, the event can be an empty document (`{}`).

## Private test events

Private test events are available only to the event creator, and they require no additional permissions to use. You can create and save up to 10 private test events per function.

**To create a private test event**

1. Open the Functions page of the Lambda console.
2. Choose the name of the function that you want to test.
3. Choose the **Test** tab.
4. Under **Test event**, do the following:
    a. Choose a **Template**.
    b. Enter a **Name** for the test.
    c. In the text entry box, enter the JSON test event.
    d. Under **Event sharing settings**, choose **Private**.
5. Choose **Save changes**.

You can also create new test events on the **Code** tab. From there, choose **Test**, **Configure test event**.

## Shareable test events

Shareable test events are test events that you can share with other AWS Identity and Access Management (IAM) users in the same AWS account. You can edit other users' shareable test events and invoke your function with them.

Lambda saves shareable test events as schemas in an Amazon EventBridge (CloudWatch Events) schema registry named `lambda-testevent-schemas`. As Lambda utilizes this registry to store and call shareable test events you create, we recommend that you do not edit this registry or create a registry using the `lambda-testevent-schemas` name.

To see, share, and edit shareable test events, you must have permissions for all of the following EventBridge (CloudWatch Events) schema registry API operations:

- `schemas.CreateRegistry`
- `schemas.CreateSchema`
- `schemas.DeleteSchema`
- `schemas.DeleteSchemaVersion`
- `schemas.DescribeRegistry`
- `schemas.DescribeSchema`
- `schemas.GetDiscoveredSchema`
- `schemas.ListSchemaVersions`
- `schemas.UpdateSchema`

Note that saving edits made to a shareable test event overwrites that event.

If you cannot create, edit, or see shareable test events, check that your account has the required permissions for these operations. If you have the required permissions but still cannot access shareable test events, check for any resource-based policies (p. 68) that might limit access to the EventBridge (CloudWatch Events) registry.

**To create a shareable test event**

1. Open the Functions page of the Lambda console.
2. Choose the name of the function that you want to test.
3. Choose the **Test** tab.
4. Under **Test event**, do the following:
   a. Choose a **Template**.
   b. Enter a **Name** for the test.
   c. In the text entry box, enter the JSON test event.
   d. Under **Event sharing settings**, choose **Shareable**.
5. Choose **Save changes**.

# Invoking functions with test events

When you run a test event in the console, Lambda synchronously invokes your function with the test event. The function runtime converts the JSON document into an object and passes it to your code's handler method for processing.

**To test a function**

1. Open the Functions page of the Lambda console.
2. Choose the name of the function that you want to test.
3. Choose the **Test** tab.
4. Under **Test event**, choose **Saved event**, and then choose the saved event that you want to use.
5. Choose **Test**.
6. To review the test results, under **Execution result**, expand **Details**.

To invoke your function without saving your test event, choose **Test** before saving. This creates an unsaved test event that Lambda preserves for the duration of the session.

You can also access your saved and unsaved test events on the **Code** tab. From there, choose **Test**, and then choose your test event.

# Deleting shareable test event schemas

When you delete shareable test events, Lambda removes them from the `lambda-testevent-schemas` registry. If you remove the last shareable test event from the registry, Lambda deletes the registry.

If you delete the function, Lambda does not delete any associated shareable test event schemas. You must clean up these resources manually from the EventBridge (CloudWatch Events) console.

# Using Lambda extensions

You can use Lambda extensions to augment your Lambda functions. For example, use Lambda extensions to integrate functions with your preferred monitoring, observability, security, and governance tools. You can choose from a broad set of tools that AWS Lambda Partners provides, or you can create your own Lambda extensions (p. 101).

Lambda supports external and internal extensions. An external extension runs as an independent process in the execution environment and continues to run after the function invocation is fully processed. Because extensions run as separate processes, you can write them in a different language than the function. All Lambda runtimes (p. 82) support extensions.

An internal extension runs as part of the runtime process. Your function accesses internal extensions by using wrapper scripts or in-process mechanisms such as `JAVA_TOOL_OPTIONS`. For more information, see Modifying the runtime environment (p. 85).

You can add extensions to a function using the Lambda console, the AWS Command Line Interface (AWS CLI), or infrastructure as code (IaC) services and tools such as AWS CloudFormation, AWS Serverless Application Model (AWS SAM), and Terraform.

You are charged for the execution time that the extension consumes (in 1 ms increments). For more pricing information for extensions, see AWS Lambda Pricing. For pricing information for partner extensions, see those partners' websites. There is no cost to install your own extensions.

**Topics**


- Execution environment (p. 254)
- Impact on performance and resources (p. 255)
- Permissions (p. 255)
- Configuring extensions (.zip file archive) (p. 255)
- Using extensions in container images (p. 256)
- Next steps (p. 256)


## Execution environment

Lambda invokes your function in an execution environment (p. 100), which provides a secure and isolated runtime environment. The execution environment manages the resources required to run your function and provides lifecycle support for the function's runtime and extensions.

The lifecycle of the execution environment includes the following phases:

- **`Init`**: In this phase, Lambda creates or unfreezes an execution environment with the configured resources, downloads the code for the function and all layers, initializes any extensions, initializes the runtime, and then runs the function's initialization code (the code outside the main handler). The `Init` phase happens either during the first invocation, or in advance of function invocations if you have enabled provisioned concurrency (p. 183).

  The `Init` phase is split into three sub-phases: `Extension init`, `Runtime init`, and `Function init`. These sub-phases ensure that all extensions and the runtime complete their setup tasks before the function code runs.
- **`Invoke`**: In this phase, Lambda invokes the function handler. After the function runs to completion, Lambda prepares to handle another function invocation.
- **`Shutdown`**: This phase is triggered if the Lambda function does not receive any invocations for a period of time. In the `Shutdown` phase, Lambda shuts down the runtime, alerts the extensions to let them

stop cleanly, and then removes the environment. Lambda sends a `Shutdown` event to each extension, which tells the extension that the environment is about to be shut down.

During the `Init` phase, Lambda extracts layers containing extensions into the `/opt` directory in the execution environment. Lambda looks for extensions in the `/opt/extensions/` directory, interprets each file as an executable bootstrap for launching the extension, and starts all extensions in parallel.

# Impact on performance and resources

The size of your function's extensions counts towards the deployment package size limit. For a .zip file archive, the total unzipped size of the function and all extensions cannot exceed the unzipped deployment package size limit of 250 MB.

Extensions can impact the performance of your function because they share function resources such as CPU, memory, and storage. For example, if an extension performs compute-intensive operations, you may see your function's execution duration increase.

Each extension must complete its initialization before Lambda invokes the function. Therefore, an extension that consumes significant initialization time can increase the latency of the function invocation.

To measure the extra time that the extension takes after the function execution, you can use the `PostRuntimeExtensionsDuration` function metric (p. 727). To measure the increase in memory used, you can use the `MaxMemoryUsed` metric. To understand the impact of a specific extension, you can run different versions of your functions side by side.

# Permissions

Extensions have access to the same resources as functions. Because extensions are executed within the same environment as the function, permissions are shared between the function and the extension.

For a .zip file archive, you can create an AWS CloudFormation template to simplify the task of attaching the same extension configuration—including AWS Identity and Access Management (IAM) permissions—to multiple functions.

# Configuring extensions (.zip file archive)

You can add an extension to your function as a Lambda layer (p. 156). Using layers enables you to share extensions across your organization or to the entire community of Lambda developers. You can add one or more extensions to a layer. You can register up to 10 extensions for a function.

You add the extension to your function using the same method as you would for any layer. For more information, see Using layers with your Lambda function (p. 219).

### Add an extension to your function (console)

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose the **Code** tab if it is not already selected.
4. Under **Layers**, choose **Edit**.
5. For **Choose a layer**, choose **Specify an ARN**.
6. For **Specify an ARN**, enter the Amazon Resource Name (ARN) of an extension layer.
7. Choose **Add**.

# Using extensions in container images

You can add extensions to your container image (p. 143). The ENTRYPOINT container image setting specifies the main process for the function. Configure the ENTRYPOINT setting in the Dockerfile, or as an override in the function configuration.

You can run multiple processes within a container. Lambda manages the lifecycle of the main process and any additional processes. Lambda uses the Extensions API (p. 101) to manage the extension lifecycle.

## Example: Adding an external extension

An external extension runs in a separate process from the Lambda function. Lambda starts a process for each extension in the `/opt/extensions/` directory. Lambda uses the Extensions API to manage the extension lifecycle. After the function has run to completion, Lambda sends a `Shutdown` event to each external extension.

**Example of adding an external extension to a Python base image**

```
FROM public.ecr.aws/lambda/python:3.8

# Copy and install the app
COPY /app /app
WORKDIR /app
RUN pip install -r requirements.txt

# Add an extension from the local directory into /opt
ADD my-extension.zip /opt
CMD python ./my-function.py
```

# Next steps

To learn more about extensions, we recommend the following resources:

- For a basic working example, see Building Extensions for AWS Lambda on the AWS Compute Blog.
- For information about extensions that AWS Lambda Partners provides, see Introducing AWS Lambda Extensions on the AWS Compute Blog.
- To view available example extensions and wrapper scripts, see AWS Lambda Extensions on the AWS Samples GitHub repository.

# Invoking functions defined as container images

For a Lambda function defined as a container image, function behavior during invocation is very similar to a function defined as a .zip file archive. The following sections highlight the similarities and differences.

**Topics**


- Function lifecycle (p. 257)
- Invoking the function (p. 257)
- Image security (p. 257)


## Function lifecycle

After you upload a new or updated container image, Lambda optimizes the image before the function can process invocations. The optimization process can take a few seconds. The function remains in the `Pending` state until the process completes. The function then transitions to the `Active` state. While the state is `Pending`, you can invoke the function, but other operations on the function fail. Invocations that occur while an image update is in progress run the code from the previous image.

If a function is not invoked for multiple weeks, Lambda reclaims its optimized version, and the function transitions to the `Inactive` state. To reactivate the function, you must invoke it. Lambda rejects the first invocation and the function enters the `Pending` state until Lambda re-optimizes the image. The function then returns to the `Active` state.

Lambda periodically fetches the associated container image from the Amazon Elastic Container Registry (Amazon ECR) repository. If the corresponding container image no longer exists on Amazon ECR or permissions are revoked, the function enters the `Failed` state, and Lambda returns a failure for any function invocations.

You can use the Lambda API to get information about a function's state. For more information, see Lambda function states (p. 248).

## Invoking the function

When you invoke the function, Lambda deploys the container image to an execution environment. Lambda initializes any extensions (p. 256) and then runs the function's initialization code (the code outside the main handler). Note that function initialization duration is included in billed execution time.

Lambda then runs the function by calling the code entry point specified in the function configuration (the ENTRYPOINT and CMD container image settings (p. 150)).

## Image security

When Lambda first downloads the container image from its original source (Amazon ECR), the container image is optimized, encrypted, and stored using authenticated convergent encryption methods. All keys that are required to decrypt customer data are protected using AWS KMS customer managed keys. To track and audit Lambda's usage of customer managed keys, you can view the AWS CloudTrail logs (p. 525).

# Lambda function URLs

A function URL is a dedicated HTTP(S) endpoint for your Lambda function. You can create and configure a function URL through the Lambda console or the Lambda API. When you create a function URL, Lambda automatically generates a unique URL endpoint for you. Once you create a function URL, its URL endpoint never changes. Function URL endpoints have the following format:

```
https://<url-id>.lambda-url.<region>.on.aws
```

Function URLs are dual stack-enabled, supporting IPv4 and IPv6. After you configure a function URL for your function, you can invoke your function through its HTTP(S) endpoint via a web browser, curl, Postman, or any HTTP client. Lambda function URLs use resource-based policies (p. 68) for security and access control. Function URLs also support cross-origin resource sharing (CORS) configuration options.

You can apply function URLs to any function alias, or to the `$LATEST` unpublished function version. You can't add a function URL to any other function version.

**Topics**


- Creating and managing Lambda function URLs (p. 259)
- Security and auth model for Lambda function URLs (p. 264)
- Invoking Lambda function URLs (p. 269)
- Monitoring Lambda function URLs (p. 276)
- Tutorial: Creating a Lambda function with a function URL (p. 278)

# Creating and managing Lambda function URLs

A function URL is a dedicated HTTP(S) endpoint for your Lambda function. You can create and configure a function URL through the Lambda console or the Lambda API. When you create a function URL, Lambda automatically generates a unique URL endpoint for you. Once you create a function URL, its URL endpoint never changes. Function URL endpoints have the following format:

```
https://<url-id>.lambda-url.<region>.on.aws
```

**Topics**


- Creating a function URL (console) (p. 259)
- Creating a function URL (AWS CLI) (p. 260)
- Adding a function URL to a CloudFormation template (p. 260)
- Cross-origin resource sharing (CORS) (p. 262)
- Throttling function URLs (p. 262)
- Deactivating function URLs (p. 263)
- Deleting function URLs (p. 263)


## Creating a function URL (console)

Follow these steps to create a function URL using the console.

### To create a function URL for an existing function (console)

1. Open the Functions page of the Lambda console.
2. Choose the name of the function that you want to create the function URL for.
3. Choose the **Configuration** tab, and then choose **Function URL**.
4. Choose **Create function URL**.
5. For **Auth type**, choose **AWS_IAM** or **NONE**. For more information about function URL authentication, see Security and auth model (p. 264).
6. (Optional) Select **Configure cross-origin resource sharing (CORS)**, and then configure the CORS settings for your function URL. For more information about CORS, see Cross-origin resource sharing (CORS) (p. 262).
7. Choose **Save**.

This creates a function URL for the `$LATEST` unpublished version of your function. The function URL appears in the **Function overview** section of the console.

### To create a function URL for an existing alias (console)

1. Open the Functions page of the Lambda console.
2. Choose the name of the function with the alias that you want to create the function URL for.
3. Choose the **Aliases** tab, and then choose the name of the alias that you want to create the function URL for.
4. Choose the **Configuration** tab, and then choose **Function URL**.
5. Choose **Create function URL**.
6. For **Auth type**, choose **AWS_IAM** or **NONE**. For more information about function URL authentication, see Security and auth model (p. 264).

7. (Optional) Select **Configure cross-origin resource sharing (CORS)**, and then configure the CORS settings for your function URL. For more information about CORS, see Cross-origin resource sharing (CORS) (p. 262).
8. Choose **Save**.

This creates a function URL for your function alias. The function URL appears in the console's **Function overview** section for your alias.

### To create a new function with a function URL (console)

**To create a new function with a function URL (console)**

1. Open the Functions page of the Lambda console.
2. Choose **Create function**.
3. Under **Basic information**, do the following:
   a. For **Function name**, enter a name for your function, such as **`my-function`**.
   b. For **Runtime**, choose the language runtime that you prefer, such as **Node.js 14.x**.
   c. For **Architecture**, choose either **x86_64** or **arm64**.
   d. Expand **Permissions**, then choose whether to create a new execution role or use an existing one.
4. Expand **Advanced settings**, and then select **Function URL**.
5. For **Auth type**, choose **AWS_IAM** or **NONE**. For more information about function URL authentication, see Security and auth model (p. 264).
6. (Optional) Select **Configure cross-origin resource sharing (CORS)**. By selecting this option during function creation, your function URL allows requests from all origins by default. You can edit the CORS settings for your function URL after creating the function. For more information about CORS, see Cross-origin resource sharing (CORS) (p. 262).
7. Choose **Create function**.

This creates a new function with a function URL for the `$LATEST` unpublished version of the function. The function URL appears in the **Function overview** section of the console.

## Creating a function URL (AWS CLI)

To create a function URL for an existing Lambda function using the AWS Command Line Interface (AWS CLI), run the following command:

```
aws lambda create-function-url-config \
    --function-name my-function \
    --qualifier prod \ // optional
    --auth-type AWS_IAM
    --cors-config {AllowOrigins="https://example.com"} // optional
```

This adds a function URL to the **`prod`** qualifier for the function **`my-function`**. For more information about these configuration parameters, see CreateFunctionUrlConfig in the API reference.

> **Note**
> To create a function URL via the AWS CLI, the function must already exist.

## Adding a function URL to a CloudFormation template

To add an `AWS::Lambda::Url` resource to your AWS CloudFormation template, use the following syntax:

## JSON

```
{
  "Type" : "AWS::Lambda::Url",
  "Properties" : {
      "AuthType" : String,
      "Cors" : Cors,
      "Qualifier" : String,
      "TargetFunctionArn" : String
    }
}
```

## YAML

```
Type: AWS::Lambda::Url
Properties:
  AuthType: String
  Cors:
    Cors
  Qualifier: String
  TargetFunctionArn: String
```

## Parameters

- (Required) `AuthType` – Defines the type of authentication for your function URL. Possible values are either `AWS_IAM` or `NONE`. To restrict access to authenticated IAM users only, set to `AWS_IAM`. To bypass IAM authentication and allow any user to make requests to your function, set to `NONE`.
- (Optional) `Cors` – Defines the CORS settings (p. 262) for your function URL. To add `Cors` to your `AWS::Lambda::Url` resource in CloudFormation, use the following syntax.

**Example AWS::Lambda::Url.Cors (JSON)**

```
{
  "AllowCredentials" : Boolean,
  "AllowHeaders" : [ String, ... ],
  "AllowMethods" : [ String, ... ],
  "AllowOrigins" : [ String, ... ],
  "ExposeHeaders" : [ String, ... ],
  "MaxAge" : Integer
}
```

**Example AWS::Lambda::Url.Cors (YAML)**

```
  AllowCredentials: Boolean
  AllowHeaders:
    - String
  AllowMethods:
    - String
  AllowOrigins:
    - String
  ExposeHeaders:
    - String
  MaxAge: Integer
```

- (Optional) `Qualifier` – The alias name.

- (Required) `TargetFunctionArn` – The name or Amazon Resource Name (ARN) of the Lambda function. Valid name formats include the following:
  - **Function name** – `my-function`
  - **Function ARN** – `arn:aws:lambda:us-west-2:123456789012:function:my-function`
  - **Partial ARN** – `123456789012:function:my-function`

# Cross-origin resource sharing (CORS)

To define how different origins can access your function URL, use cross-origin resource sharing (CORS). We recommend configuring CORS if you intend to call your function URL from a different domain. Lambda supports the following CORS headers for function URLs.

| CORS header | CORS configuration property | Example values |
|---|---|---|
| Access-Control-Allow-Origin | `AllowOrigins` | `*` (allow all origins)<br>`https://www.example.com`<br>`http://localhost:60905` |
| Access-Control-Allow-Methods | `AllowMethods` | `GET`, `POST`, `DELETE`, `*` |
| Access-Control-Allow-Headers | `AllowHeaders` | `Date`, `Keep-Alive`, `X-Custom-Header` |
| Access-Control-Expose-Headers | `ExposeHeaders` | `Date`, `Keep-Alive`, `X-Custom-Header` |
| Access-Control-Allow-Credentials | `AllowCredentials` | `TRUE` |
| Access-Control-Max-Age | `MaxAge` | `5` (default), `300` |

When you configure CORS for a function URL using the Lambda console or the AWS CLI, Lambda automatically adds the CORS headers to all responses through the function URL. Alternatively, you can manually add CORS headers to your function response. If there are conflicting headers, the configured CORS headers on the function URL take precedence.

# Throttling function URLs

Throttling limits the rate at which your function processes requests. This is useful in many situations, such as preventing your function from overloading downstream resources, or handling a sudden surge in requests.

You can throttle the rate of requests that your Lambda function processes through a function URL by configuring reserved concurrency. Reserved concurrency limits the number of maximum concurrent invocations for your function. Your function's maximum request rate per second (RPS) is equivalent to 10 times the configured reserved concurrency. For example, if you configure your function with a reserved concurrency of 100, then the maximum RPS is 1,000.

Whenever your function concurrency exceeds the reserved concurrency, your function URL returns an HTTP `429` status code. If your function receives a request that exceeds the 10x RPS maximum based on your configured reserved concurrency, you also receive an HTTP `429` error. For more information about reserved concurrency, see Managing Lambda reserved concurrency (p. 180).

# Deactivating function URLs

In an emergency, you might want to reject all traffic to your function URL. To deactivate your function URL, set the reserved concurrency to zero. This throttles all requests to your function URL, resulting in HTTP `429` status responses. To reactivate your function URL, delete the reserved concurrency configuration, or set the configuration to an amount greater than zero.

# Deleting function URLs

When you delete a function URL, you can't recover it. Creating a new function URL will result in a different URL address.

1. Open the Functions page of the Lambda console.
2. Choose the name of the function.
3. Choose the **Configuration** tab, and then choose **Function URL**.
4. Choose **Delete**.
5. Enter the word *delete* into the field to confirm the deletion.
6. Choose **Delete**.

**Note**
If you delete a function URL with auth type `NONE`, Lambda doesn't automatically delete the associated resource-based policy. If you want to delete this policy, you must manually do so.

# Security and auth model for Lambda function URLs

You can control access to your Lambda function URLs using the `AuthType` parameter combined with resource-based policies (p. 68) attached to your specific function. The configuration of these two components determines who can invoke or perform other administrative actions on your function URL.

The `AuthType` parameter determines how Lambda authenticates or authorizes requests to your function URL. When you configure your function URL, you must specify one of the following `AuthType` options:

- `AWS_IAM` – Lambda uses AWS Identity and Access Management (IAM) to authenticate and authorize requests based on the IAM principal's identity policy and the function's resource-based policy. Choose this option if you want only authenticated IAM users and roles to invoke your function via the function URL.

- `NONE` – Lambda doesn't perform any authentication before invoking your function. However, your function's resource-based policy is always in effect and must grant public access before your function URL can receive requests. Choose this option to allow public, unauthenticated access to your function URL.

In addition to `AuthType`, you can also use resource-based policies to grant permissions to other AWS accounts to invoke your function. For more information, see Using resource-based policies for Lambda (p. 68).

For additional insights into security, you can use AWS Identity and Access Management Access Analyzer to get a comprehensive analysis of external access to your function URL. IAM Access Analyzer also monitors for new or updated permissions on your Lambda functions to help you identify permissions that grant public and cross-account access. IAM Access Analyzer is free to use for any AWS customer. To get started with IAM Access Analyzer, see Using AWS IAM Access Analyzer.

This page contains examples of resource-based policies for both auth types, and also how to create these policies using the AddPermission (p. 881) API operation or the Lambda console. For information on how to invoke your function URL after you've set up permissions, see Invoking Lambda function URLs (p. 269).

**Topics**

- Using the AWS_IAM auth type (p. 264)
- Using the NONE auth type (p. 266)
- Governance and access control (p. 266)

## Using the `AWS_IAM` auth type

If you choose the `AWS_IAM` auth type, users who need to invoke your Lambda function URL must have the `lambda:InvokeFunctionUrl` permission. Depending on who makes the invocation request, you may have to grant this permission using a resource-based policy.

If the principal making the request is in the same AWS account as the function URL, then the principal must **either** have `lambda:InvokeFunctionUrl` permissions in their identity-based policy, **or** have permissions granted to them in the function's resource-based policy. In other words, a resource-based policy is optional if the user already has `lambda:InvokeFunctionUrl` permissions in their identity-based policy. Policy evaluation follows the rules outlined in Determining whether a request is allowed or denied within an account.

If the principal making the request is in a different account, then the principal must have **both** an identity-based policy that gives them `lambda:InvokeFunctionUrl` permissions **and** permissions granted to them in a resource-based policy on the function that they are trying to invoke. In these cross-account cases, policy evaluation follows the rules outlined in Determining whether a cross-account request is allowed.

For an example cross-account interaction, the following resource-based policy allows the `example` role in AWS account `444455556666` to invoke the function URL associated with function `my-function`:

**Example function URL cross-account invoke policy**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "AWS": "arn:aws:iam::444455556666:role/example"
            },
            "Action": "lambda:InvokeFunctionUrl",
            "Resource": "arn:aws:lambda:us-east-1:123456789012:function:my-function",
            "Condition": {
                "StringEquals": {
                    "lambda:FunctionUrlAuthType": "AWS_IAM"
                }
            }
        }
    ]
}
```

You can create this policy statement through the console by following these steps:

**To grant URL invocation permissions to another account (console)**

1. Open the Functions page of the Lambda console.
2. Choose the name of the function that you want to grant URL invocation permissions for.
3. Choose the **Configuration** tab, and then choose **Permissions**.
4. Under **Resource-based policy**, choose **Add permissions**.
5. Choose **Function URL**.
6. For **Auth type**, choose **AWS_IAM**.
7. (Optional) For **Statement ID**, enter a statement ID for your policy statement.
8. For **Principal**, enter the Amazon Resource Name (ARN) of the IAM user or role that you want to grant permissions to. For example: **`arn:aws:iam::444455556666:role/example`**.
9. Choose **Save**.

Alternatively, you can create this policy statement using the following add-permission AWS Command Line Interface (AWS CLI) command:

```
aws lambda add-permission --function-name my-function \
--statement-id example0-cross-account-statement \
--action lambda:InvokeFunctionUrl \
--principal arn:aws:iam::444455556666:role/example \
--function-url-auth-type AWS_IAM
```

In the previous example, the `lambda:FunctionUrlAuthType` condition key value is `AWS_IAM`. This policy only allows access when your function URL's auth type is also `AWS_IAM`.

# Using the NONE auth type

**Important**
When your function URL auth type is NONE and you have a resource-based policy that grants public access, any unauthenticated user with your function URL can invoke your function.

In some cases, you may want your function URL to be public. For example, you might want to serve requests made directly from a web browser. To allow public access to your function URL, choose the NONE auth type.

If you choose the NONE auth type, Lambda doesn't use IAM to authenticate requests to your function URL. However, users must still have `lambda:InvokeFunctionUrl` permissions in order to successfully invoke your function URL. You can grant `lambda:InvokeFunctionUrl` permissions using the following resource-based policy:

**Example function URL invoke policy for all unauthenticated principals**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": "*",
            "Action": "lambda:InvokeFunctionUrl",
            "Resource": "arn:aws:lambda:us-east-1:123456789012:function:my-function",
            "Condition": {
                "StringEquals": {
                    "lambda:FunctionUrlAuthType": "NONE"
                }
            }
        }
    ]
}
```

**Note**
When you create a function URL with auth type NONE via the console or AWS Serverless Application Model (AWS SAM), Lambda automatically creates the preceding resource-based policy statement for you. If the policy already exists, or the user or role creating the application doesn't have the appropriate permissions, then Lambda won't create it for you. If you're using the AWS CLI, AWS CloudFormation, or the Lambda API directly, you must add `lambda:InvokeFunctionUrl` permissions yourself. This makes your function public. In addition, if you delete your function URL with auth type NONE, Lambda doesn't automatically delete the associated resource-based policy. If you want to delete this policy, you must manually do so.

In this statement, the `lambda:FunctionUrlAuthType` condition key value is NONE. This policy statement allows access only when your function URL's auth type is also NONE.

If a function's resource-based policy doesn't grant `lambda:invokeFunctionUrl` permissions, then users will get a 403 Forbidden error code when they try to invoke your function URL, even if the function URL uses the NONE auth type.

# Governance and access control

In addition to function URL invocation permissions, you can also control access on actions used to configure function URLs. Lambda supports the following IAM policy actions for function URLs:

- `lambda:InvokeFunctionUrl` – Invoke a Lambda function using the function URL.

- `lambda:CreateFunctionUrlConfig` – Create a function URL and set its `AuthType`.
- `lambda:UpdateFunctionUrlConfig` – Update a function URL configuration and its `AuthType`.
- `lambda:GetFunctionUrlConfig` – View the details of a function URL.
- `lambda:ListFunctionUrlConfigs` – List function URL configurations.
- `lambda:DeleteFunctionUrlConfig` – Delete a function URL.

> **Note**
> The Lambda console supports adding permissions only for `lambda:InvokeFunctionUrl`. For all other actions, you must add permissions using the Lambda API or AWS CLI.

To allow or deny function URL access to other AWS entities, include these actions in IAM policies. For example, the following policy grants the `example` role in AWS account `444455556666` permissions to update the function URL for function **`my-function`** in account `123456789012`.

**Example cross-account function URL policy**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "AWS": "arn:aws:iam::444455556666:role/example"
            },
            "Action": "lambda:UpdateFunctionUrlConfig",
            "Resource": "arn:aws:lambda:us-east-2:123456789012:function:my-function"
        }
    ]
}
```

## Condition keys

For fine-grained access control over your function URLs, use a condition key. Lambda supports one additional condition key for function URLs: `FunctionUrlAuthType`. The `FunctionUrlAuthType` key defines an enum value describing the auth type that your function URL uses. The value can be either `AWS_IAM` or `NONE`.

You can use this condition key in policies associated with your function. For example, you might want to restrict who can make configuration changes to your function URLs. To deny all `UpdateFunctionUrlConfig` requests to any function with URL auth type `NONE`, you can define the following policy:

**Example function URL policy with explicit deny**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Deny",
            "Principal": "*",
            "Action":[
                "lambda:UpdateFunctionUrlConfig"
            ],
            "Resource": "arn:aws:lambda:us-east-1:123456789012:function:*",
            "Condition": {
                "StringEquals": {
                    "lambda:FunctionUrlAuthType": "NONE"
                }
```

```
            }
        }
    ]
}
```

To grant the `example` role in AWS account `444455556666` permissions to make `CreateFunctionUrlConfig` and `UpdateFunctionUrlConfig` requests on functions with URL auth type `AWS_IAM`, you can define the following policy:

**Example function URL policy with explicit allow**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "AWS": "arn:aws:iam::444455556666:role/example"
            },
            "Action":[
                "lambda:CreateFunctionUrlConfig",
                "lambda:UpdateFunctionUrlConfig"
            ],
            "Resource": "arn:aws:lambda:us-east-1:123456789012:function:*",
            "Condition": {
                "StringEquals": {
                    "lambda:FunctionUrlAuthType": "AWS_IAM"
                }
            }
        }
    ]
}
```

You can also use this condition key in a service control policy (SCP). Use SCPs to manage permissions across an entire organization in AWS Organizations. For example, to deny users from creating or updating function URLs that use anything other than the `AWS_IAM` auth type, use the following service control policy:

**Example function URL SCP with explicit deny**

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Deny",
            "Action":[
                "lambda:CreateFunctionUrlConfig",
                "lambda:UpdateFunctionUrlConfig"
            ],
            "Resource": "arn:aws:lambda:*:123456789012:function:*",
            "Condition": {
                "StringNotEquals": {
                    "lambda:FunctionUrlAuthType": "AWS_IAM"
                }
            }
        }
    ]
}
```

# Invoking Lambda function URLs

A function URL is a dedicated HTTP(S) endpoint for your Lambda function. You can create and configure a function URL through the Lambda console or the Lambda API. When you create a function URL, Lambda automatically generates a unique URL endpoint for you. Once you create a function URL, its URL endpoint never changes. Function URL endpoints have the following format:

```
https://<url-id>.lambda-url.<region>.on.aws
```

Function URLs are dual stack-enabled, supporting IPv4 and IPv6. After configuring your function URL, you can invoke your function through its HTTP(S) endpoint via a web browser, curl, Postman, or any HTTP client. To invoke a function URL, you must have `lambda:InvokeFunctionUrl` permissions. For more information, see Security and auth model (p. 264).

**Topics**


- Function URL invocation basics (p. 269)
- Request and response payloads (p. 269)


## Function URL invocation basics

If your function URL uses the `AWS_IAM` auth type, you must sign each HTTP request using AWS Signature Version 4 (SigV4). Tools such as awscurl, Postman, and AWS SigV4 Proxy offer built-in ways to sign your requests with SigV4.

If you don't use a tool to sign HTTP requests to your function URL, you must manually sign each request using SigV4. When your function URL receives a request, Lambda also calculates the SigV4 signature. Lambda processes the request only if the signatures match. For instructions on how to manually sign your requests with SigV4, see Signing AWS requests with Signature Version 4 in the *Amazon Web Services General Reference Guide*.

If your function URL uses the `NONE` auth type, you don't have to sign your requests using SigV4. You can invoke your function using a web browser, curl, Postman, or any HTTP client.

To test simple `GET` requests to your function, use a web browser. For example, if your function URL is `https://abcdefg.lambda-url.us-east-1.on.aws`, and it takes in a string parameter `message`, your request URL could look like this:

```
https://abcdefg.lambda-url.us-east-1.on.aws/?message=HelloWorld
```

To test other HTTP requests, such as a `POST` request, you can use a tool such as curl. For example, if you want to include some JSON data in a `POST` request to your function URL, you could use the following curl command:

```
curl -v -X POST \
      'https://abcdefg.lambda-url.us-east-1.on.aws/?message=HelloWorld' \
      -H 'content-type: application/json' \
      -d '{ "example": "test" }'
```

## Request and response payloads

When a client calls your function URL, Lambda maps the request to an event object before passing it to your function. Your function's response is then mapped to an HTTP response that Lambda sends back to the client through the function URL.

The request and response event formats follow the same schema as the Amazon API Gateway payload format version 2.0.

## Request payload format

A request payload has the following structure:

```
{
  "version": "2.0",
  "routeKey": "$default",
  "rawPath": "/my/path",
  "rawQueryString": "parameter1=value1&parameter1=value2&parameter2=value",
  "cookies": [
    "cookie1",
    "cookie2"
  ],
  "headers": {
    "header1": "value1",
    "header2": "value1,value2"
  },
  "queryStringParameters": {
    "parameter1": "value1,value2",
    "parameter2": "value"
  },
  "requestContext": {
    "accountId": "123456789012",
    "apiId": "<urlid>",
    "authentication": null,
    "authorizer": {
        "iam": {
                "accessKey": "AKIA...",
                "accountId": "111122223333",
                "callerId": "AIDA...",
                "cognitoIdentity": null,
                "principalOrgId": null,
                "userArn": "arn:aws:iam::111122223333:user/example-user",
                "userId": "AIDA..."
        }
    },
    "domainName": "<url-id>.lambda-url.us-west-2.on.aws",
    "domainPrefix": "<url-id>",
    "http": {
      "method": "POST",
      "path": "/my/path",
      "protocol": "HTTP/1.1",
      "sourceIp": "123.123.123.123",
      "userAgent": "agent"
    },
    "requestId": "id",
    "routeKey": "$default",
    "stage": "$default",
    "time": "12/Mar/2020:19:03:58 +0000",
    "timeEpoch": 1583348638390
  },
  "body": "Hello from client!",
  "pathParameters": null,
  "isBase64Encoded": false,
  "stageVariables": null
}
```

| Parameter | Description | Example |
| --- | --- | --- |
| `version` | The payload format version for this event. Lambda function URLs currently support payload format version 2.0. | `2.0` |
| `routeKey` | Function URLs don't use this parameter. Lambda sets this to `$default` as a placeholder. | `$default` |
| `rawPath` | The request path. For example, if the request URL is `https://{url-id}.lambda-url.{region}.on.aws/example/test/demo`, then the raw path value is `/example/test/demo`. | `/example/test/demo` |
| `rawQueryString` | The raw string containing the request's query string parameters. | `"?parameter1=value1&parameter2=value2"` |
| `cookies` | An array containing all cookies sent as part of the request. | `["Cookie_1=Value_1", "Cookie_2=Value_2"]` |
| `headers` | The list of request headers, presented as key-value pairs. | `{"header1": "value1", "header2": "value2"}` |
| `queryStringParameters` | The query parameters for the request. For example, if the request URL is `https://{url-id}.lambda-url.{region}.on.aws/example?name=Jane`, then the `queryStringParameters` value is a JSON object with a key of `name` and a value of `Jane`. | `{"name": "Jane"}` |
| `requestContext` | An object that contains additional information about the request, such as the `requestId`, the time of the request, and the identity of the caller if authorized via AWS Identity and Access Management (IAM). | |
| `requestContext.accountId` | The AWS account ID of the function owner. | `"123456789012"` |
| `requestContext.apiId` | The ID of the function URL. | `"33anwqw8fj"` |
| `requestContext.authentication` | Function URLs don't use this parameter. Lambda sets this to `null`. | `null` |
| `requestContext.authorizer` | An object that contains information about the caller identity, if the function URL uses the `AWS_IAM` auth type. | |

| Parameter | Description | Example |
| --- | --- | --- |
| | Otherwise, Lambda sets this to `null`. | |
| `requestContext.authorizer.iam.accessKey` | The access key of the caller identity. | `"AKIAIOSFODNN7EXAMPLE"` |
| `requestContext.authorizer.iam.accountId` | The AWS account ID of the caller identity. | `"111122223333"` |
| `requestContext.authorizer.iam.callerId` | The ID (IAM user ID) of the caller. | `"AIDACKCEVSQ6C2EXAMPLE"` |
| `requestContext.authorizer.iam.cognitoIdentity` | For Function URLs, don't use this parameter. Lambda sets this to `null` or excludes this from the JSON. | `null` |
| `requestContext.authorizer.iam.principalOrgId` | The principal organization associated with the caller identity. | `"AIDACKCEVSQORGEXAMPLE"` |
| `requestContext.authorizer.iam.userArn` | The user Amazon Resource Name (ARN) of the caller identity. | `"arn:aws:iam::111122223333:user/example-user"` |
| `requestContext.authorizer.iam.userId` | The user ID of the caller identity. | `"AIDACOSFODNN7EXAMPLE2"` |
| `requestContext.domainName` | The domain name of the function URL. | `"<url-id>.lambda-url.us-west-2.on.aws"` |
| `requestContext.domainPrefix` | The domain prefix of the function URL. | `"<url-id>"` |
| `requestContext.http` | An object that contains details about the HTTP request. | |
| `requestContext.http.method` | The HTTP method used in this request. Valid values include `GET`, `POST`, `PUT`, `HEAD`, `OPTIONS`, `PATCH`, and `DELETE`. | `GET` |
| `requestContext.http.path` | The request path. For example, if the request URL is `https://{url-id}.lambda-url.{region}.on.aws/example/test/demo`, then the path value is `/example/test/demo`. | `/example/test/demo` |
| `requestContext.http.protocol` | The protocol of the request. | `HTTP/1.1` |
| `requestContext.http.sourceIp` | The source IP address of the immediate TCP connection making the request. | `123.123.123.123` |
| `requestContext.http.userAgent` | The User-Agent request header value. | `Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) Gecko/20100101 Firefox/42.0` |

| Parameter | Description | Example |
|---|---|---|
| `requestContext.requestId` | The ID of the invocation request. You can use this ID to trace invocation logs related to your function. | `e1506fd5-9e7b-434f-bd42-4f8fa224b599` |
| `requestContext.routeKey` | Function URLs don't use this parameter. Lambda sets this to `$default` as a placeholder. | `$default` |
| `requestContext.stage` | Function URLs don't use this parameter. Lambda sets this to `$default` as a placeholder. | `$default` |
| `requestContext.time` | The timestamp of the request. | `"07/Sep/2021:22:50:22 +0000"` |
| `requestContext.timeEpoch` | The timestamp of the request, in Unix epoch time. | `"1631055022677"` |
| `body` | The body of the request. If the content type of the request is binary, the body is base64-encoded. | `{"key1": "value1", "key2": "value2"}` |
| `pathParameters` | Function URLs don't use this parameter. Lambda sets this to `null` or excludes this from the JSON. | `null` |
| `isBase64Encoded` | `TRUE` if the body is a binary payload and base64-encoded. `FALSE` otherwise. | `FALSE` |
| `stageVariables` | Function URLs don't use this parameter. Lambda sets this to `null` or excludes this from the JSON. | `null` |

## Response payload format

When your function returns a response, Lambda parses the response and converts it into an HTTP response. Function response payloads have the following format:

```
{
   "statusCode": 201,
    "headers": {
        "Content-Type": "application/json",
        "My-Custom-Header": "Custom Value"
    },
    "body": "{ \"message\": \"Hello, world!\" }",
    "cookies": [
        "Cookie_1=Value1; Expires=21 Oct 2021 07:48 GMT",
        "Cookie_2=Value2; Max-Age=78000"
    ],
    "isBase64Encoded": false
}
```

Lambda infers the response format for you. If your function returns valid JSON and doesn't return a `statusCode`, Lambda assumes the following:

- `statusCode` is `200`.
- `content-type` is `application/json`.
- `body` is the function response.
- `isBase64Encoded` is `false`.

The following examples show how the output of your Lambda function maps to the response payload, and how the response payload maps to the final HTTP response. When the client invokes your function URL, they see the HTTP response.

### Example output for a string response

| Lambda function output | Interpreted response output | HTTP response (what the client sees) |
|---|---|---|
| `"Hello, world!"` | `{ "statusCode": 200, "body": "Hello, world!", "headers": { "content-type": "application/json" }, "isBase64Encoded": false }` | `HTTP/2 200`<br>`date: Wed, 08 Sep 2021 18:02:24 GMT`<br>`content-type: application/json`<br>`content-length: 15`<br><br>`"Hello, world!"` |

### Example output for a JSON response

| Lambda function output | Interpreted response output | HTTP response (what the client sees) |
|---|---|---|
| `{ "message": "Hello, world!" }` | `{ "statusCode": 200, "body": { "message": "Hello, world!" }, "headers": { "content-type": "application/json" }, "isBase64Encoded": false }` | `HTTP/2 200`<br>`date: Wed, 08 Sep 2021 18:02:24 GMT`<br>`content-type: application/json`<br>`content-length: 34`<br><br>`{ "message": "Hello, world!" }` |

### Example output for a custom response

| Lambda function output | Interpreted response output | HTTP response (what the client sees) |
|---|---|---|
| `{ "statusCode": 201, "headers": { "Content-Type": "application/json",` | `{ "statusCode": 201, "headers": { "Content-Type": "application/json",` | `HTTP/2 201`<br>`date: Wed, 08 Sep 2021 18:02:24 GMT`<br>`content-type: application/json` |

| Lambda function output | Interpreted response output | HTTP response (what the client sees) |
|---|---|---|
| <pre>"My-Custom-Header": "Custom Value" }, "body": JSON.stringify({ "message": "Hello, world!" }), "isBase64Encoded": false }</pre> | <pre>"My-Custom-Header": "Custom Value" }, "body": JSON.stringify({ "message": "Hello, world!" }), "isBase64Encoded": false }</pre> | <pre>content-length: 27 my-custom-header: Custom Value<br><br>{ "message": "Hello, world!" }</pre> |

## Cookies

To return cookies from your function, don't manually add `set-cookie` headers. Instead, include the cookies in your response payload object. Lambda automatically interprets this and adds them as `set-cookie` headers in your HTTP response, as in the following example.

**Example output for a response returning cookies**

| Lambda function output | HTTP response (what the client sees) |
|---|---|
| <pre>{ "statusCode": 201, "headers": { "Content-Type": "application/json", "My-Custom-Header": "Custom Value" }, "body": JSON.stringify({ "message": "Hello, world!" }), "cookies": [ "Cookie_1=Value1; Expires=21 Oct 2021 07:48 GMT", "Cookie_2=Value2; Max-Age=78000" ], "isBase64Encoded": false }</pre> | <pre>HTTP/2 201 date: Wed, 08 Sep 2021 18:02:24 GMT content-type: application/json content-length: 27 my-custom-header: Custom Value set-cookie: Cookie_1=Value2; Expires=21 Oct 2021 07:48 GMT set-cookie: Cookie_2=Value2; Max-Age=78000<br><br>{ "message": "Hello, world!" }</pre> |

# Monitoring Lambda function URLs

You can use AWS CloudTrail and Amazon CloudWatch to monitor your function URLs.

**Topics**


- Monitoring function URLs with CloudTrail (p. 276)
- CloudWatch metrics for function URLs (p. 276)


## Monitoring function URLs with CloudTrail

For function URLs, Lambda automatically supports logging the following API operations as events in CloudTrail log files:

- CreateFunctionUrlConfig
- UpdateFunctionUrlConfig
- DeleteFunctionUrlConfig
- GetFunctionUrlConfig
- ListFunctionUrlConfigs

Each log entry contains information about the caller identity, when the request was made, and other details. You can see all events within the last 90 days by viewing your CloudTrail **Event history**. To retain records past 90 days, you can create a trail. For more information, see Using AWS Lambda with AWS CloudTrail (p. 523).

By default, CloudTrail doesn't log `InvokeFunctionUrl` requests, which are considered data events. However, you can turn on data event logging in CloudTrail. For more information, see Logging data events for trails in the *AWS CloudTrail User Guide*.

## CloudWatch metrics for function URLs

Lambda sends aggregated metrics about function URL requests to CloudWatch. With these metrics, you can monitor your function URLs, build dashboards, and configure alarms in the CloudWatch console.

Function URLs support the following invocation metrics. We recommend viewing these metrics with the `Sum` statistic.

- `UrlRequestCount` – The number of requests made to this function URL.
- `Url4xxError` – The number of requests that returned a 4XX HTTP status code. 4XX series codes indicate client-side errors, such as bad requests.
- `Url5xxError` – The number of requests that returned a 5XX HTTP status code. 5XX series codes indicate server-side errors, such as function errors and timeouts.

Function URLs also support the following performance metric. We recommend viewing this metric with the `Average` or `Max` statistics.

- `UrlRequestLatency` – The time between when the function URL receives a request and when the function URL returns a response.

Each of these invocation and performance metrics supports the following dimensions:

- `FunctionName` – View aggregate metrics for function URLs assigned to a function's `$LATEST` unpublished version, or to any of the function's aliases. For example, `hello-world-function`.

- `Resource` – View metrics for a specific function URL. This is defined by a function name, along with either the function's `$LATEST` unpublished version or one of the function's aliases. For example, `hello-world-function:$LATEST`.
- `ExecutedVersion` – View metrics for a specific function URL based on the executed version. You can use this dimension primarily to track the function URL assigned to the `$LATEST` unpublished version.

# Tutorial: Creating a Lambda function with a function URL

In this tutorial, you create a Lambda function defined as a .zip file archive with a **public** function URL endpoint that returns the product of two numbers. For more information about configuring function URLs, see Creating and managing function URLs (p. 259).

## Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

## Create an execution role

Create the execution role (p. 52) that gives your Lambda function permission to access AWS resources.

**To create an execution role**

1. Open the Roles page of the AWS Identity and Access Management (IAM) console.
2. Choose **Create role**.
3. Create a role with the following properties.
   - **Trusted entity** – **AWS Lambda**.
   - **Permissions** – **AWSLambdaBasicExecutionRole**.
   - **Role name** – **`lambda-url-role`**.

The **AWSLambdaBasicExecutionRole** policy has the permissions that the function needs to write logs to Amazon CloudWatch Logs.

## Create a Lambda function with a function URL (.zip file archive)

Create a Lambda function with a function URL endpoint using a .zip file archive.

**To create the function**

1. Copy the following code example into a file named `index.js`.

**Example index.js**

```
exports.handler = async (event) => {
    let body = JSON.parse(event.body)
    const product = body.num1 * body.num2;
    const response = {
        statusCode: 200,
        body: "The product of " + body.num1 + " and " + body.num2 + " is " + product,
    };
    return response;
};
```

2. Create a deployment package.

```
zip function.zip index.js
```

3. Create a Lambda function with the `create-function` command.

```
aws lambda create-function \
    --function-name my-url-function \
    --runtime nodejs14.x \
    --zip-file fileb://function.zip \
    --handler index.handler \
    --role arn:aws:iam::123456789012:role/lambda-url-role
```

4. Add a resource-based policy to your function granting permissions to allow public access to your function URL.

```
aws lambda add-permission
    --function-name my-url-function \
    --action lambda:InvokeFunctionUrl \
    --principal "*" \
    --function-url-auth-type "NONE" \
    --statement-id url
```

5. Create a URL endpoint for the function with the `create-function-url-config` command.

```
aws lambda create-function-url-config \
    --function-name my-url-function \
    --auth-type NONE
```

# Test the function URL endpoint

Invoke your Lambda function by calling your function URL endpoint using an HTTP client such as curl or Postman.

```
curl -X POST \
    'https://abcdefg.lambda-url.us-east-1.on.aws/' \
    -H 'Content-Type: application/json' \
    -d '{"num1": "10", "num2": "10"}'
```

You should see the following output:

```
The product of 10 and 10 is 100
```

# Create a Lambda function with a function URL (CloudFormation)

You can also create a Lambda function with a function URL endpoint using the AWS CloudFormation type `AWS::Lambda::Url`.

```
Resources:
  MyUrlFunction:
    Type: AWS::Lambda::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs14.x
      Role: arn:aws:iam::123456789012:role/lambda-url-role
      Code:
        ZipFile: |
          exports.handler = async (event) => {
              let body = JSON.parse(event.body)
              const product = body.num1 * body.num2;
              const response = {
                  statusCode: 200,
                  body: "The product of " + body.num1 + " and " + body.num2 + " is " +
 product,
              };
              return response;
          };
      Description: Create a function with a URL.
  MyUrlFunctionPermissions:
    Type: AWS::Lambda::Permission
    Properties:
      FunctionName: !Ref MyUrlFunction
      Action: lambda:InvokeFunctionUrl
      Principal: "*"
      FunctionUrlAuthType: NONE
  MyFunctionUrl:
    Type: AWS::Lambda::Url
    Properties:
      TargetFunctionArn: !Ref MyUrlFunction
      AuthType: NONE
```

# Create a Lambda function with a function URL (AWS SAM)

You can also create a Lambda function configured with a function URL using AWS Serverless Application Model (AWS SAM).

```
ProductFunction:
  Type: AWS::Serverless::Function
  Properties:
    CodeUri: function/.
    Handler: index.handler
    Runtime: nodejs14.x
    AutoPublishAlias: live
    FunctionUrlConfig:
      AuthType: NONE
```

# Clean up your resources

You can now delete the resources that you created for this tutorial, unless you want to retain them. By deleting AWS resources that you're no longer using, you prevent unnecessary charges to your AWS account.

### To delete the execution role

1. Open the Roles page of the IAM console.
2. Select the execution role that you created.
3. Choose **Delete role**.
4. Choose **Yes, delete**.

### To delete the Lambda function

1. Open the Functions page of the Lambda console.
2. Select the function that you created.
3. Choose **Actions**, then choose **Delete**.
4. Choose **Delete**.

# Building Lambda functions with Node.js

You can run JavaScript code with Node.js in AWS Lambda. Lambda provides runtimes (p. 82) for Node.js that run your code to process events. Your code runs in an environment that includes the AWS SDK for JavaScript, with credentials from an AWS Identity and Access Management (IAM) role that you manage.

Lambda supports the following Node.js runtimes.

**Node.js**

| Name | Identifier | SDK | Operating system | Architectures | Deprecation |
|---|---|---|---|---|---|
| Node.js 16 | `nodejs16.x` | 2.1083.0 | Amazon Linux 2 | x86_64, arm64 | |
| Node.js 14 | `nodejs14.x` | 2.1055.0 | Amazon Linux 2 | x86_64, arm64 | |
| Node.js 12 | `nodejs12.x` | 2.1055.0 | Amazon Linux 2 | x86_64, arm64 | Nov 14, 2022 |

Lambda functions use an execution role (p. 52) to get permission to write logs to Amazon CloudWatch Logs, and to access other services and resources. If you don't already have an execution role for function development, create one.

**To create an execution role**

1. Open the roles page in the IAM console.
2. Choose **Create role**.
3. Create a role with the following properties.

   - **Trusted entity** – **Lambda**.
   - **Permissions** – **AWSLambdaBasicExecutionRole**.
   - **Role name** – **`lambda-role`**.

   The **AWSLambdaBasicExecutionRole** policy has the permissions that the function needs to write logs to CloudWatch Logs.

You can add permissions to the role later, or swap it out for a different role that's specific to a single function.

**To create a Node.js function**

1. Open the Lambda console.
2. Choose **Create function**.
3. Configure the following settings:

   - **Name** – **`my-function`**.

- **Runtime** – **Node.js 16.x**.
- **Role** – **Choose an existing role**.
- **Existing role** – **`lambda-role`**.

4. Choose **Create function**.
5. To configure a test event, choose **Test**.
6. For **Event name**, enter **`test`**.
7. Choose **Save changes**.
8. To invoke the function, choose **Test**.

The console creates a Lambda function with a single source file named `index.js`. You can edit this file and add more files in the built-in code editor (p. 38). To save your changes, choose **Save**. Then, to run your code, choose **Test**.

> **Note**
> The Lambda console uses AWS Cloud9 to provide an integrated development environment in the browser. You can also use AWS Cloud9 to develop Lambda functions in your own environment. For more information, see Working with Lambda Functions in the AWS Cloud9 user guide.

The `index.js` file exports a function named `handler` that takes an event object and a context object. This is the handler function (p. 285) that Lambda calls when the function is invoked. The Node.js function runtime gets invocation events from Lambda and passes them to the handler. In the function configuration, the handler value is `index.handler`.

When you save your function code, the Lambda console creates a .zip file archive deployment package. When you develop your function code outside of the console (using an IDE) you need to create a deployment package (p. 288) to upload your code to the Lambda function.

> **Note**
> To get started with application development in your local environment, deploy one of the sample applications available in this guide's GitHub repository.

### Sample Lambda applications in Node.js

- blank-nodejs – A Node.js function that shows the use of logging, environment variables, AWS X-Ray tracing, layers, unit tests and the AWS SDK.
- nodejs-apig – A function with a public API endpoint that processes an event from API Gateway and returns an HTTP response.
- rds-mysql – A function that relays queries to a MySQL for RDS Database. This sample includes a private VPC and database instance configured with a password in AWS Secrets Manager.
- efs-nodejs – A function that uses an Amazon EFS file system in a Amazon VPC. This sample includes a VPC, file system, mount targets, and access point configured for use with Lambda.
- list-manager – A function processes events from an Amazon Kinesis data stream and update aggregate lists in Amazon DynamoDB. The function stores a record of each event in a MySQL for RDS Database in a private VPC. This sample includes a private VPC with a VPC endpoint for DynamoDB and a database instance.
- error-processor – A Node.js function generates errors for a specified percentage of requests. A CloudWatch Logs subscription invokes a second function when an error is recorded. The processor function uses the AWS SDK to gather details about the request and stores them in an Amazon S3 bucket.

The function runtime passes a context object to the handler, in addition to the invocation event. The context object (p. 293) contains additional information about the invocation, the function, and the execution environment. More information is available from environment variables.

Your Lambda function comes with a CloudWatch Logs log group. The function runtime sends details about each invocation to CloudWatch Logs. It relays any logs that your function outputs (p. 295) during invocation. If your function returns an error (p. 300), Lambda formats the error and returns it to the invoker.

# Node.js initialization

Node.js has a unique event loop model that causes its initialization behavior to be different from other runtimes. Specifically, Node.js uses a non-blocking I/O model that supports asynchronous operations. This model allows Node.js to perform efficiently for most workloads. For example, if a Node.js function makes a network call, that request may be designated as an asynchronous operation and placed into a callback queue. The function may continue to process other operations within the main call stack without getting blocked by waiting for the network call to return. Once the network call is returned, its callback is executed and then removed from the callback queue.

Some initialization tasks may run asynchronously. These asynchronous tasks are not guaranteed to complete execution prior to an invocation. For example, code that makes a network call to fetch a parameter from AWS Parameter Store may not be complete by the time Lambda executes the handler function. As a result, the variable may be null during an invocation. To avoid this, ensure that variables and other asynchronous code are fully initialized before continuing with the rest of the function's core business logic.

## Designating a function handler as an ES module

Starting with Node 14, you can guarantee completion of asynchronous initialization code prior to handler invocations by designating your code as an ES module, and using top-level await. Packages are designated as CommonJS modules by default, meaning you must first designate your function code as an ES module to use top-level await. You can do this in two ways: specifying the `type` as `module` in the function's `package.json` file, or by using the .mjs file name extension.

In the first scenario, your function code treats all .js files as ES modules, while in the second scenario, only the file you specify with .mjs is an ES module. You can mix ES modules and CommonJS modules by naming them .mjs and .cjs respectively, as .mjs files are always ES modules and .cjs files are always CommonJS modules.

For more information and an example, see Using Node.js ES Modules and Top-Level Await in AWS Lambda.

**Topics**

- AWS Lambda function handler in Node.js (p. 285)
- Deploy Node.js Lambda functions with .zip file archives (p. 288)
- Deploy Node.js Lambda functions with container images (p. 291)
- AWS Lambda context object in Node.js (p. 293)
- AWS Lambda function logging in Node.js (p. 295)
- AWS Lambda function errors in Node.js (p. 300)
- Instrumenting Node.js code in AWS Lambda (p. 304)

# AWS Lambda function handler in Node.js

The Lambda function *handler* is the method in your function code that processes events. When your function is invoked, Lambda runs the handler method. When the handler exits or returns a response, it becomes available to handle another event.

The following example function logs the contents of the event object and returns the location of the logs.

**Example index.js**

```
exports.handler =  async function(event, context) {
  console.log("EVENT: \n" + JSON.stringify(event, null, 2))
  return context.logStreamName
}
```

When you configure a function, the value of the handler setting is the file name and the name of the exported handler method, separated by a dot. The default in the console and for examples in this guide is `index.handler`. This indicates the `handler` method that's exported from the `index.js` file.

The runtime passes three arguments to the handler method. The first argument is the `event` object, which contains information from the invoker. The invoker passes this information as a JSON-formatted string when it calls Invoke (p. 993), and the runtime converts it to an object. When an AWS service invokes your function, the event structure varies by service (p. 496).

The second argument is the context object (p. 293), which contains information about the invocation, function, and execution environment. In the preceding example, the function gets the name of the log stream (p. 295) from the context object and returns it to the invoker.

The third argument, `callback`, is a function that you can call in non-async handlers (p. 286) to send a response. The callback function takes two arguments: an `Error` and a response. When you call it, Lambda waits for the event loop to be empty and then returns the response or error to the invoker. The response object must be compatible with `JSON.stringify`.

For asynchronous function handlers, you return a response, error, or promise to the runtime instead of using `callback`.

If your function has additional dependencies, use npm to include them in your deployment package (p. 289).

## Async handlers

For async handlers, you can use `return` and `throw` to send a response or error, respectively. Functions must use the `async` keyword to use these methods to return a response or error.

If your code performs an asynchronous task, return a promise to make sure that it finishes running. When you resolve or reject the promise, Lambda sends the response or error to the invoker.

**Example index.js file – HTTP request with async handler and promises**

```
const https = require('https')
let url = "https://docs.aws.amazon.com/lambda/latest/dg/welcome.html"

exports.handler = async function(event) {
  const promise = new Promise(function(resolve, reject) {
    https.get(url, (res) => {
        resolve(res.statusCode)
      }).on('error', (e) => {
```

```
        reject(Error(e))
      })
    })
  return promise
}
```

For libraries that return a promise, you can return that promise directly to the runtime.

**Example index.js file – AWS SDK with async handler and promises**

```
const AWS = require('aws-sdk')
const s3 = new AWS.S3()

exports.handler = async function(event) {
  return s3.listBuckets().promise()
}
```

## Using Node.js modules and top-level await

You can designate your function code as an ES module, allowing you to use `await` at the top level of the file, outside the scope of your function handler. This guarantees completion of asynchronous initialization code prior to handler invocations, maximizing the effectiveness of provisioned concurrency (p. 183) in reducing cold start latency. You can do this in two ways: specifying the `type` as `module` in the function's `package.json` file, or by using the .mjs file name extension.

In the first scenario, your function code treats all .js files as ES modules, while in the second scenario, only the file you specify with .mjs is an ES module. You can mix ES modules and CommonJS modules by naming them .mjs and .cjs respectively, as .mjs files are always ES modules and .cjs files are always CommonJS modules.

For more information and an example, see Using Node.js ES Modules and Top-Level Await in AWS Lambda.

# Non-async handlers

The following example function checks a URL and returns the status code to the invoker.

**Example index.js file – HTTP request with callback**

```
const https = require('https')
let url = "https://docs.aws.amazon.com/lambda/latest/dg/welcome.html"

exports.handler =  function(event, context, callback) {
  https.get(url, (res) => {
    callback(null, res.statusCode)
  }).on('error', (e) => {
    callback(Error(e))
  })
}
```

For non-async handlers, function execution continues until the event loop is empty or the function times out. The response isn't sent to the invoker until all event loop tasks are finished. If the function times out, an error is returned instead. You can configure the runtime to send the response immediately by setting context.callbackWaitsForEmptyEventLoop (p. 293) to false.

In the following example, the response from Amazon S3 is returned to the invoker as soon as it's available. The timeout running on the event loop is frozen, and it continues running the next time the function is invoked.

**Example index.js file – callbackWaitsForEmptyEventLoop**

```
const AWS = require('aws-sdk')
const s3 = new AWS.S3()

exports.handler = function(event, context, callback) {
  context.callbackWaitsForEmptyEventLoop = false
  s3.listBuckets(null, callback)
  setTimeout(function () {
    console.log('Timeout complete.')
  }, 5000)
}
```

# Deploy Node.js Lambda functions with .zip file archives

Your AWS Lambda function's code consists of scripts or compiled programs and their dependencies. You use a *deployment package* to deploy your function code to Lambda. Lambda supports two types of deployment packages: container images and .zip file archives.

To create the deployment package for a .zip file archive, you can use a built-in .zip file archive utility or any other .zip file utility (such as 7zip) for your command line tool. Note the following requirements for using a .zip file as your deployment package:

- The .zip file contains your function's code and any dependencies used to run your function's code (if applicable) on Lambda. If your function depends only on standard libraries, or AWS SDK libraries, you don't need to include these libraries in your .zip file. These libraries are included with the supported Lambda runtime (p. 82) environments.
- If the .zip file is larger than 50 MB, we recommend uploading it to your function from an Amazon Simple Storage Service (Amazon S3) bucket.
- If your deployment package contains native libraries, you can build the deployment package with AWS Serverless Application Model (AWS SAM). You can use the AWS SAM CLI `sam build` command with the `--use-container` to create your deployment package. This option builds a deployment package inside a Docker image that is compatible with the Lambda execution environment.

  For more information, see sam build in the *AWS Serverless Application Model Developer Guide*.
- You need to build the deployment package to be compatible with this instruction set architecture (p. 23) of the function.
- Lambda uses POSIX file permissions, so you may need to set permissions for the deployment package folder before you create the .zip file archive.

**Sections**

- Prerequisites (p. 288)
- Updating a function with no dependencies (p. 288)
- Updating a function with additional dependencies (p. 289)

## Prerequisites

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

## Updating a function with no dependencies

To update a function by using the Lambda API, use the UpdateFunctionCode (p. 1088) operation. Create an archive that contains your function code, and upload it using the AWS Command Line Interface (AWS CLI).

**To update a Node.js function with no dependencies**

1. Create a .zip file archive.

```
zip function.zip index.js
```

2. To upload the package, use the `update-function-code` command.

```
aws lambda update-function-code --function-name my-function --zip-file fileb://
function.zip
```

You should see the following output:

```
{
    "FunctionName": "my-function",
    "FunctionArn": "arn:aws:lambda:us-west-2:123456789012:function:my-function",
    "Runtime": "nodejs12.x",
    "Role": "arn:aws:iam::123456789012:role/lambda-role",
    "Handler": "index.handler",
    "CodeSha256": "Qf0hMc1I2di6YFMi9aXm3JtGTmcDbjniEuiYonYptAk=",
    "Version": "$LATEST",
    "TracingConfig": {
        "Mode": "Active"
    },
    "RevisionId": "983ed1e3-ca8e-434b-8dc1-7d72ebadd83d",
    ...
}
```

# Updating a function with additional dependencies

If your function depends on libraries other than the AWS SDK for JavaScript, use npm to include them in your deployment package. Ensure that the Node.js version in your local environment matches the Node.js version of your function. If any of the libraries use native code, use an Amazon Linux environment to create the deployment package.

You can add the SDK for JavaScript to the deployment package if you need a newer version than the one included on the runtime (p. 282), or to ensure that the version doesn't change in the future.

If your deployment package contains native libraries, you can build the deployment package with AWS Serverless Application Model (AWS SAM). You can use the AWS SAM CLI `sam build` command with the `--use-container` to create your deployment package. This option builds a deployment package inside a Docker image that is compatible with the Lambda execution environment.

For more information, see sam build in the *AWS Serverless Application Model Developer Guide*.

As an alternative, you can create the deployment package using an Amazon EC2 instance that provides an Amazon Linux environment. For instructions, see Using Packages and Native nodejs Modules in AWS in the AWS compute blog.

### To update a Node.js function with dependencies

1. Open a command line terminal or shell. Ensure that the Node.js version in your local environment matches the Node.js version of your function.
2. Create a folder for the deployment package. The following steps assume that the folder is named `my-function`.
3. Install libraries in the node_modules directory using the `npm install` command.

```
npm install aws-xray-sdk
```

This creates a folder structure that's similar to the following:

```
~/my-function
### index.js
### node_modules
    ### async
    ### async-listener
    ### atomic-batcher
    ### aws-sdk
    ### aws-xray-sdk
    ### aws-xray-sdk-core
```

4. Create a .zip file that contains the contents of your project folder. Use the `r` (recursive) option to ensure that zip compresses the subfolders.

```
zip -r function.zip .
```

5. Upload the package using the `update-function-code` command.

```
aws lambda update-function-code --function-name my-function --zip-file fileb://
function.zip
```

You should see the following output:

```
{
    "FunctionName": "my-function",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "Runtime": "nodejs12.x",
    "Role": "arn:aws:iam::123456789012:role/lambda-role",
    "Handler": "index.handler",
    "CodeSha256": "Qf0hMc1I2di6YFMi9aXm3JtGTmcDbjniEuiYonYptAk=",
    "Version": "$LATEST",
    "TracingConfig": {
        "Mode": "Active"
    },
    "RevisionId": "983ed1e3-ca8e-434b-8dc1-7d72ebadd83d",
    ...
}
```

In addition to code and libraries, your deployment package can also contain executable files and other resources. For more information, see Running Arbitrary Executables in AWS Lambda in the AWS Compute Blog.

# Deploy Node.js Lambda functions with container images

You can deploy your Lambda function code as a container image (p. 143). AWS provides the following resources to help you build a container image for your Node.js function:

- AWS base images for Lambda

  These base images are preloaded with a language runtime and other components that are required to run the image on Lambda. AWS provides a Dockerfile for each of the base images to help with building your container image.
- Open-source runtime interface clients (RIC)

  If you use a community or private enterprise base image, you must add a Runtime interface client (p. 145) to the base image to make it compatible with Lambda.
- Open-source runtime interface emulator (RIE)

  Lambda provides a runtime interface emulator for you to test your function locally. The base images for Lambda and base images for custom runtimes include the RIE. For other base images, you can download the RIE for testing your image (p. 146) locally.

The workflow for a function defined as a container image includes these steps:

1. Build your container image using the resources listed in this topic.
2. Upload the image to your Amazon ECR container registry (p. 153).
3. Create (p. 138) the Lambda function or update the function code (p. 141) to deploy the image to an existing function.

**Topics**

- AWS base images for Node.js (p. 291)
- Using a Node.js base image (p. 292)
- Node.js runtime interface clients (p. 292)
- Deploy the container image (p. 292)

## AWS base images for Node.js

AWS provides the following base images for Node.js:

| Tags | Runtime | Operating system | Dockerfile | Deprecation |
|---|---|---|---|---|
| 16 | Node.js 16 | Amazon Linux 2 | Dockerfile for Node.js 16 on GitHub | |
| 14 | Node.js 14 | Amazon Linux 2 | Dockerfile for Node.js 14 on GitHub | |
| 12 | Node.js 12 | Amazon Linux 2 | Dockerfile for Node.js 12 on GitHub | Nov 14, 2022 |

Amazon ECR repository: gallery.ecr.aws/lambda/nodejs

# Using a Node.js base image

For instructions on how to use a Node.js base image, choose the **usage** tab on AWS Lambda base images for Node.js in the *Amazon ECR repository*.

# Node.js runtime interface clients

Install the runtime interface client for Node.js using the npm package manager:

```
npm install aws-lambda-ric
```

For package details, see Lambda RIC on the npm website.

You can also download the Node.js runtime interface client from GitHub.

# Deploy the container image

For a new function, you deploy the Node.js image when you create the function (p. 138). For an existing function, if you rebuild the container image, you need to redeploy the image by updating the function code (p. 141).

# AWS Lambda context object in Node.js

When Lambda runs your function, it passes a context object to the handler (p. 285). This object provides methods and properties that provide information about the invocation, function, and execution environment.

### Context methods

- `getRemainingTimeInMillis()` – Returns the number of milliseconds left before the execution times out.

### Context properties

- `functionName` – The name of the Lambda function.
- `functionVersion` – The version (p. 173) of the function.
- `invokedFunctionArn` – The Amazon Resource Name (ARN) that's used to invoke the function. Indicates if the invoker specified a version number or alias.
- `memoryLimitInMB` – The amount of memory that's allocated for the function.
- `awsRequestId` – The identifier of the invocation request.
- `logGroupName` – The log group for the function.
- `logStreamName` – The log stream for the function instance.
- `identity` – (mobile apps) Information about the Amazon Cognito identity that authorized the request.
  - `cognitoIdentityId` – The authenticated Amazon Cognito identity.
  - `cognitoIdentityPoolId` – The Amazon Cognito identity pool that authorized the invocation.
- `clientContext` – (mobile apps) Client context that's provided to Lambda by the client application.
  - `client.installation_id`
  - `client.app_title`
  - `client.app_version_name`
  - `client.app_version_code`
  - `client.app_package_name`
  - `env.platform_version`
  - `env.platform`
  - `env.make`
  - `env.model`
  - `env.locale`
  - `Custom` – Custom values that are set by the client application.
- `callbackWaitsForEmptyEventLoop` – Set to false to send the response right away when the callback (p. 286) runs, instead of waiting for the Node.js event loop to be empty. If this is false, any outstanding events continue to run during the next invocation.

The following example function logs context information and returns the location of the logs.

### Example index.js file

```
exports.handler = async function(event, context) {
  console.log('Remaining time: ', context.getRemainingTimeInMillis())
  console.log('Function name: ', context.functionName)
  return context.logStreamName
```

```
}
```

# AWS Lambda function logging in Node.js

AWS Lambda automatically monitors Lambda functions on your behalf and sends function metrics to Amazon CloudWatch. Your Lambda function comes with a CloudWatch Logs log group and a log stream for each instance of your function. The Lambda runtime environment sends details about each invocation to the log stream, and relays logs and other output from your function's code.

This page describes how to produce log output from your Lambda function's code, or access logs using the AWS Command Line Interface, the Lambda console, or the CloudWatch console.

**Sections**


- Creating a function that returns logs (p. 295)
- Using the Lambda console (p. 296)
- Using the CloudWatch console (p. 296)
- Using the AWS Command Line Interface (AWS CLI) (p. 296)
- Deleting logs (p. 299)


## Creating a function that returns logs

To output logs from your function code, you can use methods on the console object, or any logging library that writes to `stdout` or `stderr`. The following example logs the values of environment variables and the event object.

**Example index.js file – Logging**

```
exports.handler = async function(event, context) {
  console.log("ENVIRONMENT VARIABLES\n" + JSON.stringify(process.env, null, 2))
  console.info("EVENT\n" + JSON.stringify(event, null, 2))
  console.warn("Event not processed.")
  return context.logStreamName
}
```

**Example log format**

```
START RequestId: c793869b-ee49-115b-a5b6-4fd21e8dedac Version: $LATEST
2019-06-07T19:11:20.562Z c793869b-ee49-115b-a5b6-4fd21e8dedac INFO ENVIRONMENT VARIABLES
{
  "AWS_LAMBDA_FUNCTION_VERSION": "$LATEST",
  "AWS_LAMBDA_LOG_GROUP_NAME": "/aws/lambda/my-function",
  "AWS_LAMBDA_LOG_STREAM_NAME": "2019/06/07/[$LATEST]e6f4a0c4241adcd70c262d34c0bbc85c",
  "AWS_EXECUTION_ENV": "AWS_Lambda_nodejs12.x",
  "AWS_LAMBDA_FUNCTION_NAME": "my-function",
  "PATH": "/var/lang/bin:/usr/local/bin:/usr/bin/:/bin:/opt/bin",
  "NODE_PATH": "/opt/nodejs/node10/node_modules:/opt/nodejs/node_modules:/var/runtime/
node_modules",
  ...
}
2019-06-07T19:11:20.563Z c793869b-ee49-115b-a5b6-4fd21e8dedac INFO EVENT
{
  "key": "value"
}
2019-06-07T19:11:20.564Z c793869b-ee49-115b-a5b6-4fd21e8dedac WARN Event not processed.
END RequestId: c793869b-ee49-115b-a5b6-4fd21e8dedac
REPORT RequestId: c793869b-ee49-115b-a5b6-4fd21e8dedac Duration: 128.83 ms Billed Duration:
 200 ms Memory Size: 128 MB Max Memory Used: 74 MB Init Duration: 166.62 ms XRAY TraceId:
 1-5d9d007f-0a8c7fd02xmpl480aed55ef0 SegmentId: 3d752xmpl1bbe37e Sampled: true
```

The Node.js runtime logs the `START`, `END`, and `REPORT` lines for each invocation. It adds a timestamp, request ID, and log level to each entry logged by the function. The report line provides the following details.

**Report Log**

- **RequestId** – The unique request ID for the invocation.
- **Duration** – The amount of time that your function's handler method spent processing the event.
- **Billed Duration** – The amount of time billed for the invocation.
- **Memory Size** – The amount of memory allocated to the function.
- **Max Memory Used** – The amount of memory used by the function.
- **Init Duration** – For the first request served, the amount of time it took the runtime to load the function and run code outside of the handler method.
- **XRAY TraceId** – For traced requests, the AWS X-Ray trace ID (p. 715).
- **SegmentId** – For traced requests, the X-Ray segment ID.
- **Sampled** – For traced requests, the sampling result.

You can view logs in the Lambda console, in the CloudWatch Logs console, or from the command line.

# Using the Lambda console

You can use the Lambda console to view log output after you invoke a Lambda function. For more information, see Accessing Amazon CloudWatch logs for AWS Lambda (p. 730).

# Using the CloudWatch console

You can use the Amazon CloudWatch console to view logs for all Lambda function invocations.

**To view logs on the CloudWatch console**

1. Open the Log groups page on the CloudWatch console.
2. Choose the log group for your function (**/aws/lambda/*your-function-name***).
3. Choose a log stream.

Each log stream corresponds to an instance of your function (p. 100). A log stream appears when you update your Lambda function, and when additional instances are created to handle multiple concurrent invocations. To find logs for a specific invocation, we recommend instrumenting your function with AWS X-Ray. X-Ray records details about the request and the log stream in the trace.

To use a sample application that correlates logs and traces with X-Ray, see Error processor sample application for AWS Lambda (p. 807).

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

You can use the AWS CLI to retrieve logs for an invocation using the `--log-type` command option. The response contains a `LogResult` field that contains up to 4 KB of base64-encoded logs from the invocation.

### Example retrieve a log ID

The following example shows how to retrieve a *log ID* from the `LogResult` field for a function named `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail
```

You should see the following output:

```
{
    "StatusCode": 200,
    "LogResult":
 "U1RBUlQgUmVxdWVzdElkOiA4N2QwNDRiOC1mMTU0LTExZTgtOGNkYS0yOTc0YzVlNGZiMjEgVmVyc2lvb...",
    "ExecutedVersion": "$LATEST"
}
```

### Example decode the logs

In the same command prompt, use the `base64` utility to decode the logs. The following example shows how to retrieve base64-encoded logs for `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail \
--query 'LogResult' --output text |  base64 -d
```

You should see the following output:

```
START RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8 Version: $LATEST
"AWS_SESSION_TOKEN": "AgoJb3JpZ2luX2VjELj...", "_X_AMZN_TRACE_ID": "Root=1-5d02e5ca-
f5792818b6fe8368e5b51d50;Parent=191db58857df8395;Sampled=0"",ask/lib:/opt/lib",
END RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8
REPORT RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8  Duration: 79.67 ms      Billed
 Duration: 80 ms         Memory Size: 128 MB     Max Memory Used: 73 MB
```

The `base64` utility is available on Linux, macOS, and Ubuntu on Windows. macOS users may need to use `base64 -D`.

### Example get-logs.sh script

In the same command prompt, use the following script to download the last five log events. The script uses `sed` to remove quotes from the output file, and sleeps for 15 seconds to allow time for the logs to become available. The output includes the response from Lambda and the output from the `get-log-events` command.

Copy the contents of the following code sample and save in your Lambda project directory as `get-logs.sh`.

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

```
#!/bin/bash
```

```
aws lambda invoke --function-name my-function --cli-binary-format raw-in-base64-out --
payload '{"key": "value"}' out
sed -i'' -e 's/"//g' out
sleep 15
aws logs get-log-events --log-group-name /aws/lambda/my-function --log-stream-name stream1
 --limit 5
```

### Example macOS and Linux (only)

In the same command prompt, macOS and Linux users may need to run the following command to ensure the script is executable.

```
chmod -R 755 get-logs.sh
```

### Example retrieve the last five log events

In the same command prompt, run the following script to get the last five log events.

```
./get-logs.sh
```

You should see the following output:

```
{
    "StatusCode": 200,
    "ExecutedVersion": "$LATEST"
}
{
    "events": [
        {
            "timestamp": 1559763003171,
            "message": "START RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf Version:
 $LATEST\n",
            "ingestionTime": 1559763003309
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tENVIRONMENT VARIABLES\r{\r  \"AWS_LAMBDA_FUNCTION_VERSION\": \"$LATEST\",\r ...",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tEVENT\r{\r  \"key\": \"value\"\r}\n",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "END RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\n",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "REPORT RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\tDuration:
 26.73 ms\tBilled Duration: 27 ms \tMemory Size: 128 MB\tMax Memory Used: 75 MB\t\n",
            "ingestionTime": 1559763018353
        }
    ],
    "nextForwardToken": "f/34783877304859518393868359594929986069206639495374241795",
    "nextBackwardToken": "b/34783877303811383369537420289090800615709599058929582080"
}
```

# Deleting logs

Log groups aren't deleted automatically when you delete a function. To avoid storing logs indefinitely, delete the log group, or configure a retention period after which logs are deleted automatically.

# AWS Lambda function errors in Node.js

When your code raises an error, Lambda generates a JSON representation of the error. This error document appears in the invocation log and, for synchronous invocations, in the output.

This page describes how to view Lambda function invocation errors for the Node.js runtime using the Lambda console and the AWS CLI.

**Sections**


- Syntax (p. 300)
- How it works (p. 300)
- Using the Lambda console (p. 301)
- Using the AWS Command Line Interface (AWS CLI) (p. 301)
- Error handling in other AWS services (p. 302)
- What's next? (p. 303)


## Syntax

**Example index.js file – Reference error**

```
exports.handler = async function() {
    return x + 10
  }
```

This code results in a reference error. Lambda catches the error and generates a JSON document with fields for the error message, the type, and the stack trace.

```
{
    "errorType": "ReferenceError",
    "errorMessage": "x is not defined",
    "trace": [
      "ReferenceError: x is not defined",
      "    at Runtime.exports.handler (/var/task/index.js:2:3)",
      "    at Runtime.handleOnce (/var/runtime/Runtime.js:63:25)",
      "    at process._tickCallback (internal/process/next_tick.js:68:7)"
    ]
  }
```

## How it works

When you invoke a Lambda function, Lambda receives the invocation request and validates the permissions in your execution role, verifies that the event document is a valid JSON document, and checks parameter values.

If the request passes validation, Lambda sends the request to a function instance. The Lambda runtime (p. 82) environment converts the event document into an object, and passes it to your function handler.

If Lambda encounters an error, it returns an exception type, message, and HTTP status code that indicates the cause of the error. The client or service that invoked the Lambda function can handle the error programmatically, or pass it along to an end user. The correct error handling behavior depends on the type of application, the audience, and the source of the error.

The following list describes the range of status codes you can receive from Lambda.

**2xx**

A `2xx` series error with a `X-Amz-Function-Error` header in the response indicates a Lambda runtime or function error. A `2xx` series status code indicates that Lambda accepted the request, but instead of an error code, Lambda indicates the error by including the `X-Amz-Function-Error` header in the response.

**4xx**

A `4xx` series error indicates an error that the invoking client or service can fix by modifying the request, requesting permission, or by retrying the request. `4xx` series errors other than `429` generally indicate an error with the request.

**5xx**

A `5xx` series error indicates an issue with Lambda, or an issue with the function's configuration or resources. `5xx` series errors can indicate a temporary condition that can be resolved without any action by the user. These issues can't be addressed by the invoking client or service, but a Lambda function's owner may be able to fix the issue.

For a complete list of invocation errors, see InvokeFunction errors (p. 995).

# Using the Lambda console

You can invoke your function on the Lambda console by configuring a test event and viewing the output. The output is captured in the function's execution logs and, when active tracing (p. 715) is enabled, in AWS X-Ray.

### To invoke a function on the Lambda console

1. Open the Functions page of the Lambda console.
2. Choose the function to test, and choose **Test**.
3. Under **Test event**, select **New event**.
4. Select a **Template**.
5. For **Name**, enter a name for the test. In the text entry box, enter the JSON test event.
6. Choose **Save changes**.
7. Choose **Test**.

The Lambda console invokes your function synchronously (p. 225) and displays the result. To see the response, logs, and other information, expand the **Details** section.

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

When you invoke a Lambda function in the AWS CLI, the AWS CLI splits the response into two documents. The AWS CLI response is displayed in your command prompt. If an error has occurred, the response contains a `FunctionError` field. The invocation response or error returned by the function is written to an output file. For example, `output.json` or `output.txt`.

The following invoke command example demonstrates how to invoke a function and write the invocation response to an `output.txt` file.

```
aws lambda invoke   \
  --function-name my-function   \
      --cli-binary-format raw-in-base64-out  \
          --payload '{"key1": "value1", "key2": "value2", "key3": "value3"}' output.txt
```

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

You should see the AWS CLI response in your command prompt:

```
{
    "StatusCode": 200,
    "FunctionError": "Unhandled",
    "ExecutedVersion": "$LATEST"
}
```

You should see the function invocation response in the `output.txt` file. In the same command prompt, you can also view the output in your command prompt using:

```
cat output.txt
```

You should see the invocation response in your command prompt.

```
{"errorType":"ReferenceError","errorMessage":"x is not defined","trace":["ReferenceError:
 x is not defined"," at Runtime.exports.handler (/var/task/index.js:2:3)"," at
 Runtime.handleOnce (/var/runtime/Runtime.js:63:25)"," at process._tickCallback (internal/
process/next_tick.js:68:7)"]}
```

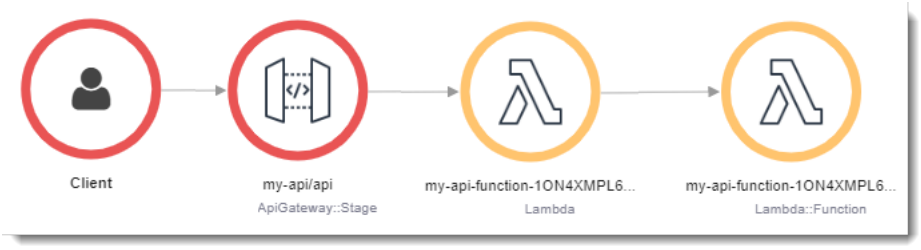
Lambda also records up to 256 KB of the error object in the function's logs. For more information, see AWS Lambda function logging in Node.js (p. 295).

# Error handling in other AWS services

When another AWS service invokes your function, the service chooses the invocation type and retry behavior. AWS services can invoke your function on a schedule, in response to a lifecycle event on a resource, or to serve a request from a user. Some services invoke functions asynchronously and let Lambda handle errors, while others retry or pass errors back to the user.

For example, API Gateway treats all invocation and function errors as internal errors. If the Lambda API rejects the invocation request, API Gateway returns a `500` error code. If the function runs but returns an error, or returns a response in the wrong format, API Gateway returns a 502 error code. To customize the error response, you must catch errors in your code and format a response in the required format.

We recommend using AWS X-Ray to determine the source of an error and its cause. X-Ray allows you to find out which component encountered an error, and see details about the errors. The following example shows a function error that resulted in a `502` response from API Gateway.



For more information, see Instrumenting Node.js code in AWS Lambda (p. 304).

# What's next?

- Learn how to show logging events for your Lambda function on the the section called "Logging" (p. 295) page.

# Instrumenting Node.js code in AWS Lambda

Lambda integrates with AWS X-Ray to help you trace, debug, and optimize Lambda applications. You can use X-Ray to trace a request as it traverses resources in your application, which may include Lambda functions and other AWS services.

To send tracing data to X-Ray, you can use one of two SDK libraries:

- AWS Distro for OpenTelemetry (ADOT) – A secure, production-ready, AWS-supported distribution of the OpenTelemetry (OTel) SDK.
- AWS X-Ray SDK for Node.js – An SDK for generating and sending trace data to X-Ray.

Both ADOT and the X-Ray SDK offer ways to send your telemetry data to the X-Ray service. You can then use X-Ray to view, filter, and gain insights into your application's performance metrics to identify issues and opportunities for optimization.

> **Important**
> **ADOT is the preferred method for instrumenting your Lambda functions**. We recommend using ADOT for all new applications. However, due to the flexibility OpenTelemetry offers, your Lambda function invocations may experience cold start latency increases. If you're optimizing for low-latency and also do not require OpenTelemetry's advanced capabilities such as telemetry correlation and dynamically configurable backend destinations, you may want to use the AWS X-Ray SDK over ADOT.

**Sections**

- Using ADOT to instrument your Node.js functions (p. 304)
- Using the X-Ray SDK to instrument your Node.js functions (p. 304)
- Activating tracing with the Lambda console (p. 305)
- Activating tracing with the Lambda API (p. 306)
- Activating tracing with AWS CloudFormation (p. 306)
- Interpreting an X-Ray trace (p. 306)
- Storing runtime dependencies in a layer (X-Ray SDK) (p. 308)

## Using ADOT to instrument your Node.js functions

ADOT provides fully managed Lambda layers (p. 14) that package everything you need to collect telemetry data using the OTel SDK. By consuming this layer, you can instrument your Lambda functions without having to modify any function code. You can also configure your layer to do custom initialization of OTel. For more information, see Custom configuration for the ADOT Collector on Lambda in the ADOT documentation.

For Node.js runtimes, you can add the **AWS managed Lambda layer for ADOT Javascript** to automatically instrument your functions. For detailed instructions on how to add this layer, see AWS Distro for OpenTelemetry Lambda Support for JavaScript in the ADOT documentation.

## Using the X-Ray SDK to instrument your Node.js functions

To record details about calls that your Lambda function makes to other resources in your application, you can also use the AWS X-Ray SDK for Node.js. To get the SDK, add the `aws-xray-sdk-core` package to your application's dependencies.

**Example blank-nodejs/package.json**

```
{
  "name": "blank-nodejs",
  "version": "1.0.0",
  "private": true,
  "devDependencies": {
    "aws-sdk": "2.631.0",
    "jest": "25.4.0"
  },
  "dependencies": {
    "aws-xray-sdk-core": "1.1.2"
  },
  "scripts": {
    "test": "jest"
  }
}
```

To instrument AWS SDK clients, wrap the `aws-sdk` library with the `captureAWS` method.

**Example blank-nodejs/function/index.js – Tracing an AWS SDK client**

```
const AWSXRay = require('aws-xray-sdk-core')
const AWS = AWSXRay.captureAWS(require('aws-sdk'))

// Create client outside of handler to reuse
const lambda = new AWS.Lambda()

// Handler
exports.handler = async function(event, context) {
  event.Records.forEach(record => {
  ...
```

The Lambda runtime sets some environment variables to configure the X-Ray SDK. For example, Lambda sets `AWS_XRAY_CONTEXT_MISSING` to `LOG_ERROR` to avoid throwing runtime errors from the X-Ray SDK. To set a custom context missing strategy, override the environment variable in your function configuration to have no value, and then you can set the context missing strategy programmatically.

**Example Example initialization code**

```
const AWSXRay = require('aws-xray-sdk-core');

// Configure the context missing strategy to do nothing
AWSXRay.setContextMissingStrategy(() => {});
```

For more information, see the section called “Environment variables” (p. 166).

After you add the correct dependencies and make the necessary code changes, activate tracing in your function's configuration via the Lambda console or the API.

# Activating tracing with the Lambda console

To toggle active tracing on your Lambda function with the console, follow these steps:

**To turn on active tracing**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **Monitoring and operations tools**.

4. Choose **Edit**.
5. Under **X-Ray**, toggle on **Active tracing**.
6. Choose **Save**.

# Activating tracing with the Lambda API

Configure tracing on your Lambda function with the AWS CLI or AWS SDK, use the following API operations:

- UpdateFunctionConfiguration (p. 1098)
- GetFunctionConfiguration (p. 967)
- CreateFunction (p. 904)

The following example AWS CLI command enables active tracing on a function named **my-function**.

```
aws lambda update-function-configuration --function-name my-function \
--tracing-config Mode=Active
```

Tracing mode is part of the version-specific configuration when you publish a version of your function. You can't change the tracing mode on a published version.

# Activating tracing with AWS CloudFormation

To activate tracing on an `AWS::Lambda::Function` resource in an AWS CloudFormation template, use the `TracingConfig` property.

**Example function-inline.yml – Tracing configuration**

```
Resources:
  function:
    Type: AWS::Lambda::Function
    Properties:
      TracingConfig:
        Mode: Active
      ...
```

For an AWS Serverless Application Model (AWS SAM) `AWS::Serverless::Function` resource, use the `Tracing` property.

**Example template.yml – Tracing configuration**

```
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      Tracing: Active
      ...
```

# Interpreting an X-Ray trace

Your function needs permission to upload trace data to X-Ray. When you activate tracing in the Lambda console, Lambda adds the required permissions to your function's execution role (p. 52). Otherwise, add the AWSXRayDaemonWriteAccess policy to the execution role.

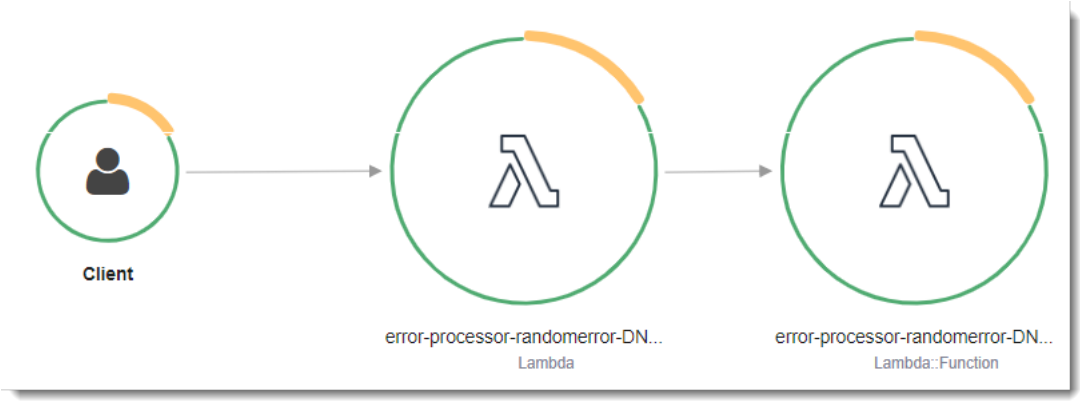
After you've configured active tracing, you can observe specific requests through your application. The X-Ray service graph shows information about your application and all its components. The following example from the error processor (p. 807) sample application shows an application with two functions. The primary function processes events and sometimes returns errors. The second function at the top processes errors that appear in the first's log group and uses the AWS SDK to call X-Ray, Amazon Simple Storage Service (Amazon S3), and Amazon CloudWatch Logs.



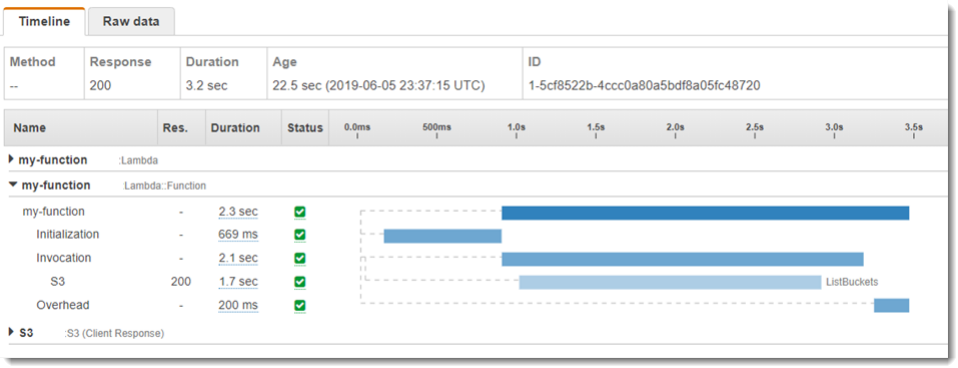

X-Ray doesn't trace all requests to your application. X-Ray applies a sampling algorithm to ensure that tracing is efficient, while still providing a representative sample of all requests. The sampling rate is 1 request per second and 5 percent of additional requests.

> **Note**
> You cannot configure the X-Ray sampling rate for your functions.

When using active tracing, Lambda records 2 segments per trace, which creates two nodes on the service graph. The following image highlights these two nodes for the primary function from the error processor example above.




The first node on the left represents the Lambda service, which receives the invocation request. The second node represents your specific Lambda function. The following example shows a trace with these two segments. Both are named **my-function**, but one has an origin of `AWS::Lambda` and the other has origin `AWS::Lambda::Function`.




This example expands the function segment to show its three subsegments:

- **Initialization** – Represents time spent loading your function and running initialization code (p. 22). This subsegment only appears for the first event that each instance of your function processes.
- **Invocation** – Represents the time spent running your handler code.
- **Overhead** – Represents the time the Lambda runtime spends preparing to handle the next event.

You can also instrument HTTP clients, record SQL queries, and create custom subsegments with annotations and metadata. For more information, see the AWS X-Ray SDK for Node.js in the *AWS X-Ray Developer Guide*.

> **Pricing**
> You can use X-Ray tracing for free each month up to a certain limit as part of the AWS Free Tier. Beyond that threshold, X-Ray charges for trace storage and retrieval. For more information, see AWS X-Ray pricing.

# Storing runtime dependencies in a layer (X-Ray SDK)

If you use the X-Ray SDK to instrument AWS SDK clients your function code, your deployment package can become quite large. To avoid uploading runtime dependencies every time you update your function code, package the X-Ray SDK in a Lambda layer (p. 156).

The following example shows an `AWS::Serverless::LayerVersion` resource that stores the AWS X-Ray SDK for Node.js.

**Example template.yml – Dependencies layer**

```
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      CodeUri: function/.
      Tracing: Active
      Layers:
        - !Ref libs
      ...
  libs:
    Type: AWS::Serverless::LayerVersion
    Properties:
      LayerName: blank-nodejs-lib
      Description: Dependencies for the blank sample app.
      ContentUri: lib/.
      CompatibleRuntimes:
        - nodejs12.x
```

With this configuration, you update the library layer only if you change your runtime dependencies. Since the function deployment package contains only your code, this can help reduce upload times.

Creating a layer for dependencies requires build changes to generate the layer archive prior to deployment. For a working example, see the blank-nodejs sample application.

# Building Lambda functions with TypeScript

You can use the Node.js runtime to run TypeScript code in AWS Lambda. Because Node.js doesn't run TypeScript code natively, you must first transpile your TypeScript code into JavaScript. Then, use the JavaScript files to deploy your function code to Lambda. Your code runs in an environment that includes the AWS SDK for JavaScript, with credentials from an AWS Identity and Access Management (IAM) role that you manage.

Lambda supports the following Node.js runtimes.

**Node.js**

| Name | Identifier | SDK | Operating system | Architectures | Deprecation |
|---|---|---|---|---|---|
| Node.js 16 | `nodejs16.x` | 2.1083.0 | Amazon Linux 2 | x86_64, arm64 | |
| Node.js 14 | `nodejs14.x` | 2.1055.0 | Amazon Linux 2 | x86_64, arm64 | |
| Node.js 12 | `nodejs12.x` | 2.1055.0 | Amazon Linux 2 | x86_64, arm64 | Nov 14, 2022 |

## Setting up a TypeScript development environment

Use a local integrated development environment (IDE), text editor, or AWS Cloud9 to write your TypeScript function code. You can't create TypeScript code on the Lambda console.

To transpile your TypeScript code, set up a compiler such as esbuild or Microsoft's TypeScript compiler (`tsc`) , which is bundled with the TypeScript distribution. You can use the AWS Serverless Application Model (AWS SAM) or the AWS Cloud Development Kit (AWS CDK) to simplify building and deploying TypeScript code. Both tools use esbuild to transpile TypeScript code into JavaScript.

When using esbuild, consider the following:

- There are several TypeScript caveats.
- You must configure your TypeScript transpilation settings to match the Node.js runtime that you plan to use. For more information, see Target in the esbuild documentation. For an example of a **tsconfig.json** file that demonstrates how to target a specific Node.js version supported by Lambda, refer to the TypeScript GitHub repository.
- esbuild doesn't perform type checks. To check types, use the `tsc` compiler. Run `tsc -noEmit` or add a `"noEmit"` parameter to your **tsconfig.json** file, as shown in the following example. This configures `tsc` to not emit JavaScript files. After checking types, use esbuild to convert the TypeScript files into JavaScript.

**Example tsconfig.json**

```
{
```

```
  "compilerOptions": {
    "target": "es2020",
    "strict": true,
    "preserveConstEnums": true,
    "noEmit": true,
    "sourceMap": false,
    "module":"commonjs",
    "moduleResolution":"node",
    "esModuleInterop": true,
    "skipLibCheck": true,
    "forceConsistentCasingInFileNames": true,
    "isolatedModules": true,
  },
  "exclude": ["node_modules", "**/*.test.ts"]
}
```

**Topics**


- AWS Lambda function handler in TypeScript (p. 312)
- Deploy transpiled TypeScript code in Lambda with .zip file archives (p. 314)
- Deploy transpiled TypeScript code in Lambda with container images (p. 319)
- AWS Lambda function errors in TypeScript (p. 322)

# AWS Lambda function handler in TypeScript

The AWS Lambda function *handler* is the method in your function code that processes events. When your function is invoked, Lambda runs the handler method. When the handler exits or returns a response, it becomes available to handle another event.

The Node.js runtime passes three arguments to the handler method:

- The `event` object: Contains information from the invoker.
- The context object (p. 293): Contains information about the invocation, function, and execution environment.
- The third argument, `callback`, is a function that you can call in non-async handlers to send a response. For async handlers, you return a response, error, or promise to the runtime instead of using `callback`.

## Non-async handlers

For non-async handlers, the runtime passes the event object, the context object (p. 293), and the callback function to the handler method. The response object in the callback function must be compatible with `JSON.stringify`.

**Example TypeScript function – synchronous**

```
import { Context, APIGatewayProxyCallback, APIGatewayEvent } from 'aws-lambda';

export const lambdaHandler = (event: APIGatewayEvent, context: Context, callback:
 APIGatewayProxyCallback): void => {
    console.log(`Event: ${JSON.stringify(event, null, 2)}`);
    console.log(`Context: ${JSON.stringify(context, null, 2)}`);
    callback(null, {
        statusCode: 200,
        body: JSON.stringify({
            message: 'hello world',
        }),
    });
};
```

## Async handlers

For async handlers, you can use `return` and `throw` to send a response or error, respectively. Functions must use the `async` keyword to use these methods to return a response or error.

If your code performs an asynchronous task, return a promise to make sure that it finishes running. When you resolve or reject the promise, Lambda sends the response or error to the invoker.

**Example TypeScript function – asynchronous**

```
import { Context, APIGatewayProxyResult, APIGatewayEvent } from 'aws-lambda';

export const lambdaHandler = async (event: APIGatewayEvent, context: Context):
 Promise<APIGatewayProxyResult> => {
    console.log(`Event: ${JSON.stringify(event, null, 2)}`);
    console.log(`Context: ${JSON.stringify(context, null, 2)}`);
    return {
        statusCode: 200,
        body: JSON.stringify({
```

```
            message: 'hello world',
        }),
    };
};
```

# Using types for the event object

We recommend that you don't use the any type for the handler arguments and return type because you lose the ability to check types. Instead, generate an event using the sam local generate-event AWS Serverless Application Model CLI command, or use an open-source definition from the @types/aws-lambda package.

### Generating an event using the sam local generate-event command

1. Generate an Amazon Simple Storage Service (Amazon S3) proxy event.

```
sam local generate-event s3 put >> S3PutEvent.json
```

2. Use the quicktype utility to generate type definitions from the **S3PutEvent.json** file.

```
npm install -g quicktype
quicktype S3PutEvent.json -o S3PutEvent.ts
```

3. Use the generated types in your code.

```
import { S3PutEvent } from './S3PutEvent';

export const lambdaHandler = async (event: S3PutEvent): Promise<void> => {
  event.Records.map((record) => console.log(record.s3.object.key));
};
```

### Generating an event using an open-source definition from the @types/aws-lambda package

1. Add the @types/aws-lambda package as a development dependency.

```
npm install -D @types/aws-lambda
```

2. Use the types in your code.

```
import { S3Event } from "aws-lambda";

export const lambdaHandler = async (event: S3Event): Promise<void> => {
  event.Records.map((record) => console.log(record.s3.object.key));
};
```

# Deploy transpiled TypeScript code in Lambda with .zip file archives

Before you can deploy TypeScript code to AWS Lambda, you need to transpile it into JavaScript. This page explains three ways to build and deploy TypeScript code to Lambda:

- Using the AWS Serverless Application Model (AWS SAM) (p. 314)
- Using the AWS Cloud Development Kit (AWS CDK) (p. 315)
- Using the AWS Command Line Interface (AWS CLI) and esbuild (p. 317)

The AWS SAM and AWS CDK simplify building and deploying TypeScript functions. The AWS SAM template specification provides a simple and clean syntax to describe the Lambda functions, APIs, permissions, configurations, and events that make up your serverless application. The AWS CDK lets you build reliable, scalable, cost-effective applications in the cloud with the considerable expressive power of a programming language. The AWS CDK is intended for moderately to highly experienced AWS users. Both the AWS CDK and the AWS SAM use esbuild to transpile TypeScript code into JavaScript.

## Using the AWS SAM to deploy TypeScript code to Lambda

Follow the steps below to download, build, and deploy a sample Hello World TypeScript application using the AWS SAM. This application implements a basic API backend. It consists of an Amazon API Gateway endpoint and a Lambda function. When you send a GET request to the API Gateway endpoint, the Lambda function is invoked. The function returns a `hello world` message.

> **Note**
> The AWS SAM uses esbuild to create Node.js Lambda functions from TypeScript code. esbuild support is currently in public preview. During public preview, esbuild support may be subject to backwards incompatible changes.

### Prerequisites

To complete the steps in this section, you must have the following:

- AWS CLI version 2
- AWS SAM CLI version 1.39 or later
- Node.js 14.x or later

### Deploy a sample AWS SAM application

1. Initialize the application using the Hello World TypeScript template.

```
sam init --app-template hello-world-typescript --name sam-app --package-type Zip --
runtime nodejs16.x
```

2. (Optional) The sample application includes configurations for commonly used tools, such as ESLlint for code linting and Jest for unit testing. To run lint and test commands:

```
cd sam-app/hello-world
npm install
npm run lint
npm run test
```

3. Build the app. The `--beta-features` option is required because esbuild support is in public preview.

```
cd sam-app
sam build --beta-features
```

4. Deploy the app.

```
sam deploy --guided
```

5. Follow the on-screen prompts. To accept the default options provided in the interactive experience, respond with `Enter`.
6. The output shows the endpoint for the REST API. Open the endpoint in a browser to test the function. You should see this response:

```
{"message":"hello world"}
```

7. This is a public API endpoint that is accessible over the internet. We recommend that you delete the endpoint after testing.

```
sam delete
```

# Using the AWS CDK to deploy TypeScript code to Lambda

Follow the steps below to build and deploy a sample TypeScript application using the AWS CDK. This application implements a basic API backend. It consists of an API Gateway endpoint and a Lambda function. When you send a GET request to the API Gateway endpoint, the Lambda function is invoked. The function returns a `hello world` message.

### Prerequisites

To complete the steps in this section, you must have the following:

- AWS CLI version 2
- AWS CDK version 2
- Node.js 14.x or later

### Deploy a sample AWS CDK application

1. Create a project directory for your new application.

```
mkdir hello-world
cd hello-world
```

2. Initialize the app.

```
cdk init app --language typescript
```

3. Add the @types/aws-lambda package as a development dependency.

```
npm install -D @types/aws-lambda
```

4. Open the **lib** directory. You should see a file called **hello-world-stack.ts**. Create two new files in this directory: **hello-world.function.ts** and **hello-world.ts**.
5. Open **hello-world.function.ts** and add the following code to the file. This is the code for the Lambda function.

```
import { Context, APIGatewayProxyResult, APIGatewayEvent } from 'aws-lambda';

export const handler = async (event: APIGatewayEvent, context: Context):
 Promise<APIGatewayProxyResult> => {
    console.log(`Event: ${JSON.stringify(event, null, 2)}`);
    console.log(`Context: ${JSON.stringify(context, null, 2)}`);
    return {
        statusCode: 200,
        body: JSON.stringify({
            message: 'hello world',
        }),
    };
};
```

6. Open **hello-world.ts** and add the following code to the file. This contains the NodejsFunction construct, which creates the Lambda function, and the LambdaRestApi construct, which creates the REST API.

```
import { Construct } from 'constructs';
import { NodejsFunction } from 'aws-cdk-lib/aws-lambda-nodejs';
import { LambdaRestApi } from 'aws-cdk-lib/aws-apigateway';

export class HelloWorld extends Construct {
  constructor(scope: Construct, id: string) {
    super(scope, id);
    const helloFunction = new NodejsFunction(this, 'function');
    new LambdaRestApi(this, 'apigw', {
      handler: helloFunction,
    });
  }
}
```

   The `NodejsFunction` construct assumes the following by default:

   - Your function handler is called `handler`.
   - The .ts file that contains the function code (**hello-world.function.ts**) is in the same directory as the .ts file that contains the construct (**hello-world.ts**). The construct uses the construct's ID ("hello-world") and the name of the Lambda handler file ("function") to find the function code. For example, if your function code is in a file called **hello-world.my-function.ts**, the **hello-world.ts** file must reference the function code like this:

     ```
     const helloFunction = new NodejsFunction(this, 'my-function');
     ```

   You can change this behavior and configure other esbuild parameters. For more information, see Configuring esbuild in the AWS CDK API reference.
7. Open **hello-world-stack.ts**. This is the code that defines your AWS CDK stack. Replace the code with the following:

```
import { Stack, StackProps } from 'aws-cdk-lib';
import { Construct } from 'constructs';
import { HelloWorld } from './hello-world';

export class HelloWorldStack extends Stack {
```

```
  constructor(scope: Construct, id: string, props?: StackProps) {
    super(scope, id, props);
    new HelloWorld(this, 'hello-world');
  }
}
```

8. Deploy your application.

```
cdk deploy
```

9. The AWS CDK builds and packages the Lambda function using esbuild, and then deploys the function to the Lambda runtime. The output shows the endpoint for the REST API. Open the endpoint in a browser to test the function. You should see this response:

```
{"message":"hello world"}
```

   This is a public API endpoint that is accessible over the internet. We recommend that you delete the endpoint after testing.

# Using the AWS CLI and esbuild to deploy TypeScript code to Lambda

The following example demonstrates how to transpile and deploy TypeScript code to Lambda using esbuild and the AWS CLI. esbuild produces one JavaScript file with all dependencies. This is the only file that you need to add to the .zip archive.

### Prerequisites

To complete the steps in this section, you must have the following:

- AWS CLI version 2
- Node.js 14.x or later
- An execution role (p. 52) for the Lambda function

### Deploy a sample function

1. On your local machine, create a project directory for your new function.
2. Create a new Node.js project with npm or a package manager of your choice.

```
npm init
```

3. Add the @types/aws-lambda and esbuild packages as development dependencies.

```
npm install -D @types/aws-lambda esbuild
```

4. Create a new file called **index.ts**. Add the following code to the new file. This is the code for the Lambda function. The function returns a `hello world` message. The function doesn't create any API Gateway resources.

```
import { Context, APIGatewayProxyResult, APIGatewayEvent } from 'aws-lambda';

export const handler = async (event: APIGatewayEvent, context: Context):
 Promise<APIGatewayProxyResult> => {
  console.log(`Event: ${JSON.stringify(event, null, 2)}`);
```

```
  console.log(`Context: ${JSON.stringify(context, null, 2)}`);
  return {
      statusCode: 200,
      body: JSON.stringify({
          message: 'hello world',
      }),
   };
};
```

5. Add a build script to the **package.json** file. This configures esbuild to automatically create the .zip deployment package. For more information, see Build scripts in the esbuild documentation.

```
  "scripts": {
  "prebuild": "rm -rf dist",
  "build": "esbuild index.ts --bundle --minify --sourcemap --platform=node --
target=es2020 --outfile=dist/index.js",
  "postbuild": "cd dist && zip -r index.zip index.js*"
},
```

6. Build the package.

```
npm run build
```

7. Create a Lambda function using the .zip deployment package. Replace the highlighted text with the Amazon Resource Name (ARN) of your execution role (p. 52).

```
aws lambda create-function --function-name hello-world --runtime "nodejs16.x" --
role arn:aws:iam::123456789012:role/lambda-ex --zip-file "fileb://dist/index.zip" --
handler index.handler
```

8. Run a test event (p. 252) to confirm that the function returns the following response. If you want to invoke this function using API Gateway, create and configure a REST API.

```
{
  "statusCode": 200,
  "body": "{\"message\":\"hello world\"}"
}
```

# Deploy transpiled TypeScript code in Lambda with container images

You can deploy your TypeScript code to an AWS Lambda function as a Node.js container image (p. 143). AWS provides base images (p. 291) for Node.js to help you build the container image. These base images are preloaded with a language runtime and other components that are required to run the image on Lambda. AWS provides a Dockerfile for each of the base images to help with building your container image.

If you use a community or private enterprise base image, you must add the Node.js runtime interface client (RIC) (p. 292) to the base image to make it compatible with Lambda. For more information, see Creating images from alternative base images (p. 152).

Lambda provides a runtime interface emulator (RIE) for you to test your function locally. The base images for Lambda and base images for custom runtimes include the RIE. For other base images, you can download the RIE for testing your image locally (p. 146).

## Using a Node.js base image to build and package TypeScript function code

### Prerequisites

To complete the steps in this section, you must have the following:

- AWS Command Line Interface (AWS CLI) version 2
- Docker

  The following instructions use Docker CLI commands to create the container image. To install Docker, see Get Docker on the Docker website.
- Node.js 14.x or later

### To create an image from an AWS base image for Lambda

1. On your local machine, create a project directory for your new function.
2. Create a new Node.js project with `npm` or a package manager of your choice.

```
npm init
```

3. Add the @types/aws-lambda and esbuild packages as development dependencies.

```
npm install -D @types/aws-lambda esbuild
```

4. Add a build script to the **package.json** file.

```
  "scripts": {
  "build": "esbuild index.ts --bundle --minify --sourcemap --platform=node --
target=es2020 --outfile=dist/index.js"
}
```

5. Create a new file called **index.ts**. Add the following sample code to the new file. This is the code for the Lambda function. The function returns a `hello world` message.

```
import { Context, APIGatewayProxyResult, APIGatewayEvent } from 'aws-lambda';
```

```
export const handler = async (event: APIGatewayEvent, context: Context):
 Promise<APIGatewayProxyResult> => {
    console.log(`Event: ${JSON.stringify(event, null, 2)}`);
    console.log(`Context: ${JSON.stringify(context, null, 2)}`);
    return {
        statusCode: 200,
        body: JSON.stringify({
            message: 'hello world',
        }),
    };
};
```

6. Create a new Dockerfile with the following configuration:

   - Set the `FROM` property to the URI of the base image.
   - Set the `CMD` argument to specify the Lambda function handler.

   **Example Dockerfile**

   The following Dockerfile uses a multi-stage build. The first step transpiles the TypeScript code into JavaScript. The second step produces a container image that contains only JavaScript files and production dependencies.

```
FROM public.ecr.aws/lambda/nodejs:16 as builder
WORKDIR /usr/app
COPY package.json index.ts  ./
RUN npm install
RUN npm run build


FROM public.ecr.aws/lambda/nodejs:16
WORKDIR ${LAMBDA_TASK_ROOT}
COPY --from=builder /usr/app/dist/* ./
CMD ["index.handler"]
```

7. Build your image.

```
docker build -t hello-world .
```

8. Authenticate the Docker CLI to your Amazon Elastic Container Registry (Amazon ECR) registry.

```
aws ecr get-login-password --region us-east-1 | docker login --username AWS --password-
stdin 123456789012.dkr.ecr.us-east-1.amazonaws.com
```

9. Create a repository in Amazon ECR using the `create-repository` command.

```
aws ecr create-repository --repository-name hello-world --image-scanning-configuration
 scanOnPush=true --image-tag-mutability MUTABLE
```

10. Tag your image to match your repository name, and deploy the image to Amazon ECR using the `docker push` command.

```
docker tag  hello-world:latest 123456789012.dkr.ecr.us-east-1.amazonaws.com/hello-
world:latest
docker push 123456789012.dkr.ecr.us-east-1.amazonaws.com/hello-world:latest
```

11. Create and test (p. 138) the Lambda function.

To update the function code, you must create a new image version and store the image in the Amazon ECR repository. For more information, see Updating function code (p. 141).

# AWS Lambda function errors in TypeScript

If an exception occurs in TypeScript code that's transpiled into JavaScript, use source map files to determine where the error occurred. Source map files allow debuggers to map compiled JavaScript files to the TypeScript source code.

For example, the following code results in an error:

```
export const handler = async (event: unknown): Promise<unknown> => {
    throw new Error('Some exception');
};
```

AWS Lambda catches the error and generates a JSON document. However, this JSON document refers to the compiled JavaScript file (**app.js**), not the TypeScript source file.

```
{
  "errorType": "Error",
  "errorMessage": "Some exception",
  "stack": [
      "Error: Some exception",
      "    at Runtime.p [as handler] (/var/task/app.js:1:491)",
      "    at Runtime.handleOnce (/var/runtime/Runtime.js:66:25)"
  ]
}
```

### To get an error response that maps to your TypeScript source file

**Note**
The following steps aren't valid for Lambda@Edge functions because Lambda@Edge doesn't support environment variables.

1. Generate a source map file with esbuild or another TypeScript compiler. Example:

   ```
   esbuild app.ts –sourcemap –outfile=output.js
   ```

2. Add the source map to your deployment.
3. Turn on source maps for the Node.js runtime by adding `--enable-source-maps` to your `NODE_OPTIONS`.

### Example for the AWS Serverless Application Model (AWS SAM)

```
Globals:
    Function:
      Environment:
        Variables:
          NODE_OPTIONS: '--enable-source-maps'
```

Make sure that the esbuild properties in your **template.yaml** file include `Sourcemap: true`. Example:

```
Metadata: # Manage esbuild properties
  BuildMethod: esbuild
  BuildProperties:
    Minify: true
    Target: "es2020"
    Sourcemap: true
    EntryPoints:
```

```
    - app.ts
```

### Example Example for the AWS Cloud Development Kit (AWS CDK)

To use a source map with an AWS CDK application, add the following code to the file that contains the NodejsFunction construct.

```
const helloFunction = new NodejsFunction(this, 'function',{
  bundling: {
    minify: true,
  sourceMap: true
  },
  environment:{
    NODE_OPTIONS: '--enable-source-maps',
  }
});
```

When you use a source map in your code, you get an error response similar to the following. This response shows that the error happened at line 2, column 11 in the **app.ts** file.

```
{
  "errorType": "Error",
  "errorMessage": "Some exception",
  "stack": [
      "Error: Some exception",
      "    at Runtime.p (/private/var/folders/3c/0d4wz7dn2y75bw_hxdwc0h6w0000gr/T/
tmpfmxb4ziy/app.ts:2:11)",
      "    at Runtime.handleOnce (/var/runtime/Runtime.js:66:25)"
  ]
}
```

The following topics about the Node.js runtime are also relevant for TypeScript:

- AWS Lambda context object in Node.js (p. 293)
- AWS Lambda function logging in Node.js (p. 295)
- Instrumenting Node.js code in AWS Lambda (p. 304)

# Building Lambda functions with Python

You can run Python code in AWS Lambda. Lambda provides runtimes (p. 82) for Python that run your code to process events. Your code runs in an environment that includes the SDK for Python (Boto3), with credentials from an AWS Identity and Access Management (IAM) role that you manage.

Lambda supports the following Python runtimes.

**Python**

| Name | Identifier | SDK | Operating system | Architectures | Deprecation |
|---|---|---|---|---|---|
| Python 3.9 | `python3.9` | boto3-1.20.32 botocore-1.23.32 | Amazon Linux 2 | x86_64, arm64 | |
| Python 3.8 | `python3.8` | boto3-1.20.32 botocore-1.23.32 | Amazon Linux 2 | x86_64, arm64 | |
| Python 3.7 | `python3.7` | boto3-1.20.32 botocore-1.23.32 | Amazon Linux | x86_64 | |

The runtime information in this table undergoes continuous updates. For more information on using AWS SDKs in Lambda, see Managing AWS SDKs in Lambda functions.

### To create a Python function

1. Open the Lambda console.
2. Choose **Create function**.
3. Configure the following settings:
   - **Name** – **`my-function`**.
   - **Runtime** – **Python 3.9**.
   - **Role** – **Choose an existing role**.
   - **Existing role** – **`lambda-role`**.
4. Choose **Create function**.
5. To configure a test event, choose **Test**.
6. For **Event name**, enter **`test`**.
7. Choose **Save changes**.
8. To invoke the function, choose **Test**.

The console creates a Lambda function with a single source file named `lambda_function`. You can edit this file and add more files in the built-in code editor (p. 38). To save your changes, choose **Save**. Then, to run your code, choose **Test**.

> **Note**
> The Lambda console uses AWS Cloud9 to provide an integrated development environment in the browser. You can also use AWS Cloud9 to develop Lambda functions in your own

environment. For more information, see Working with Lambda Functions in the AWS Cloud9 user guide.

**Note**
To get started with application development in your local environment, deploy one of the sample applications available in this guide's GitHub repository.

### Sample Lambda applications in Python

- blank-python – A Python function that shows the use of logging, environment variables, AWS X-Ray tracing, layers, unit tests and the AWS SDK.

Your Lambda function comes with a CloudWatch Logs log group. The function runtime sends details about each invocation to CloudWatch Logs. It relays any logs that your function outputs (p. 340) during invocation. If your function returns an error (p. 345), Lambda formats the error and returns it to the invoker.

**Topics**


- Lambda function handler in Python (p. 326)
- Deploy Python Lambda functions with .zip file archives (p. 330)
- Deploy Python Lambda functions with container images (p. 335)
- AWS Lambda context object in Python (p. 338)
- AWS Lambda function logging in Python (p. 340)
- AWS Lambda function errors in Python (p. 345)
- Instrumenting Python code in AWS Lambda (p. 349)

# Lambda function handler in Python

**Note**
End of support for the Python 3.6 runtime started on July 18, 2022. For more information, see the section called "Runtime deprecation policy" (p. 83).

The Lambda function *handler* is the method in your function code that processes events. When your function is invoked, Lambda runs the handler method. When the handler exits or returns a response, it becomes available to handle another event.

You can use the following general syntax when creating a function handler in Python:

```
def handler_name(event, context):
    ...
    return some_value
```

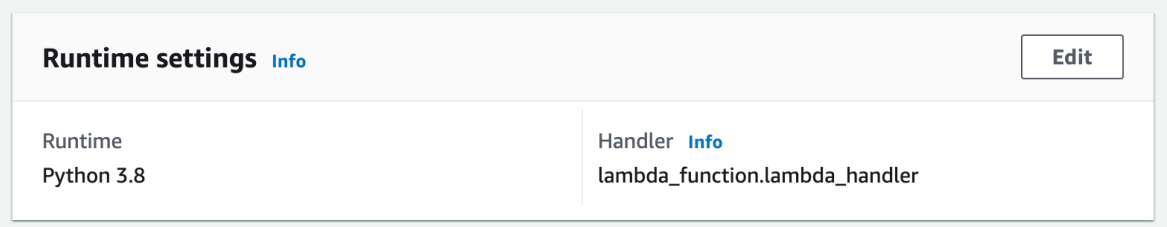
## Naming

The Lambda function handler name specified at the time that you create a Lambda function is derived from:

- The name of the file in which the Lambda handler function is located.
- The name of the Python handler function.

A function handler can be any name; however, the default name in the Lambda console is `lambda_function.lambda_handler`. This function handler name reflects the function name (`lambda_handler`) and the file where the handler code is stored (`lambda_function.py`).

To change the function handler name in the Lambda console, on the **Runtime settings** pane, choose **Edit**.




## How it works

When Lambda invokes your function handler, the Lambda runtime (p. 82) passes two arguments to the function handler:

- The first argument is the event object. An event is a JSON-formatted document that contains data for a Lambda function to process. The Lambda runtime (p. 82) converts the event to an object and passes it to your function code. It is usually of the Python `dict` type. It can also be `list`, `str`, `int`, `float`, or the `NoneType` type.

  The event object contains information from the invoking service. When you invoke a function, you determine the structure and contents of the event. When an AWS service invokes your function, the service defines the event structure. For more information about events from AWS services, see Using AWS Lambda with other services (p. 496).

- The second argument is the context object (p. 338). A context object is passed to your function by Lambda at runtime. This object provides methods and properties that provide information about the invocation, function, and runtime environment.

# Returning a value

Optionally, a handler can return a value. What happens to the returned value depends on the invocation type (p. 224) and the service (p. 496) that invoked the function. For example:

- If you use the `RequestResponse` invocation type, such as Synchronous invocation (p. 225), AWS Lambda returns the result of the Python function call to the client invoking the Lambda function (in the HTTP response to the invocation request, serialized into JSON). For example, AWS Lambda console uses the `RequestResponse` invocation type, so when you invoke the function on the console, the console will display the returned value.
- If the handler returns objects that can't be serialized by `json.dumps`, the runtime returns an error.
- If the handler returns `None`, as Python functions without a `return` statement implicitly do, the runtime returns `null`.
- If you use the `Event` invocation type (an asynchronous invocation (p. 228)), the value is discarded.

**Note**
In Python 3.9 and later releases, Lambda includes the requestId of the invocation in the error response.

# Examples

The following section shows examples of Python functions you can use with Lambda. If you use the Lambda console to author your function, you do not need to attach a .zip archive file (p. 330) to run the functions in this section. These functions use standard Python libraries which are included with the Lambda runtime you selected. For more information, see Lambda deployment packages (p. 35).

## Returning a message

The following example shows a function called `lambda_handler` that uses the `python3.8` Lambda runtime (p. 82). The function accepts user input of a first and last name, and returns a message that contains data from the event it received as input.

```
def lambda_handler(event, context):
    message = 'Hello {} {}!'.format(event['first_name'], event['last_name'])
    return {
        'message' : message
    }
```

You can use the following event data to invoke the function:

```
{
    "first_name": "John",
    "last_name": "Smith"
}
```

The response shows the event data passed as input:

```
{
    "message": "Hello John Smith!"
```

```
}
```

## Parsing a response

The following example shows a function called `lambda_handler` that uses the `python3.8` Lambda runtime (p. 82). The function uses event data passed by Lambda at runtime. It parses the environment variable (p. 166) in `AWS_REGION` returned in the JSON response.

```
import os
import json

def lambda_handler(event, context):
    json_region = os.environ['AWS_REGION']
    return {
        "statusCode": 200,
        "headers": {
            "Content-Type": "application/json"
        },
        "body": json.dumps({
            "Region ": json_region
        })
    }
```

You can use any event data to invoke the function:

```
{
  "key1": "value1",
  "key2": "value2",
  "key3": "value3"
}
```

Lambda runtimes set several environment variables during initialization. For more information on the environment variables returned in the response at runtime, see Using AWS Lambda environment variables (p. 166).

The function in this example depends on a successful response (in `200`) from the Invoke API. For more information on the Invoke API status, see the Invoke (p. 993) Response Syntax.

## Returning a calculation

The following example Lambda Python function code on GitHub shows a function called `lambda_handler` that uses the `python3.6` Lambda runtime (p. 82). The function accepts user input and returns a calculation to the user.

```
import logging

logger = logging.getLogger()
logger.setLevel(logging.INFO)

def lambda_handler(event, context):
    ...
    result = None
    action = event.get('action')
    if action == 'increment':
        result = event.get('number', 0) + 1
        logger.info('Calculated result of %s', result)
    else:
        logger.error("%s is not a valid action.", action)
```

```
    response = {'result': result}
    return response
```

You can use the following event data to invoke the function:

```
{
    "action": "increment",
    "number": 3
}
```

# Deploy Python Lambda functions with .zip file archives

**Note**
End of support for the Python 3.6 runtime started on July 18, 2022. For more information, see the section called "Runtime deprecation policy" (p. 83).

Your AWS Lambda function's code consists of scripts or compiled programs and their dependencies. You use a *deployment package* to deploy your function code to Lambda. Lambda supports two types of deployment packages: container images and .zip file archives.

To create the deployment package for a .zip file archive, you can use a built-in .zip file archive utility or any other .zip file utility (such as 7zip) for your command line tool. Note the following requirements for using a .zip file as your deployment package:

- The .zip file contains your function's code and any dependencies used to run your function's code (if applicable) on Lambda. If your function depends only on standard libraries, or AWS SDK libraries, you don't need to include these libraries in your .zip file. These libraries are included with the supported Lambda runtime (p. 82) environments.
- If the .zip file is larger than 50 MB, we recommend uploading it to your function from an Amazon Simple Storage Service (Amazon S3) bucket.
- If your deployment package contains native libraries, you can build the deployment package with AWS Serverless Application Model (AWS SAM). You can use the AWS SAM CLI `sam build` command with the `--use-container` to create your deployment package. This option builds a deployment package inside a Docker image that is compatible with the Lambda execution environment.

  For more information, see sam build in the *AWS Serverless Application Model Developer Guide*.
- You need to build the deployment package to be compatible with this instruction set architecture (p. 23) of the function.
- Lambda uses POSIX file permissions, so you may need to set permissions for the deployment package folder before you create the .zip file archive.

**Note**
A python package may contain initialization code in the __init__.py file. Prior to Python 3.9, Lambda did not run the __init__.py code for packages in the function handler's directory or parent directories. In Python 3.9 and later releases, Lambda runs the init code for packages in these directories during initialization.
Note that Lambda runs the init code only when the execution environment is first initialized, not for each function invocation in that initialized environment.

**Topics**

- Prerequisites (p. 330)
- What is a runtime dependency? (p. 331)
- Deployment package with no dependencies (p. 331)
- Deployment package with dependencies (p. 331)
- Using a virtual environment (p. 332)
- Deploy your .zip file to the function (p. 333)

## Prerequisites

You need the AWS Command Line Interface (AWS CLI) to call service API operations. To install the AWS CLI, see Installing the AWS CLI in the AWS Command Line Interface User Guide.

# What is a runtime dependency?

A deployment package (p. 35) is required to create or update a Lambda function with or without runtime dependencies. The deployment package acts as the source bundle to run your function's code and dependencies (if applicable) on Lambda.

A dependency can be any package, module or other assembly dependency that is not included with the Lambda runtime (p. 82) environment for your function's code.

The following describes a Lambda function without runtime dependencies:

- If your function's code is in Python 3.8 or later, and it depends only on standard Python math and logging libraries, you don't need to include the libraries in your .zip file. These libraries are included with the Python runtime.
- If your function's code depends on the AWS SDK for Python (Boto3), you don't need to include the boto3 library in your .zip file. These libraries are included with Python3.8 and later runtimes.

Note: Lambda periodically updates the Boto3 libraries to enable the latest set of features and security updates. To have full control of the dependencies your function uses, package all of your dependencies with your deployment package.

# Deployment package with no dependencies

Create the .zip file for your deployment package.

**To create the deployment package**

1. Open a command prompt and create a `my-math-function` project directory. For example, on macOS:

   ```
   mkdir my-math-function
   ```

2. Navigate to the `my-math-function` project directory.

   ```
   cd my-math-function
   ```

3. Copy the contents of the sample Python code from GitHub and save it in a new file named `lambda_function.py`. Your directory structure should look like this:

   ```
   my-math-function$
   | lambda_function.py
   ```

4. Add the `lambda_function.py` file to the root of the .zip file.

   ```
   zip my-deployment-package.zip lambda_function.py
   ```

   This generates a `my-deployment-package.zip` file in your project directory. The command produces the following output:

   ```
   adding: lambda_function.py (deflated 50%)
   ```

# Deployment package with dependencies

Create the .zip file for your deployment package.

**To create the deployment package**

1. Open a command prompt and create a `my-sourcecode-function` project directory. For example, on macOS:

```
mkdir my-sourcecode-function
```

2. Navigate to the `my-sourcecode-function` project directory.

```
cd my-sourcecode-function
```

3. Copy the contents of the following sample Python code and save it in a new file named `lambda_function.py`:

```
import requests
def lambda_handler(event, context):
    response = requests.get("https://www.example.com/")
    print(response.text)
    return response.text
```

   Your directory structure should look like this:

```
my-sourcecode-function$
| lambda_function.py
```

4. Install the requests library to a new `package` directory.

```
pip install --target ./package requests
```

5. Create a deployment package with the installed library at the root.

```
cd package
zip -r ../my-deployment-package.zip .
```

   This generates a `my-deployment-package.zip` file in your project directory. The command produces the following output:

```
adding: chardet/ (stored 0%)
adding: chardet/enums.py (deflated 58%)
...
```

6. Add the `lambda_function.py` file to the root of the zip file.

```
cd ..
zip -g my-deployment-package.zip lambda_function.py
```

# Using a virtual environment

**To update a Python function using a virtual environment**

1. Activate the virtual environment. For example:

```
~/my-function$ source myvenv/bin/activate
```

2. Install libraries with pip.

```
(myvenv) ~/my-function$ pip install requests
```

3. Deactivate the virtual environment.

```
(myvenv) ~/my-function$ deactivate
```

4. Create a deployment package with the installed libraries at the root.

```
~/my-function$cd myvenv/lib/python3.8/site-packages
zip -r ../../../../my-deployment-package.zip .
```

The last command saves the deployment package to the root of the `my-function` directory.

**Tip**
A library may appear in `site-packages` or `dist-packages` and the first folder `lib` or `lib64`. You can use the `pip show` command to locate a specific package.

5. Add function code files to the root of your deployment package.

```
~/my-function/myvenv/lib/python3.8/site-packages$ cd ../../../../
~/my-function$ zip -g my-deployment-package.zip lambda_function.py
```

After you complete this step, you should have the following directory structure:

```
my-deployment-package.zip$
  # lambda_function.py
  # __pycache__
  # certifi/
  # certifi-2020.6.20.dist-info/
  # chardet/
  # chardet-3.0.4.dist-info/
  ...
```

# Deploy your .zip file to the function

To deploy the new code to your function, you upload the new .zip file deployment package. You can use the Lambda console (p. 133) to upload a .zip file to the function, or you can use the UpdateFunctionCode (p. 1088) CLI command.

The following example uploads a file named **my-deployment-package.zip**. Use the fileb:// file prefix to upload the binary .zip file to Lambda.

```
~/my-function$ aws lambda update-function-code --function-name MyLambdaFunction --zip-file
 fileb://my-deployment-package.zip
  {
  "FunctionName": "mylambdafunction",
  "FunctionArn": "arn:aws:lambda:us-west-2:123456789012:function:mylambdafunction",
  "Runtime": "python3.9",
  "Role": "arn:aws:iam::123456789012:role/lambda-role",
  "Handler": "lambda_function.lambda_handler",
  "CodeSize": 5912988,
  "CodeSha256": "A2P0NUWq1J+LtSbkuP8tm9uNYqs1TAa3M76ptmZCw5g=",
  "Version": "$LATEST",
  "RevisionId": "5afdc7dc-2fcb-4ca8-8f24-947939ca707f",
  ...
  }
```

# Deploy Python Lambda functions with container images

**Note**
End of support for the Python 3.6 runtime started on July 18, 2022. For more information, see the section called "Runtime deprecation policy" (p. 83).

You can deploy your Lambda function code as a container image (p. 143). AWS provides the following resources to help you build a container image for your Python function:

- AWS base images for Lambda

  These base images are preloaded with a language runtime and other components that are required to run the image on Lambda. AWS provides a Dockerfile for each of the base images to help with building your container image.
- Open-source runtime interface clients (RIC)

  If you use a community or private enterprise base image, you must add a Runtime interface client (p. 145) to the base image to make it compatible with Lambda.
- Open-source runtime interface emulator (RIE)

  Lambda provides a runtime interface emulator for you to test your function locally. The base images for Lambda and base images for custom runtimes include the RIE. For other base images, you can download the RIE for testing your image (p. 146) locally.

The workflow for a function defined as a container image includes these steps:

1. Build your container image using the resources listed in this topic.
2. Upload the image to your Amazon ECR container registry (p. 153).
3. Create (p. 138) the Lambda function or update the function code (p. 141) to deploy the image to an existing function.

**Topics**

- AWS base images for Python (p. 335)
- Create a Python image from an AWS base image (p. 336)
- Create a Python image from an alternative base image (p. 337)
- Python runtime interface clients (p. 337)
- Deploy the container image (p. 337)

## AWS base images for Python

AWS provides the following base images for Python:

| Tags | Runtime | Operating system | Dockerfile | Deprecation |
|---|---|---|---|---|
| 3.9 | Python 3.9 | Amazon Linux 2 | Dockerfile for Python 3.9 on GitHub | |

| Tags | Runtime | Operating system | Dockerfile | Deprecation |
|---|---|---|---|---|
| 3.8 | Python 3.8 | Amazon Linux 2 | Dockerfile for Python 3.8 on GitHub | |
| 3.7 | Python 3.7 | Amazon Linux | Dockerfile for Python 3.7 on GitHub | |

Amazon ECR repository: gallery.ecr.aws/lambda/python

# Create a Python image from an AWS base image

When you build a container image for Python using an AWS base image, you only need to copy the python app to the container and install any dependencies.

If your function has dependencies, your local Python environment must match the version in the base image that you specify in the Dockerfile.

**To build and deploy a Python function with the `python:3.8` base image.**

1. On your local machine, create a project directory for your new function.
2. In your project directory, add a file named `app.py` containing your function code. The following example shows a simple Python handler.

```
import sys
def handler(event, context):
    return 'Hello from AWS Lambda using Python' + sys.version + '!'
```

3. In your project directory, add a file named `requirements.txt`. List each required library as a separate line in this file. Leave the file empty if there are no dependencies.
4. Use a text editor to create a Dockerfile in your project directory. The following example shows the Dockerfile for the handler that you created in the previous step. Install any dependencies under the ${LAMBDA_TASK_ROOT} directory alongside the function handler to ensure that the Lambda runtime can locate them when the function is invoked.

```
FROM public.ecr.aws/lambda/python:3.8

# Copy function code
COPY app.py ${LAMBDA_TASK_ROOT}

# Install the function's dependencies using file requirements.txt
# from your project folder.

COPY requirements.txt  .
RUN  pip3 install -r requirements.txt --target "${LAMBDA_TASK_ROOT}"

# Set the CMD to your handler (could also be done as a parameter override outside of
 the Dockerfile)
CMD [ "app.handler" ]
```

5. To create the container image, follow steps 4 through 7 in Create an image from an AWS base image for Lambda (p. 150).

# Create a Python image from an alternative base image

When you use an alternative base image, you need to install the Python runtime interface client (p. 337)

For an example of how to create a Python image from an Alpine base image, see Container image support for Lambda on the AWS Blog.

# Python runtime interface clients

Install the runtime interface client (p. 145) for Python using the pip package manager:

```
pip install awslambdaric
```

For package details, see Lambda RIC on the Python Package Index (PyPI) website.

You can also download the Python runtime interface client from GitHub.

# Deploy the container image

For a new function, you deploy the Python image when you create the function (p. 138). For an existing function, if you rebuild the container image, you need to redeploy the image by updating the function code (p. 141).

# AWS Lambda context object in Python

**Note**
End of support for the Python 3.6 runtime started on July 18, 2022. For more information, see the section called "Runtime deprecation policy" (p. 83).

When Lambda runs your function, it passes a context object to the handler (p. 326). This object provides methods and properties that provide information about the invocation, function, and execution environment. For more information on how the context object is passed to the function handler, see Lambda function handler in Python (p. 326).

### Context methods

- `get_remaining_time_in_millis` – Returns the number of milliseconds left before the execution times out.

### Context properties

- `function_name` – The name of the Lambda function.
- `function_version` – The version (p. 173) of the function.
- `invoked_function_arn` – The Amazon Resource Name (ARN) that's used to invoke the function. Indicates if the invoker specified a version number or alias.
- `memory_limit_in_mb` – The amount of memory that's allocated for the function.
- `aws_request_id` – The identifier of the invocation request.
- `log_group_name` – The log group for the function.
- `log_stream_name` – The log stream for the function instance.
- `identity` – (mobile apps) Information about the Amazon Cognito identity that authorized the request.
  - `cognito_identity_id` – The authenticated Amazon Cognito identity.
  - `cognito_identity_pool_id` – The Amazon Cognito identity pool that authorized the invocation.
- `client_context` – (mobile apps) Client context that's provided to Lambda by the client application.
  - `client.installation_id`
  - `client.app_title`
  - `client.app_version_name`
  - `client.app_version_code`
  - `client.app_package_name`
  - `custom` – A `dict` of custom values set by the mobile client application.
  - `env` – A `dict` of environment information provided by the AWS SDK.

The following example shows a handler function that logs context information.

### Example handler.py

```
import time

def lambda_handler(event, context):
    print("Lambda function ARN:", context.invoked_function_arn)
    print("CloudWatch log stream name:", context.log_stream_name)
    print("CloudWatch log group name:",  context.log_group_name)
    print("Lambda Request ID:", context.aws_request_id)
    print("Lambda function memory limits in MB:", context.memory_limit_in_mb)
```

```
    # We have added a 1 second delay so you can see the time remaining in
get_remaining_time_in_millis.
    time.sleep(1)
    print("Lambda time remaining in MS:", context.get_remaining_time_in_millis())
```

In addition to the options listed above, you can also use the AWS X-Ray SDK for Instrumenting Python code in AWS Lambda (p. 349) to identify critical code paths, trace their performance and capture the data for analysis.

# AWS Lambda function logging in Python

**Note**
End of support for the Python 3.6 runtime started on July 18, 2022. For more information, see the section called "Runtime deprecation policy" (p. 83).

AWS Lambda automatically monitors Lambda functions on your behalf and sends function metrics to Amazon CloudWatch. Your Lambda function comes with a CloudWatch Logs log group and a log stream for each instance of your function. The Lambda runtime environment sends details about each invocation to the log stream, and relays logs and other output from your function's code.

This page describes how to produce log output from your Lambda function's code, or access logs using the AWS Command Line Interface, the Lambda console, or the CloudWatch console.

**Sections**


- Creating a function that returns logs (p. 340)
- Using the Lambda console (p. 341)
- Using the CloudWatch console (p. 341)
- Using the AWS Command Line Interface (AWS CLI) (p. 341)
- Deleting logs (p. 343)
- Logging library (p. 343)


## Creating a function that returns logs

To output logs from your function code, you can use the `print` method, or any logging library that writes to `stdout` or `stderr`. The following example logs the values of environment variables and the event object.

**Example lambda_function.py**

```
import os

def lambda_handler(event, context):
    print('## ENVIRONMENT VARIABLES')
    print(os.environ)
    print('## EVENT')
    print(event)
```

**Example log format**

```
START RequestId: 8f507cfc-xmpl-4697-b07a-ac58fc914c95 Version: $LATEST
## ENVIRONMENT VARIABLES
environ({'AWS_LAMBDA_LOG_GROUP_NAME': '/aws/lambda/my-function',
 'AWS_LAMBDA_LOG_STREAM_NAME': '2020/01/31/[$LATEST]3893xmpl7fac4485b47bb75b671a283c',
 'AWS_LAMBDA_FUNCTION_NAME': 'my-function', ...})
## EVENT
{'key': 'value'}
END RequestId: 8f507cfc-xmpl-4697-b07a-ac58fc914c95
REPORT RequestId: 8f507cfc-xmpl-4697-b07a-ac58fc914c95  Duration: 15.74 ms  Billed
 Duration: 16 ms Memory Size: 128 MB Max Memory Used: 56 MB  Init Duration: 130.49 ms
XRAY TraceId: 1-5e34a614-10bdxmplf1fb44f07bc535a1   SegmentId: 07f5xmpl2d1f6f85 Sampled:
 true
```

The Python runtime logs the `START`, `END`, and `REPORT` lines for each invocation. The report line provides the following details.

**Report Log**

- **RequestId** – The unique request ID for the invocation.
- **Duration** – The amount of time that your function's handler method spent processing the event.
- **Billed Duration** – The amount of time billed for the invocation.
- **Memory Size** – The amount of memory allocated to the function.
- **Max Memory Used** – The amount of memory used by the function.
- **Init Duration** – For the first request served, the amount of time it took the runtime to load the function and run code outside of the handler method.
- **XRAY TraceId** – For traced requests, the AWS X-Ray trace ID (p. 715).
- **SegmentId** – For traced requests, the X-Ray segment ID.
- **Sampled** – For traced requests, the sampling result.

# Using the Lambda console

You can use the Lambda console to view log output after you invoke a Lambda function. For more information, see Accessing Amazon CloudWatch logs for AWS Lambda (p. 730).

# Using the CloudWatch console

You can use the Amazon CloudWatch console to view logs for all Lambda function invocations.

**To view logs on the CloudWatch console**

1. Open the Log groups page on the CloudWatch console.
2. Choose the log group for your function (**/aws/lambda/*your-function-name***).
3. Choose a log stream.

Each log stream corresponds to an instance of your function (p. 100). A log stream appears when you update your Lambda function, and when additional instances are created to handle multiple concurrent invocations. To find logs for a specific invocation, we recommend instrumenting your function with AWS X-Ray. X-Ray records details about the request and the log stream in the trace.

To use a sample application that correlates logs and traces with X-Ray, see Error processor sample application for AWS Lambda (p. 807).

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

You can use the AWS CLI to retrieve logs for an invocation using the `--log-type` command option. The response contains a `LogResult` field that contains up to 4 KB of base64-encoded logs from the invocation.

**Example retrieve a log ID**

The following example shows how to retrieve a *log ID* from the `LogResult` field for a function named `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail
```

You should see the following output:

```
{
    "StatusCode": 200,
    "LogResult":
 "U1RBUlQgUmVxdWVzdElkOiA4N2QwNDRiOC1mMTU0LTExZTgtOGNkYS0yOTc0YzVlNGZiMjEgVmVyc2lvb...",
    "ExecutedVersion": "$LATEST"
}
```

### Example decode the logs

In the same command prompt, use the `base64` utility to decode the logs. The following example shows how to retrieve base64-encoded logs for `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail \
--query 'LogResult' --output text |  base64 -d
```

You should see the following output:

```
START RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8 Version: $LATEST
"AWS_SESSION_TOKEN": "AgoJb3JpZ2luX2VjELj...", "_X_AMZN_TRACE_ID": "Root=1-5d02e5ca-
f5792818b6fe8368e5b51d50;Parent=191db58857df8395;Sampled=0"",ask/lib:/opt/lib",
END RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8
REPORT RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8  Duration: 79.67 ms      Billed
 Duration: 80 ms         Memory Size: 128 MB     Max Memory Used: 73 MB
```

The `base64` utility is available on Linux, macOS, and Ubuntu on Windows. macOS users may need to use `base64 -D`.

### Example get-logs.sh script

In the same command prompt, use the following script to download the last five log events. The script uses `sed` to remove quotes from the output file, and sleeps for 15 seconds to allow time for the logs to become available. The output includes the response from Lambda and the output from the `get-log-events` command.

Copy the contents of the following code sample and save in your Lambda project directory as `get-logs.sh`.

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

```
#!/bin/bash
aws lambda invoke --function-name my-function --cli-binary-format raw-in-base64-out --
payload '{"key": "value"}' out
sed -i'' -e 's/"//g' out
sleep 15
aws logs get-log-events --log-group-name /aws/lambda/my-function --log-stream-name stream1
 --limit 5
```

### Example macOS and Linux (only)

In the same command prompt, macOS and Linux users may need to run the following command to ensure the script is executable.

```
chmod -R 755 get-logs.sh
```

### Example retrieve the last five log events

In the same command prompt, run the following script to get the last five log events.

```
./get-logs.sh
```

You should see the following output:

```
{
    "StatusCode": 200,
    "ExecutedVersion": "$LATEST"
}
{
    "events": [
        {
            "timestamp": 1559763003171,
            "message": "START RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf Version:
 $LATEST\n",
            "ingestionTime": 1559763003309
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tENVIRONMENT VARIABLES\r{\r  \"AWS_LAMBDA_FUNCTION_VERSION\": \"$LATEST\",\r ...",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tEVENT\r{\r  \"key\": \"value\"\r}\n",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "END RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\n",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "REPORT RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\tDuration:
 26.73 ms\tBilled Duration: 27 ms \tMemory Size: 128 MB\tMax Memory Used: 75 MB\t\n",
            "ingestionTime": 1559763018353
        }
    ],
    "nextForwardToken": "f/34783877304859518393868359594929986069206639495374241795",
    "nextBackwardToken": "b/34783877303811383369537420289090800615709599058929582080"
}
```

# Deleting logs

Log groups aren't deleted automatically when you delete a function. To avoid storing logs indefinitely, delete the log group, or configure a retention period after which logs are deleted automatically.

# Logging library

For more detailed logs, use the logging library.

```
import os
import logging
logger = logging.getLogger()
logger.setLevel(logging.INFO)

def lambda_handler(event, context):
    logger.info('## ENVIRONMENT VARIABLES')
    logger.info(os.environ)
    logger.info('## EVENT')
    logger.info(event)
```

The output from `logger` includes the log level, timestamp, and request ID.

```
START RequestId: 1c8df7d3-xmpl-46da-9778-518e6eca8125 Version: $LATEST
[INFO]  2020-01-31T22:12:58.534Z    1c8df7d3-xmpl-46da-9778-518e6eca8125    ## ENVIRONMENT
 VARIABLES

[INFO]  2020-01-31T22:12:58.534Z    1c8df7d3-xmpl-46da-9778-518e6eca8125
    environ({'AWS_LAMBDA_LOG_GROUP_NAME': '/aws/lambda/my-function',
 'AWS_LAMBDA_LOG_STREAM_NAME': '2020/01/31/[$LATEST]1bbe51xmplb34a2788dbaa7433b0aa4d',
 'AWS_LAMBDA_FUNCTION_NAME': 'my-function', ...})

[INFO]  2020-01-31T22:12:58.535Z    1c8df7d3-xmpl-46da-9778-518e6eca8125    ## EVENT

[INFO]  2020-01-31T22:12:58.535Z    1c8df7d3-xmpl-46da-9778-518e6eca8125    {'key':
 'value'}

END RequestId: 1c8df7d3-xmpl-46da-9778-518e6eca8125
REPORT RequestId: 1c8df7d3-xmpl-46da-9778-518e6eca8125  Duration: 2.75 ms   Billed
 Duration: 3 ms Memory Size: 128 MB Max Memory Used: 56 MB  Init Duration: 113.51 ms
XRAY TraceId: 1-5e34a66a-474xmpl7c2534a87870b4370   SegmentId: 073cxmpl3e442861 Sampled:
 true
```

# AWS Lambda function errors in Python

**Note**
End of support for the Python 3.6 runtime started on July 18, 2022. For more information, see the section called "Runtime deprecation policy" (p. 83).

When your code raises an error, Lambda generates a JSON representation of the error. This error document appears in the invocation log and, for synchronous invocations, in the output.

This page describes how to view Lambda function invocation errors for the Python runtime using the Lambda console and the AWS CLI.

**Sections**


- How it works (p. 345)
- Using the Lambda console (p. 346)
- Using the AWS Command Line Interface (AWS CLI) (p. 346)
- Error handling in other AWS services (p. 347)
- Error examples (p. 347)
- Sample applications (p. 348)
- What's next? (p. 303)


## How it works

When you invoke a Lambda function, Lambda receives the invocation request and validates the permissions in your execution role, verifies that the event document is a valid JSON document, and checks parameter values.

If the request passes validation, Lambda sends the request to a function instance. The Lambda runtime (p. 82) environment converts the event document into an object, and passes it to your function handler.

If Lambda encounters an error, it returns an exception type, message, and HTTP status code that indicates the cause of the error. The client or service that invoked the Lambda function can handle the error programmatically, or pass it along to an end user. The correct error handling behavior depends on the type of application, the audience, and the source of the error.

The following list describes the range of status codes you can receive from Lambda.

**`2xx`**

A `2xx` series error with a `X-Amz-Function-Error` header in the response indicates a Lambda runtime or function error. A `2xx` series status code indicates that Lambda accepted the request, but instead of an error code, Lambda indicates the error by including the `X-Amz-Function-Error` header in the response.

**`4xx`**

A `4xx` series error indicates an error that the invoking client or service can fix by modifying the request, requesting permission, or by retrying the request. `4xx` series errors other than `429` generally indicate an error with the request.

**`5xx`**

A `5xx` series error indicates an issue with Lambda, or an issue with the function's configuration or resources. `5xx` series errors can indicate a temporary condition that can be resolved without any action by the user. These issues can't be addressed by the invoking client or service, but a Lambda function's owner may be able to fix the issue.

For a complete list of invocation errors, see InvokeFunction errors (p. 995).

# Using the Lambda console

You can invoke your function on the Lambda console by configuring a test event and viewing the output. The output is captured in the function's execution logs and, when active tracing (p. 715) is enabled, in AWS X-Ray.

**To invoke a function on the Lambda console**

1. Open the Functions page of the Lambda console.
2. Choose the function to test, and choose **Test**.
3. Under **Test event**, select **New event**.
4. Select a **Template**.
5. For **Name**, enter a name for the test. In the text entry box, enter the JSON test event.
6. Choose **Save changes**.
7. Choose **Test**.

The Lambda console invokes your function synchronously (p. 225) and displays the result. To see the response, logs, and other information, expand the **Details** section.

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

When you invoke a Lambda function in the AWS CLI, the AWS CLI splits the response into two documents. The AWS CLI response is displayed in your command prompt. If an error has occurred, the response contains a `FunctionError` field. The invocation response or error returned by the function is written to an output file. For example, `output.json` or `output.txt`.

The following invoke command example demonstrates how to invoke a function and write the invocation response to an `output.txt` file.

```
aws lambda invoke   \
  --function-name my-function   \
      --cli-binary-format raw-in-base64-out  \
          --payload '{"key1": "value1", "key2": "value2", "key3": "value3"}' output.txt
```

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

You should see the AWS CLI response in your command prompt:

```
{
    "StatusCode": 200,
    "FunctionError": "Unhandled",
    "ExecutedVersion": "$LATEST"
}
```

You should see the function invocation response in the `output.txt` file. In the same command prompt, you can also view the output in your command prompt using:

```
cat output.txt
```

You should see the invocation response in your command prompt.

```
{"errorMessage": "'action'", "errorType": "KeyError", "stackTrace": ["  File \"/var/task/
lambda_function.py\", line 36, in lambda_handler\n    result = ACTIONS[event['action']]
(event['number'])\n"]}
```

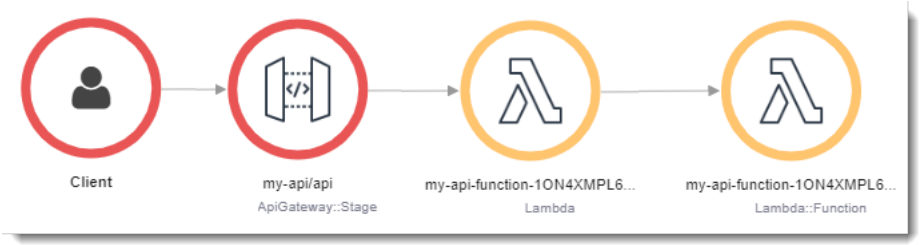
Lambda also records up to 256 KB of the error object in the function's logs. For more information, see AWS Lambda function logging in Python (p. 340).

# Error handling in other AWS services

When another AWS service invokes your function, the service chooses the invocation type and retry behavior. AWS services can invoke your function on a schedule, in response to a lifecycle event on a resource, or to serve a request from a user. Some services invoke functions asynchronously and let Lambda handle errors, while others retry or pass errors back to the user.

For example, API Gateway treats all invocation and function errors as internal errors. If the Lambda API rejects the invocation request, API Gateway returns a `500` error code. If the function runs but returns an error, or returns a response in the wrong format, API Gateway returns a 502 error code. To customize the error response, you must catch errors in your code and format a response in the required format.

We recommend using AWS X-Ray to determine the source of an error and its cause. X-Ray allows you to find out which component encountered an error, and see details about the errors. The following example shows a function error that resulted in a `502` response from API Gateway.




For more information, see Instrumenting Python code in AWS Lambda (p. 349).

# Error examples

The following section shows common errors you may receive when creating, updating, or invoking your function using the Python Lambda runtimes (p. 82).

**Example Runtime exception – ImportError**

```
{
  "errorMessage": "Unable to import module 'lambda_function': Cannot import name '_imaging'
 from 'PIL' (/var/task/PIL/__init__.py)",
  "errorType": "Runtime.ImportModuleError"
}
```

This error is a result of using the AWS Command Line Interface (AWS CLI) to upload a deployment package that contains a C or C++ library. For example, the Pillow (PIL), numpy, or pandas library.

We recommend using the AWS SAM CLI sam build command with the `--use-container` option to create your deployment package. Using the AWS SAM CLI with this option creates a Docker container with a Lambda-like environment that is compatible with Lambda.

**Example JSON serialization error – Runtime.MarshalError**

```
{
  "errorMessage": "Unable to marshal response: Object of type AttributeError is not JSON
 serializable",
  "errorType": "Runtime.MarshalError"
}
```

This error can be the result of the base64-encoding mechanism you are using in your function code. For example:

```
import base64
encrypted_data = base64.b64encode(payload_enc).decode("utf-8")
```

This error can also be the result of not specifying your .zip file as a binary file when you created or updated your function. We recommend using the fileb:// command option to upload your deployment package (.zip file).

```
aws lambda create-function --function-name my-function --zip-file fileb://my-deployment-
package.zip --handler lambda_function.lambda_handler --runtime python3.8 --role
 arn:aws:iam::your-account-id:role/lambda-ex
```

# Sample applications

The GitHub repository for this guide includes sample applications that demonstrate the use of the errors. Each sample application includes scripts for easy deployment and cleanup, an AWS Serverless Application Model (AWS SAM) template, and supporting resources.

**Sample Lambda applications in Python**

- blank-python – A Python function that shows the use of logging, environment variables, AWS X-Ray tracing, layers, unit tests and the AWS SDK.

# What's next?

- Learn how to show logging events for your Lambda function on the the section called "Logging" (p. 340) page.

# Instrumenting Python code in AWS Lambda

> **Note**
> End of support for the Python 3.6 runtime started on July 18, 2022. For more information, see the section called “Runtime deprecation policy” (p. 83).

Lambda integrates with AWS X-Ray to help you trace, debug, and optimize Lambda applications. You can use X-Ray to trace a request as it traverses resources in your application, which may include Lambda functions and other AWS services.

To send tracing data to X-Ray, you can use one of two SDK libraries:

- AWS Distro for OpenTelemetry (ADOT) – A secure, production-ready, AWS-supported distribution of the OpenTelemetry (OTel) SDK.
- AWS X-Ray SDK for Python – An SDK for generating and sending trace data to X-Ray.

Both ADOT and the X-Ray SDK offer ways to send your telemetry data to the X-Ray service. You can then use X-Ray to view, filter, and gain insights into your application's performance metrics to identify issues and opportunities for optimization.

> **Important**
> **ADOT is the preferred method for instrumenting your Lambda functions**. We recommend using ADOT for all new applications. However, due to the flexibility OpenTelemetry offers, your Lambda function invocations may experience cold start latency increases. If you're optimizing for low-latency and also do not require OpenTelemetry's advanced capabilities such as telemetry correlation and dynamically configurable backend destinations, you may want to use the AWS X-Ray SDK over ADOT.

**Sections**

- Using ADOT to instrument your Python functions (p. 349)
- Using the X-Ray SDK to instrument your Python functions (p. 350)
- Activating tracing with the Lambda console (p. 350)
- Activating tracing with the Lambda API (p. 350)
- Activating tracing with AWS CloudFormation (p. 351)
- Interpreting an X-Ray trace (p. 351)
- Storing runtime dependencies in a layer (X-Ray SDK) (p. 353)

## Using ADOT to instrument your Python functions

ADOT provides fully managed Lambda layers (p. 14) that package everything you need to collect telemetry data using the OTel SDK. By consuming this layer, you can instrument your Lambda functions without having to modify any function code. You can also configure your layer to do custom initialization of OTel. For more information, see Custom configuration for the ADOT Collector on Lambda in the ADOT documentation.

For Python runtimes, you can add the **AWS managed Lambda layer for ADOT Python** to automatically instrument your functions. This layer works for both arm64 and x86_64 architectures. For detailed instructions on how to add this layer, see AWS Distro for OpenTelemetry Lambda Support for Python in the ADOT documentation.

# Using the X-Ray SDK to instrument your Python functions

To record details about calls that your Lambda function makes to other resources in your application, you can also use the AWS X-Ray SDK for Python. To get the SDK, add the `aws-xray-sdk` package to your application's dependencies.

**Example requirements.txt**

```
jsonpickle==1.3
aws-xray-sdk==2.4.3
```

In your function code, you can instrument AWS SDK clients by patching the `boto3` library with the `aws_xray_sdk.core` module.

**Example function – Tracing an AWS SDK client**

```
import boto3
from aws_xray_sdk.core import xray_recorder
from aws_xray_sdk.core import patch_all

logger = logging.getLogger()
logger.setLevel(logging.INFO)
patch_all()

client = boto3.client('lambda')
client.get_account_settings()

def lambda_handler(event, context):
    logger.info('## ENVIRONMENT VARIABLES\r' + jsonpickle.encode(dict(**os.environ)))
  ...
```

After you add the correct dependencies and make the necessary code changes, activate tracing in your function's configuration via the Lambda console or the API.

# Activating tracing with the Lambda console

To toggle active tracing on your Lambda function with the console, follow these steps:

**To turn on active tracing**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **Monitoring and operations tools**.
4. Choose **Edit**.
5. Under **X-Ray**, toggle on **Active tracing**.
6. Choose **Save**.

# Activating tracing with the Lambda API

Configure tracing on your Lambda function with the AWS CLI or AWS SDK, use the following API operations:

- UpdateFunctionConfiguration (p. 1098)
- GetFunctionConfiguration (p. 967)
- CreateFunction (p. 904)

The following example AWS CLI command enables active tracing on a function named **my-function**.

```
aws lambda update-function-configuration --function-name my-function \
--tracing-config Mode=Active
```

Tracing mode is part of the version-specific configuration when you publish a version of your function. You can't change the tracing mode on a published version.

# Activating tracing with AWS CloudFormation

To activate tracing on an `AWS::Lambda::Function` resource in an AWS CloudFormation template, use the `TracingConfig` property.

**Example function-inline.yml – Tracing configuration**

```
Resources:
  function:
    Type: AWS::Lambda::Function
    Properties:
      TracingConfig:
        Mode: Active
      ...
```

For an AWS Serverless Application Model (AWS SAM) `AWS::Serverless::Function` resource, use the `Tracing` property.

**Example template.yml – Tracing configuration**

```
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      Tracing: Active
      ...
```

# Interpreting an X-Ray trace

Your function needs permission to upload trace data to X-Ray. When you activate tracing in the Lambda console, Lambda adds the required permissions to your function's execution role (p. 52). Otherwise, add the AWSXRayDaemonWriteAccess policy to the execution role.

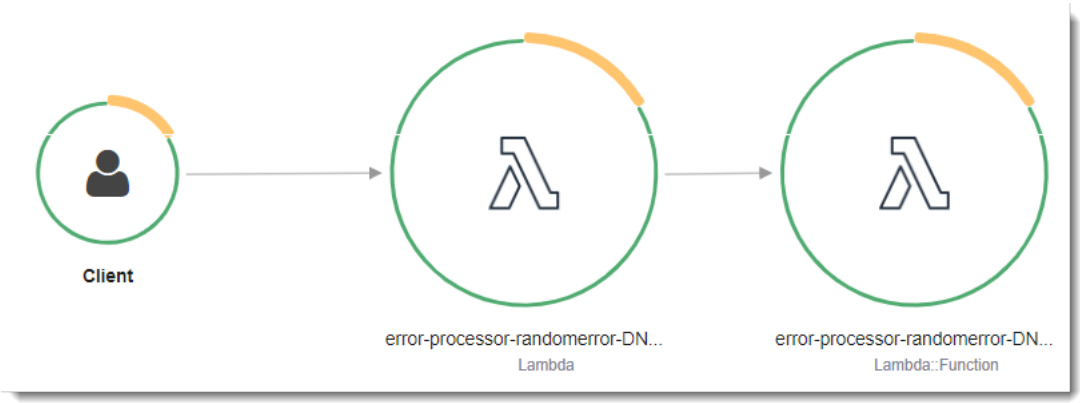
After you've configured active tracing, you can observe specific requests through your application. The X-Ray service graph shows information about your application and all its components. The following example from the error processor (p. 807) sample application shows an application with two functions. The primary function processes events and sometimes returns errors. The second function at the top processes errors that appear in the first's log group and uses the AWS SDK to call X-Ray, Amazon Simple Storage Service (Amazon S3), and Amazon CloudWatch Logs.



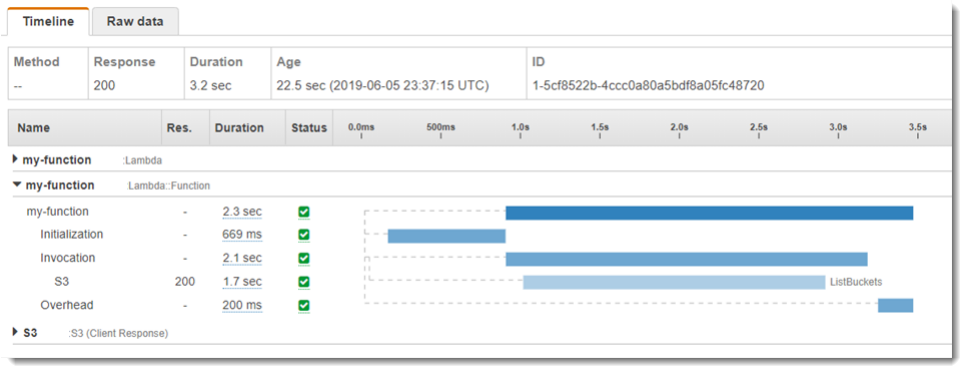

X-Ray doesn't trace all requests to your application. X-Ray applies a sampling algorithm to ensure that tracing is efficient, while still providing a representative sample of all requests. The sampling rate is 1 request per second and 5 percent of additional requests.

> **Note**
> You cannot configure the X-Ray sampling rate for your functions.

When using active tracing, Lambda records 2 segments per trace, which creates two nodes on the service graph. The following image highlights these two nodes for the primary function from the error processor example above.




The first node on the left represents the Lambda service, which receives the invocation request. The second node represents your specific Lambda function. The following example shows a trace with these two segments. Both are named **my-function**, but one has an origin of `AWS::Lambda` and the other has origin `AWS::Lambda::Function`.



This example expands the function segment to show its three subsegments:

- **Initialization** – Represents time spent loading your function and running initialization code (p. 22). This subsegment only appears for the first event that each instance of your function processes.
- **Invocation** – Represents the time spent running your handler code.
- **Overhead** – Represents the time the Lambda runtime spends preparing to handle the next event.

You can also instrument HTTP clients, record SQL queries, and create custom subsegments with annotations and metadata. For more information, see the AWS X-Ray SDK for Python in the *AWS X-Ray Developer Guide*.

> **Pricing**
> You can use X-Ray tracing for free each month up to a certain limit as part of the AWS Free Tier. Beyond that threshold, X-Ray charges for trace storage and retrieval. For more information, see AWS X-Ray pricing.

# Storing runtime dependencies in a layer (X-Ray SDK)

If you use the X-Ray SDK to instrument AWS SDK clients your function code, your deployment package can become quite large. To avoid uploading runtime dependencies every time you update your function code, package the X-Ray SDK in a Lambda layer (p. 156).

The following example shows an `AWS::Serverless::LayerVersion` resource that stores the AWS X-Ray SDK for Python.

**Example template.yml – Dependencies layer**

```
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      CodeUri: function/.
      Tracing: Active
      Layers:
        - !Ref libs
      ...
  libs:
    Type: AWS::Serverless::LayerVersion
    Properties:
      LayerName: blank-python-lib
      Description: Dependencies for the blank-python sample app.
      ContentUri: package/.
      CompatibleRuntimes:
        - python3.8
```

With this configuration, you update the library layer only if you change your runtime dependencies. Since the function deployment package contains only your code, this can help reduce upload times.

Creating a layer for dependencies requires build changes to generate the layer archive prior to deployment. For a working example, see the blank-python sample application.

# Building Lambda functions with Ruby

You can run Ruby code in AWS Lambda. Lambda provides runtimes (p. 82) for Ruby that run your code to process events. Your code runs in an environment that includes the AWS SDK for Ruby, with credentials from an AWS Identity and Access Management (IAM) role that you manage.

Lambda supports the following Ruby runtimes.

**Ruby**

| Name | Identifier | SDK | Operating system | Architectures | Deprecation |
|---|---|---|---|---|---|
| Ruby 2.7 | `ruby2.7` | 3.1.0 | Amazon Linux 2 | x86_64, arm64 | |

> **Note**
> For end of support information about Ruby 2.5, see the section called "Runtime deprecation policy" (p. 83).

Lambda functions use an execution role (p. 52) to get permission to write logs to Amazon CloudWatch Logs, and to access other services and resources. If you don't already have an execution role for function development, create one.

### To create an execution role

1. Open the roles page in the IAM console.
2. Choose **Create role**.
3. Create a role with the following properties.

   - **Trusted entity** – **Lambda**.
   - **Permissions** – **AWSLambdaBasicExecutionRole**.
   - **Role name** – **`lambda-role`**.

   The **AWSLambdaBasicExecutionRole** policy has the permissions that the function needs to write logs to CloudWatch Logs.

You can add permissions to the role later, or swap it out for a different role that's specific to a single function.

### To create a Ruby function

1. Open the Lambda console.
2. Choose **Create function**.
3. Configure the following settings:

   - **Name** – **`my-function`**.
   - **Runtime** – **Ruby 2.7**.

   - **Role** – **Choose an existing role**.
   - **Existing role** – **`lambda-role`**.
4. Choose **Create function**.
5. To configure a test event, choose **Test**.
6. For **Event name**, enter **`test`**.
7. Choose **Save changes**.
8. To invoke the function, choose **Test**.

The console creates a Lambda function with a single source file named `lambda_function.rb`. You can edit this file and add more files in the built-in code editor (p. 38). To save your changes, choose **Save**. Then, to run your code, choose **Test**.

> **Note**
> The Lambda console uses AWS Cloud9 to provide an integrated development environment in the browser. You can also use AWS Cloud9 to develop Lambda functions in your own environment. For more information, see Working with Lambda Functions in the AWS Cloud9 user guide.

The `lambda_function.rb` file exports a function named `lambda_handler` that takes an event object and a context object. This is the handler function (p. 357) that Lambda calls when the function is invoked. The Ruby function runtime gets invocation events from Lambda and passes them to the handler. In the function configuration, the handler value is `lambda_function.lambda_handler`.

When you save your function code, the Lambda console creates a .zip file archive deployment package. When you develop your function code outside of the console (using an IDE) you need to create a deployment package (p. 358) to upload your code to the Lambda function.

> **Note**
> To get started with application development in your local environment, deploy one of the sample applications available in this guide's GitHub repository.
>
> **Sample Lambda applications in Ruby**
>
> - blank-ruby – A Ruby function that shows the use of logging, environment variables, AWS X-Ray tracing, layers, unit tests and the AWS SDK.
> - Ruby Code Samples for AWS Lambda – Code samples written in Ruby that demonstrate how to interact with AWS Lambda.

The function runtime passes a context object to the handler, in addition to the invocation event. The context object (p. 364) contains additional information about the invocation, the function, and the execution environment. More information is available from environment variables.

Your Lambda function comes with a CloudWatch Logs log group. The function runtime sends details about each invocation to CloudWatch Logs. It relays any logs that your function outputs (p. 365) during invocation. If your function returns an error (p. 370), Lambda formats the error and returns it to the invoker.

**Topics**


- AWS Lambda function handler in Ruby (p. 357)
- Deploy Ruby Lambda functions with .zip file archives (p. 358)
- Deploy Ruby Lambda functions with container images (p. 361)
- AWS Lambda context object in Ruby (p. 364)
- AWS Lambda function logging in Ruby (p. 365)
- AWS Lambda function errors in Ruby (p. 370)

- Instrumenting Ruby code in AWS Lambda (p. 374)

# AWS Lambda function handler in Ruby

The Lambda function *handler* is the method in your function code that processes events. When your function is invoked, Lambda runs the handler method. When the handler exits or returns a response, it becomes available to handle another event.

In the following example, the file `function.rb` defines a handler method named `handler`. The handler function takes two objects as input and returns a JSON document.

**Example function.rb**

```
require 'json'

def handler(event:, context:)
    { event: JSON.generate(event), context: JSON.generate(context.inspect) }
end
```

In your function configuration, the `handler` setting tells Lambda where to find the handler. For the preceding example, the correct value for this setting is **`function.handler`**. It includes two names separated by a dot: the name of the file and the name of the handler method.

You can also define your handler method in a class. The following example defines a handler method named `process` on a class named `Handler` in a module named `LambdaFunctions`.

**Example source.rb**

```
module LambdaFunctions
  class Handler
    def self.process(event:,context:)
      "Hello!"
    end
  end
end
```

In this case, the handler setting is **`source.LambdaFunctions::Handler.process`**.

The two objects that the handler accepts are the invocation event and context. The event is a Ruby object that contains the payload that's provided by the invoker. If the payload is a JSON document, the event object is a Ruby hash. Otherwise, it's a string. The context object (p. 364) has methods and properties that provide information about the invocation, the function, and the execution environment.

The function handler is executed every time your Lambda function is invoked. Static code outside of the handler is executed once per instance of the function. If your handler uses resources like SDK clients and database connections, you can create them outside of the handler method to reuse them for multiple invocations.

Each instance of your function can process multiple invocation events, but it only processes one event at a time. The number of instances processing an event at any given time is your function's *concurrency*. For more information about the Lambda execution environment, see AWS Lambda execution environment (p. 100).

# Deploy Ruby Lambda functions with .zip file archives

Your AWS Lambda function's code consists of scripts or compiled programs and their dependencies. You use a *deployment package* to deploy your function code to Lambda. Lambda supports two types of deployment packages: container images and .zip file archives.

To create the deployment package for a .zip file archive, you can use a built-in .zip file archive utility or any other .zip file utility (such as 7zip) for your command line tool. Note the following requirements for using a .zip file as your deployment package:

- The .zip file contains your function's code and any dependencies used to run your function's code (if applicable) on Lambda. If your function depends only on standard libraries, or AWS SDK libraries, you don't need to include these libraries in your .zip file. These libraries are included with the supported Lambda runtime (p. 82) environments.
- If the .zip file is larger than 50 MB, we recommend uploading it to your function from an Amazon Simple Storage Service (Amazon S3) bucket.
- If your deployment package contains native libraries, you can build the deployment package with AWS Serverless Application Model (AWS SAM). You can use the AWS SAM CLI `sam build` command with the `--use-container` to create your deployment package. This option builds a deployment package inside a Docker image that is compatible with the Lambda execution environment.

  For more information, see sam build in the *AWS Serverless Application Model Developer Guide*.
- You need to build the deployment package to be compatible with this instruction set architecture (p. 23) of the function.
- Lambda uses POSIX file permissions, so you may need to set permissions for the deployment package folder before you create the .zip file archive.

**Sections**

- Prerequisites (p. 358)
- Tools and libraries (p. 358)
- Updating a function with no dependencies (p. 359)
- Updating a function with additional dependencies (p. 359)

## Prerequisites

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

## Tools and libraries

Lambda provides the following tools and libraries for the Ruby runtime:

**Tools and libraries for Ruby**

- AWS SDK for Ruby: the official AWS SDK for the Ruby programming language.

# Updating a function with no dependencies

To update a function by using the Lambda API, use the UpdateFunctionCode (p. 1088) operation. Create an archive that contains your function code, and upload it using the AWS Command Line Interface (AWS CLI).

### To update a Ruby function with no dependencies

1. Create a .zip file archive.

```
zip function.zip function.rb
```

2. To upload the package, use the `update-function-code` command.

```
aws lambda update-function-code --function-name my-function --zip-file fileb://
function.zip
```

   You should see the following output:

```
{
    "FunctionName": "my-function",
    "FunctionArn": "arn:aws:lambda:us-west-2:123456789012:function:my-function",
    "Runtime": "ruby2.5",
    "Role": "arn:aws:iam::123456789012:role/lambda-role",
    "Handler": "function.handler",
    "CodeSha256": "Qf0hMc1I2di6YFMi9aXm3JtGTmcDbjniEuiYonYptAk=",
    "Version": "$LATEST",
    "TracingConfig": {
        "Mode": "Active"
    },
    "RevisionId": "983ed1e3-ca8e-434b-8dc1-7d72ebadd83d",
    ...
}
```

# Updating a function with additional dependencies

If your function depends on libraries other than the AWS SDK for Ruby, install them to a local directory with Bundler, and include them in your deployment package.

### To update a Ruby function with dependencies

1. Install libraries in the vendor directory using the `bundle` command.

```
bundle config set --local path 'vendor/bundle' \
bundle install
```

   You should see the following output:

```
Fetching gem metadata from https://rubygems.org/.............
Resolving dependencies...
Fetching aws-eventstream 1.0.1
Installing aws-eventstream 1.0.1
...
```

This installs the gems in the project directory instead of the system location, and sets `vendor/bundle` as the default path for future installations. To later install gems globally, use `bundle config set --local system 'true'`.

2. Create a .zip file archive.

```
zip -r function.zip function.rb vendor
```

You should see the following output:

```
adding: function.rb (deflated 37%)
  adding: vendor/ (stored 0%)
  adding: vendor/bundle/ (stored 0%)
  adding: vendor/bundle/ruby/ (stored 0%)
  adding: vendor/bundle/ruby/2.7.0/ (stored 0%)
  adding: vendor/bundle/ruby/2.7.0/build_info/ (stored 0%)
  adding: vendor/bundle/ruby/2.7.0/cache/ (stored 0%)
  adding: vendor/bundle/ruby/2.7.0/cache/aws-eventstream-1.0.1.gem (deflated 36%)
...
```

3. Update the function code.

```
aws lambda update-function-code --function-name my-function --zip-file fileb://
function.zip
```

You should see the following output:

```
{
    "FunctionName": "my-function",
    "FunctionArn": "arn:aws:lambda:us-west-2:123456789012:function:my-function",
    "Runtime": "ruby2.5",
    "Role": "arn:aws:iam::123456789012:role/lambda-role",
    "Handler": "function.handler",
    "CodeSize": 300,
    "CodeSha256": "Qf0hMc1I2di6YFMi9aXm3JtGTmcDbjniEuiYonYptAk=",
    "Version": "$LATEST",
    "RevisionId": "983ed1e3-ca8e-434b-8dc1-7d72ebadd83d",
    ...
}
```

# Deploy Ruby Lambda functions with container images

You can deploy your Lambda function code as a container image (p. 143). AWS provides the following resources to help you build a container image for your Ruby function:

- AWS base images for Lambda

  These base images are preloaded with a language runtime and other components that are required to run the image on Lambda. AWS provides a Dockerfile for each of the base images to help with building your container image.
- Open-source runtime interface clients (RIC)

  If you use a community or private enterprise base image, you must add a Runtime interface client (p. 145) to the base image to make it compatible with Lambda.
- Open-source runtime interface emulator (RIE)

  Lambda provides a runtime interface emulator for you to test your function locally. The base images for Lambda and base images for custom runtimes include the RIE. For other base images, you can download the RIE for testing your image (p. 146) locally.

The workflow for a function defined as a container image includes these steps:

1. Build your container image using the resources listed in this topic.
2. Upload the image to your Amazon ECR container registry (p. 153).
3. Create (p. 138) the Lambda function or update the function code (p. 141) to deploy the image to an existing function.

**Topics**

- AWS base images for Ruby (p. 361)
- Using a Ruby base image (p. 362)
- Ruby runtime interface clients (p. 362)
- Create a Ruby image from an AWS base image (p. 362)
- Deploy the container image (p. 363)

## AWS base images for Ruby

AWS provides the following base images for Ruby:

| Tags | Runtime | Operating system | Dockerfile | Deprecation |
|---|---|---|---|---|
| 2.7 | Ruby 2.7 | Amazon Linux 2 | Dockerfile for Ruby 2.7 on GitHub | |

Amazon ECR repository: gallery.ecr.aws/lambda/ruby

# Using a Ruby base image

For instructions on how to use a Ruby base image, choose the **usage** tab on AWS Lambda base images for Ruby in the *Amazon ECR repository*.

# Ruby runtime interface clients

Install the runtime interface client for Ruby using the RubyGems.org package manager:

```
gem install aws_lambda_ric
```

For package details, see Lambda RIC on RubyGems.org.

You can also download the Ruby runtime interface client from GitHub.

# Create a Ruby image from an AWS base image

When you build a container image for Ruby using an AWS base image, you only need to copy the ruby app to the container and install any dependencies.

**To build and deploy a Ruby function with the `ruby:2.7` base image.**

1. On your local machine, create a project directory for your new function.
2. In your project directory, add a file named `app.rb` containing your function code. The following example shows a simple Ruby handler.

```
module LambdaFunction
  class Handler
    def self.process(event:,context:)
      "Hello from Ruby 2.7 container image!"
    end
  end
end
```

3. Use a text editor to create a Dockerfile in your project directory. The following example shows the Dockerfile for the handler that you created in the previous step. Install any dependencies under the ${LAMBDA_TASK_ROOT} directory alongside the function handler to ensure that the Lambda runtime can locate them when the function is invoked.

```
FROM public.ecr.aws/lambda/ruby:2.7

# Copy function code
COPY app.rb ${LAMBDA_TASK_ROOT}

# Copy dependency management file
COPY Gemfile ${LAMBDA_TASK_ROOT}

# Install dependencies under LAMBDA_TASK_ROOT
ENV GEM_HOME=${LAMBDA_TASK_ROOT}
RUN bundle install

# Set the CMD to your handler (could also be done as a parameter override outside of
 the Dockerfile)
CMD [ "app.LambdaFunction::Handler.process" ]
```

4. To create the container image, follow steps 4 through 7 in Create an image from an AWS base image for Lambda (p. 150).

# Deploy the container image

For a new function, you deploy the Ruby image when you create the function (p. 138). For an existing function, if you rebuild the container image, you need to redeploy the image by updating the function code (p. 141).

# AWS Lambda context object in Ruby

When Lambda runs your function, it passes a context object to the handler (p. 357). This object provides methods and properties that provide information about the invocation, function, and execution environment.

### Context methods

- `get_remaining_time_in_millis` – Returns the number of milliseconds left before the execution times out.

### Context properties

- `function_name` – The name of the Lambda function.
- `function_version` – The version (p. 173) of the function.
- `invoked_function_arn` – The Amazon Resource Name (ARN) that's used to invoke the function. Indicates if the invoker specified a version number or alias.
- `memory_limit_in_mb` – The amount of memory that's allocated for the function.
- `aws_request_id` – The identifier of the invocation request.
- `log_group_name` – The log group for the function.
- `log_stream_name` – The log stream for the function instance.
- `deadline_ms`– The date that the execution times out, in Unix time milliseconds.
- `identity` – (mobile apps) Information about the Amazon Cognito identity that authorized the request.
- `client_context`– (mobile apps) Client context that's provided to Lambda by the client application.

# AWS Lambda function logging in Ruby

AWS Lambda automatically monitors Lambda functions on your behalf and sends function metrics to Amazon CloudWatch. Your Lambda function comes with a CloudWatch Logs log group and a log stream for each instance of your function. The Lambda runtime environment sends details about each invocation to the log stream, and relays logs and other output from your function's code.

This page describes how to produce log output from your Lambda function's code, or access logs using the AWS Command Line Interface, the Lambda console, or the CloudWatch console.

**Sections**


- Creating a function that returns logs (p. 365)
- Using the Lambda console (p. 366)
- Using the CloudWatch console (p. 366)
- Using the AWS Command Line Interface (AWS CLI) (p. 367)
- Deleting logs (p. 369)


## Creating a function that returns logs

To output logs from your function code, you can use `puts` statements, or any logging library that writes to `stdout` or `stderr`. The following example logs the values of environment variables and the event object.

**Example lambda_function.rb**

```
# lambda_function.rb

def handler(event:, context:)
    puts "## ENVIRONMENT VARIABLES"
    puts ENV.to_a
    puts "## EVENT"
    puts event.to_a
end
```

For more detailed logs, use the logger library.

```
# lambda_function.rb

require 'logger'

def handler(event:, context:)
  logger = Logger.new($stdout)
  logger.info('## ENVIRONMENT VARIABLES')
  logger.info(ENV.to_a)
  logger.info('## EVENT')
  logger.info(event)
  event.to_a
end
```

The output from `logger` includes the timestamp, process ID, log level, and request ID.

```
I, [2019-10-26T10:04:01.689856 #8]  INFO 6573a3a0-2fb1-4e78-a582-2c769282e0bd -- : ## EVENT
I, [2019-10-26T10:04:01.689874 #8]  INFO 6573a3a0-2fb1-4e78-a582-2c769282e0bd -- :
 {"key1"=>"value1", "key2"=>"value2", "key3"=>"value3"}
```

### Example log format

```
START RequestId: 50aba555-99c8-4b21-8358-644ee996a05f Version: $LATEST
## ENVIRONMENT VARIABLES
AWS_LAMBDA_FUNCTION_VERSION
$LATEST
AWS_LAMBDA_LOG_GROUP_NAME
/aws/lambda/my-function
AWS_LAMBDA_LOG_STREAM_NAME
2020/01/31/[$LATEST]3f34xmpl069f4018b4a773bcfe8ed3f9
AWS_EXECUTION_ENV
AWS_Lambda_ruby2.5
...
## EVENT
key
value
END RequestId: 50aba555-xmpl-4b21-8358-644ee996a05f
REPORT RequestId: 50aba555-xmpl-4b21-8358-644ee996a05f Duration: 12.96 ms Billed Duration:
 13 ms Memory Size: 128 MB Max Memory Used: 48 MB Init Duration: 117.86 ms
XRAY TraceId: 1-5e34a246-2a04xmpl0fa44eb60ea08c5f SegmentId: 454xmpl46ca1c7d3 Sampled: true
```

The Ruby runtime logs the `START`, `END`, and `REPORT` lines for each invocation. The report line provides the following details.

### Report Log

- **RequestId** – The unique request ID for the invocation.
- **Duration** – The amount of time that your function's handler method spent processing the event.
- **Billed Duration** – The amount of time billed for the invocation.
- **Memory Size** – The amount of memory allocated to the function.
- **Max Memory Used** – The amount of memory used by the function.
- **Init Duration** – For the first request served, the amount of time it took the runtime to load the function and run code outside of the handler method.
- **XRAY TraceId** – For traced requests, the AWS X-Ray trace ID (p. 715).
- **SegmentId** – For traced requests, the X-Ray segment ID.
- **Sampled** – For traced requests, the sampling result.

# Using the Lambda console

You can use the Lambda console to view log output after you invoke a Lambda function. For more information, see Accessing Amazon CloudWatch logs for AWS Lambda (p. 730).

# Using the CloudWatch console

You can use the Amazon CloudWatch console to view logs for all Lambda function invocations.

### To view logs on the CloudWatch console

1. Open the Log groups page on the CloudWatch console.
2. Choose the log group for your function (**/aws/lambda/*your-function-name***).
3. Choose a log stream.

Each log stream corresponds to an instance of your function (p. 100). A log stream appears when you update your Lambda function, and when additional instances are created to handle multiple concurrent

invocations. To find logs for a specific invocation, we recommend instrumenting your function with AWS X-Ray. X-Ray records details about the request and the log stream in the trace.

To use a sample application that correlates logs and traces with X-Ray, see Error processor sample application for AWS Lambda (p. 807).

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

You can use the AWS CLI to retrieve logs for an invocation using the `--log-type` command option. The response contains a `LogResult` field that contains up to 4 KB of base64-encoded logs from the invocation.

### Example retrieve a log ID

The following example shows how to retrieve a *log ID* from the `LogResult` field for a function named `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail
```

You should see the following output:

```
{
    "StatusCode": 200,
    "LogResult":
 "U1RBUlQgUmVxdWVzdElkOiA4N2QwNDRiOC1mMTU0LTExZTgtOGNkYS0yOTc0YzVlNGZiMjEgVmVyc2lvb...",
    "ExecutedVersion": "$LATEST"
}
```

### Example decode the logs

In the same command prompt, use the `base64` utility to decode the logs. The following example shows how to retrieve base64-encoded logs for `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail \
--query 'LogResult' --output text |  base64 -d
```

You should see the following output:

```
START RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8 Version: $LATEST
"AWS_SESSION_TOKEN": "AgoJb3JpZ2luX2VjELj...", "_X_AMZN_TRACE_ID": "Root=1-5d02e5ca-
f5792818b6fe8368e5b51d50;Parent=191db58857df8395;Sampled=0"",ask/lib:/opt/lib",
END RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8
REPORT RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8  Duration: 79.67 ms      Billed
 Duration: 80 ms         Memory Size: 128 MB     Max Memory Used: 73 MB
```

The `base64` utility is available on Linux, macOS, and Ubuntu on Windows. macOS users may need to use `base64 -D`.

### Example get-logs.sh script

In the same command prompt, use the following script to download the last five log events. The script uses `sed` to remove quotes from the output file, and sleeps for 15 seconds to allow time for the logs to

become available. The output includes the response from Lambda and the output from the `get-log-events` command.

Copy the contents of the following code sample and save in your Lambda project directory as `get-logs.sh`.

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

```
#!/bin/bash
aws lambda invoke --function-name my-function --cli-binary-format raw-in-base64-out --
payload '{"key": "value"}' out
sed -i'' -e 's/"//g' out
sleep 15
aws logs get-log-events --log-group-name /aws/lambda/my-function --log-stream-name stream1
 --limit 5
```

### Example macOS and Linux (only)

In the same command prompt, macOS and Linux users may need to run the following command to ensure the script is executable.

```
chmod -R 755 get-logs.sh
```

### Example retrieve the last five log events

In the same command prompt, run the following script to get the last five log events.

```
./get-logs.sh
```

You should see the following output:

```
{
    "StatusCode": 200,
    "ExecutedVersion": "$LATEST"
}
{
    "events": [
        {
            "timestamp": 1559763003171,
            "message": "START RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf Version:
 $LATEST\n",
            "ingestionTime": 1559763003309
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tENVIRONMENT VARIABLES\r{\r  \"AWS_LAMBDA_FUNCTION_VERSION\": \"$LATEST\",\r ...",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tEVENT\r{\r  \"key\": \"value\"\r}\n",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "END RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\n",
```

```
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "REPORT RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\tDuration:
 26.73 ms\tBilled Duration: 27 ms \tMemory Size: 128 MB\tMax Memory Used: 75 MB\t\n",
            "ingestionTime": 1559763018353
        }
    ],
    "nextForwardToken": "f/34783877304859518393868359594929986069206639495374241795",
    "nextBackwardToken": "b/34783877303811383369537420289090800615709599058929582080"
}
```


# Deleting logs

Log groups aren't deleted automatically when you delete a function. To avoid storing logs indefinitely, delete the log group, or configure a retention period after which logs are deleted automatically.

# AWS Lambda function errors in Ruby

When your code raises an error, Lambda generates a JSON representation of the error. This error document appears in the invocation log and, for synchronous invocations, in the output.

This page describes how to view Lambda function invocation errors for the Ruby runtime using the Lambda console and the AWS CLI.

**Sections**


- Syntax (p. 370)
- How it works (p. 370)
- Using the Lambda console (p. 371)
- Using the AWS Command Line Interface (AWS CLI) (p. 371)
- Error handling in other AWS services (p. 372)
- Sample applications (p. 373)
- What's next? (p. 373)


## Syntax

**Example function.rb**

```
def handler(event:, context:)
    puts "Processing event..."
    [1, 2, 3].first("two")
    "Success"
end
```

This code results in a type error. Lambda catches the error and generates a JSON document with fields for the error message, the type, and the stack trace.

```
{
  "errorMessage": "no implicit conversion of String into Integer",
  "errorType": "Function<TypeError>",
  "stackTrace": [
    "/var/task/function.rb:3:in `first'",
    "/var/task/function.rb:3:in `handler'"
  ]
}
```

## How it works

When you invoke a Lambda function, Lambda receives the invocation request and validates the permissions in your execution role, verifies that the event document is a valid JSON document, and checks parameter values.

If the request passes validation, Lambda sends the request to a function instance. The Lambda runtime (p. 82) environment converts the event document into an object, and passes it to your function handler.

If Lambda encounters an error, it returns an exception type, message, and HTTP status code that indicates the cause of the error. The client or service that invoked the Lambda function can handle the error programmatically, or pass it along to an end user. The correct error handling behavior depends on the type of application, the audience, and the source of the error.

The following list describes the range of status codes you can receive from Lambda.

**2xx**

A `2xx` series error with a `X-Amz-Function-Error` header in the response indicates a Lambda runtime or function error. A `2xx` series status code indicates that Lambda accepted the request, but instead of an error code, Lambda indicates the error by including the `X-Amz-Function-Error` header in the response.

**4xx**

A `4xx` series error indicates an error that the invoking client or service can fix by modifying the request, requesting permission, or by retrying the request. `4xx` series errors other than `429` generally indicate an error with the request.

**5xx**

A `5xx` series error indicates an issue with Lambda, or an issue with the function's configuration or resources. `5xx` series errors can indicate a temporary condition that can be resolved without any action by the user. These issues can't be addressed by the invoking client or service, but a Lambda function's owner may be able to fix the issue.

For a complete list of invocation errors, see InvokeFunction errors (p. 995).

# Using the Lambda console

You can invoke your function on the Lambda console by configuring a test event and viewing the output. The output is captured in the function's execution logs and, when active tracing (p. 715) is enabled, in AWS X-Ray.

### To invoke a function on the Lambda console

1. Open the Functions page of the Lambda console.
2. Choose the function to test, and choose **Test**.
3. Under **Test event**, select **New event**.
4. Select a **Template**.
5. For **Name**, enter a name for the test. In the text entry box, enter the JSON test event.
6. Choose **Save changes**.
7. Choose **Test**.

The Lambda console invokes your function synchronously (p. 225) and displays the result. To see the response, logs, and other information, expand the **Details** section.

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

When you invoke a Lambda function in the AWS CLI, the AWS CLI splits the response into two documents. The AWS CLI response is displayed in your command prompt. If an error has occurred, the response contains a `FunctionError` field. The invocation response or error returned by the function is written to an output file. For example, `output.json` or `output.txt`.

The following invoke command example demonstrates how to invoke a function and write the invocation response to an `output.txt` file.

```
aws lambda invoke   \
  --function-name my-function   \
      --cli-binary-format raw-in-base64-out  \
          --payload '{"key1": "value1", "key2": "value2", "key3": "value3"}' output.txt
```

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

You should see the AWS CLI response in your command prompt:

```
{
    "StatusCode": 200,
    "FunctionError": "Unhandled",
    "ExecutedVersion": "$LATEST"
}
```

You should see the function invocation response in the `output.txt` file. In the same command prompt, you can also view the output in your command prompt using:

```
cat output.txt
```

You should see the invocation response in your command prompt.

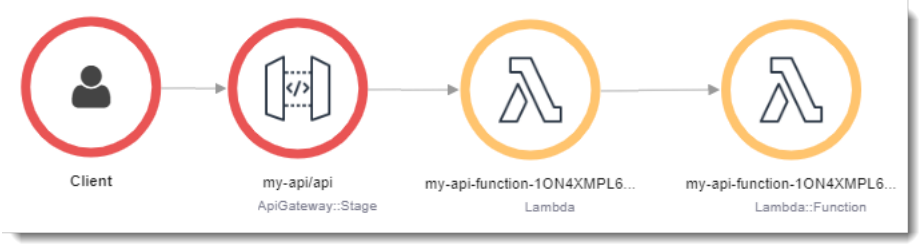
```
{"errorMessage":"no implicit conversion of String into
 Integer","errorType":"Function<TypeError>","stackTrace":["/var/task/function.rb:3:in
 `first'","/var/task/function.rb:3:in `handler'"]}
```

# Error handling in other AWS services

When another AWS service invokes your function, the service chooses the invocation type and retry behavior. AWS services can invoke your function on a schedule, in response to a lifecycle event on a resource, or to serve a request from a user. Some services invoke functions asynchronously and let Lambda handle errors, while others retry or pass errors back to the user.

For example, API Gateway treats all invocation and function errors as internal errors. If the Lambda API rejects the invocation request, API Gateway returns a `500` error code. If the function runs but returns an error, or returns a response in the wrong format, API Gateway returns a 502 error code. To customize the error response, you must catch errors in your code and format a response in the required format.

We recommend using AWS X-Ray to determine the source of an error and its cause. X-Ray allows you to find out which component encountered an error, and see details about the errors. The following example shows a function error that resulted in a `502` response from API Gateway.




For more information, see Instrumenting Ruby code in AWS Lambda (p. 374).

# Sample applications

The following sample code is available for the Ruby runtime.

**Sample Lambda applications in Ruby**

- blank-ruby – A Ruby function that shows the use of logging, environment variables, AWS X-Ray tracing, layers, unit tests and the AWS SDK.
- Ruby Code Samples for AWS Lambda – Code samples written in Ruby that demonstrate how to interact with AWS Lambda.

# What's next?

- Learn how to show logging events for your Lambda function on the the section called "Logging" (p. 365) page.

# Instrumenting Ruby code in AWS Lambda

Lambda integrates with AWS X-Ray to enable you to trace, debug, and optimize Lambda applications. You can use X-Ray to trace a request as it traverses resources in your application, from the frontend API to storage and database on the backend. By simply adding the X-Ray SDK library to your build configuration, you can record errors and latency for any call that your function makes to an AWS service.

After you've configured active tracing, you can observe specific requests through your application. The X-Ray service graph shows information about your application and all its components. The following example from the error processor (p. 807) sample application shows an application with two functions. The primary function processes events and sometimes returns errors. The second function at the top processes errors that appear in the first's log group and uses the AWS SDK to call X-Ray, Amazon Simple Storage Service (Amazon S3), and Amazon CloudWatch Logs.




To toggle active tracing on your Lambda function with the console, follow these steps:

### To turn on active tracing

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **Monitoring and operations tools**.
4. Choose **Edit**.
5. Under **X-Ray**, toggle on **Active tracing**.
6. Choose **Save**.

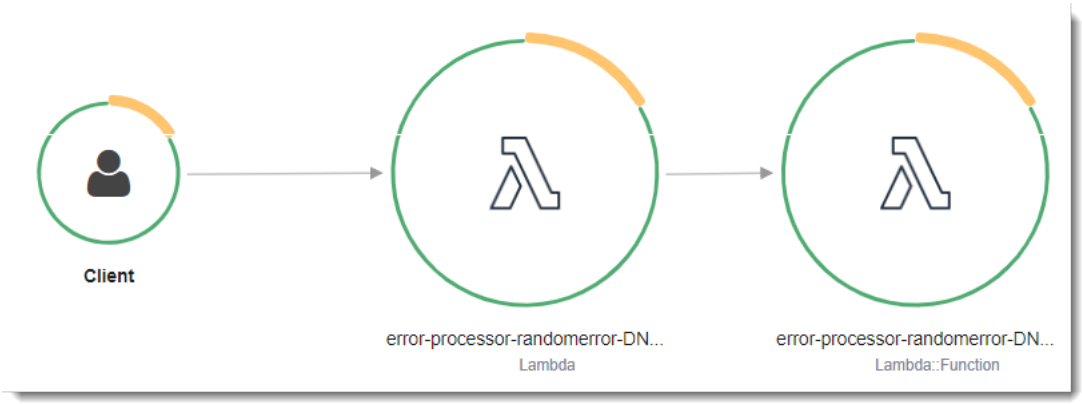
> **Pricing**
> You can use X-Ray tracing for free each month up to a certain limit as part of the AWS Free Tier. Beyond that threshold, X-Ray charges for trace storage and retrieval. For more information, see AWS X-Ray pricing.

Your function needs permission to upload trace data to X-Ray. When you activate tracing in the Lambda console, Lambda adds the required permissions to your function's execution role (p. 52). Otherwise, add the AWSXRayDaemonWriteAccess policy to the execution role.

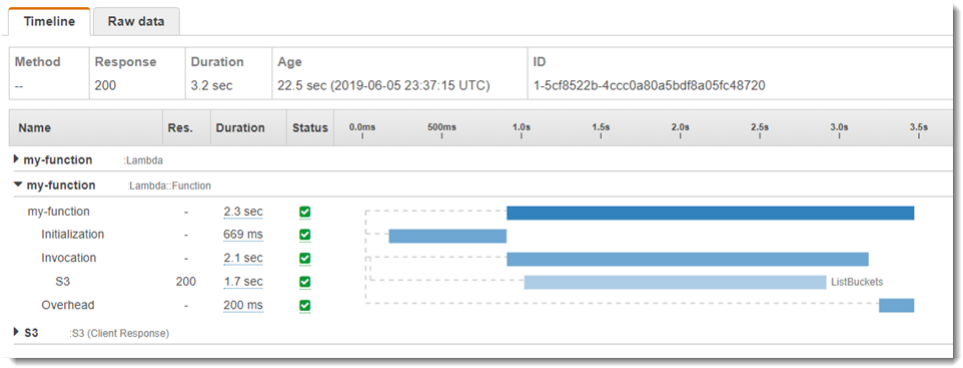
X-Ray doesn't trace all requests to your application. X-Ray applies a sampling algorithm to ensure that tracing is efficient, while still providing a representative sample of all requests. The sampling rate is 1 request per second and 5 percent of additional requests.

> **Note**
> You cannot configure the X-Ray sampling rate for your functions.

When using active tracing, Lambda records 2 segments per trace, which creates two nodes on the service graph. The following image highlights these two nodes for the primary function from the error processor example above.




The first node on the left represents the Lambda service, which receives the invocation request. The second node represents your specific Lambda function. The following example shows a trace with these two segments. Both are named **my-function**, but one has an origin of `AWS::Lambda` and the other has origin `AWS::Lambda::Function`.




This example expands the function segment to show its three subsegments:

- **Initialization** – Represents time spent loading your function and running initialization code (p. 22). This subsegment only appears for the first event that each instance of your function processes.
- **Invocation** – Represents the time spent running your handler code.
- **Overhead** – Represents the time the Lambda runtime spends preparing to handle the next event.

You can instrument your handler code to record metadata and trace downstream calls. To record detail about calls that your handler makes to other resources and services, use the X-Ray SDK for Ruby. To get the SDK, add the `aws-xray-sdk` package to your application's dependencies.

**Example blank-ruby/function/Gemfile**

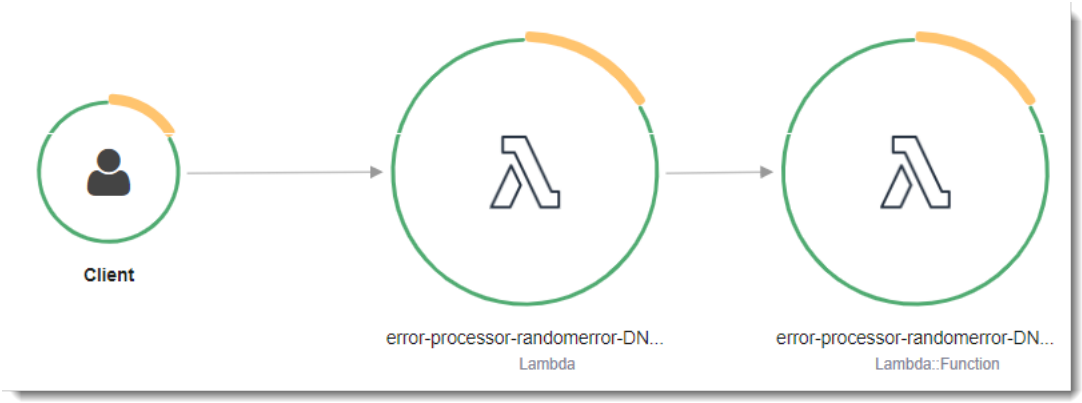
```
# Gemfile
source 'https://rubygems.org'

gem 'aws-xray-sdk', '0.11.4'
gem 'aws-sdk-lambda', '1.39.0'
gem 'test-unit', '3.3.5'
```

To instrument AWS SDK clients, require the `aws-xray-sdk/lambda` module after creating a client in initialization code.

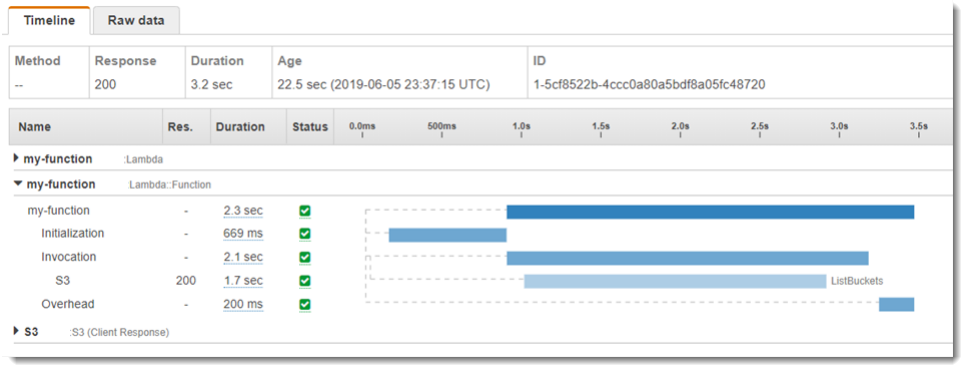
**Example blank-ruby/function/lambda_function.rb – Tracing an AWS SDK client**

```
# lambda_function.rb
require 'logger'
require 'json'
require 'aws-sdk-lambda'
$client = Aws::Lambda::Client.new()
$client.get_account_settings()

require 'aws-xray-sdk/lambda'

def lambda_handler(event:, context:)
  logger = Logger.new($stdout)
  ...
```

When using active tracing, Lambda records 2 segments per trace, which creates two nodes on the service graph. The following image highlights these two nodes for the primary function from the error processor example above.




The first node on the left represents the Lambda service, which receives the invocation request. The second node represents your specific Lambda function. The following example shows a trace with these two segments. Both are named **my-function**, but one has an origin of `AWS::Lambda` and the other has origin `AWS::Lambda::Function`.




This example expands the function segment to show its three subsegments:

- **Initialization** – Represents time spent loading your function and running initialization code (p. 22). This subsegment only appears for the first event that each instance of your function processes.

- **Invocation** – Represents the time spent running your handler code.
- **Overhead** – Represents the time the Lambda runtime spends preparing to handle the next event.

You can also instrument HTTP clients, record SQL queries, and create custom subsegments with annotations and metadata. For more information, see The X-Ray SDK for Ruby in the AWS X-Ray Developer Guide.

**Sections**

- Enabling active tracing with the Lambda API (p. 377)
- Enabling active tracing with AWS CloudFormation (p. 377)
- Storing runtime dependencies in a layer (p. 378)

# Enabling active tracing with the Lambda API

To manage tracing configuration with the AWS CLI or AWS SDK, use the following API operations:

- UpdateFunctionConfiguration (p. 1098)
- GetFunctionConfiguration (p. 967)
- CreateFunction (p. 904)

The following example AWS CLI command enables active tracing on a function named **my-function**.

```
aws lambda update-function-configuration --function-name my-function \
--tracing-config Mode=Active
```

Tracing mode is part of the version-specific configuration when you publish a version of your function. You can't change the tracing mode on a published version.

# Enabling active tracing with AWS CloudFormation

To activate tracing on an `AWS::Lambda::Function` resource in an AWS CloudFormation template, use the `TracingConfig` property.

**Example function-inline.yml – Tracing configuration**

```
Resources:
  function:
    Type: AWS::Lambda::Function
    Properties:
      TracingConfig:
        Mode: Active
      ...
```

For an AWS Serverless Application Model (AWS SAM) `AWS::Serverless::Function` resource, use the `Tracing` property.

**Example template.yml – Tracing configuration**

```
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      Tracing: Active
```

```
      ...
```

# Storing runtime dependencies in a layer

If you use the X-Ray SDK to instrument AWS SDK clients your function code, your deployment package can become quite large. To avoid uploading runtime dependencies every time you update your function code, package the X-Ray SDK in a Lambda layer (p. 156).

The following example shows an `AWS::Serverless::LayerVersion` resource that stores X-Ray SDK for Ruby.

**Example template.yml – Dependencies layer**

```
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      CodeUri: function/.
      Tracing: Active
      Layers:
        - !Ref libs
      ...
  libs:
    Type: AWS::Serverless::LayerVersion
    Properties:
      LayerName: blank-ruby-lib
      Description: Dependencies for the blank-ruby sample app.
      ContentUri: lib/.
      CompatibleRuntimes:
        - ruby2.5
```

With this configuration, you update the library layer only if you change your runtime dependencies. Since the function deployment package contains only your code, this can help reduce upload times.

Creating a layer for dependencies requires build changes to generate the layer archive prior to deployment. For a working example, see the blank-ruby sample application.

# Building Lambda functions with Java

You can run Java code in AWS Lambda. Lambda provides runtimes (p. 82) for Java that run your code to process events. Your code runs in an Amazon Linux environment that includes AWS credentials from an AWS Identity and Access Management (IAM) role that you manage.

Lambda supports the following Java runtimes.

**Java**

| Name | Identifier | Operating system | Architectures | Deprecation |
|---|---|---|---|---|
| Java 11 | `java11` | Amazon Linux 2 | x86_64, arm64 | |
| Java 8 | `java8.al2` | Amazon Linux 2 | x86_64, arm64 | |
| Java 8 | `java8` | Amazon Linux | x86_64 | |

Lambda provides the following libraries for Java functions:

- com.amazonaws:aws-lambda-java-core (required) – Defines handler method interfaces and the context object that the runtime passes to the handler. If you define your own input types, this is the only library that you need.
- com.amazonaws:aws-lambda-java-events – Input types for events from services that invoke Lambda functions.
- com.amazonaws:aws-lambda-java-log4j2 – An appender library for Apache Log4j 2 that you can use to add the request ID for the current invocation to your function logs (p. 398).
- AWS SDK for Java 2.0 – The official AWS SDK for the Java programming language.

Lambda functions use an execution role (p. 52) to get permission to write logs to Amazon CloudWatch Logs, and to access other services and resources. If you don't already have an execution role for function development, create one.

**To create an execution role**

1. Open the roles page in the IAM console.
2. Choose **Create role**.
3. Create a role with the following properties.

   - **Trusted entity** – **Lambda**.
   - **Permissions** – **AWSLambdaBasicExecutionRole**.
   - **Role name** – **`lambda-role`**.

   The **AWSLambdaBasicExecutionRole** policy has the permissions that the function needs to write logs to CloudWatch Logs.

You can add permissions to the role later, or swap it out for a different role that's specific to a single function.

### To create a Java function

1. Open the Lambda console.
2. Choose **Create function**.
3. Configure the following settings:
   - **Name** – **`my-function`**.
   - **Runtime** – **Java 11**.
   - **Role** – **Choose an existing role**.
   - **Existing role** – **`lambda-role`**.
4. Choose **Create function**.
5. To configure a test event, choose **Test**.
6. For **Event name**, enter **`test`**.
7. Choose **Save changes**.
8. To invoke the function, choose **Test**.

The console creates a Lambda function with a handler class named `Hello`. Since Java is a compiled language, you can't view or edit the source code in the Lambda console, but you can modify its configuration, invoke it, and configure triggers.

> **Note**
> To get started with application development in your local environment, deploy one of the sample applications (p. 419) available in this guide's GitHub repository.

The `Hello` class has a function named `handleRequest` that takes an event object and a context object. This is the handler function (p. 382) that Lambda calls when the function is invoked. The Java function runtime gets invocation events from Lambda and passes them to the handler. In the function configuration, the handler value is `example.Hello::handleRequest`.

To update the function's code, you create a deployment package, which is a .zip file archive that contains your function code. As your function development progresses, you will want to store your function code in source control, add libraries, and automate deployments. Start by creating a deployment package (p. 386) and updating your code at the command line.

The function runtime passes a context object to the handler, in addition to the invocation event. The context object (p. 395) contains additional information about the invocation, the function, and the execution environment. More information is available from environment variables.

Your Lambda function comes with a CloudWatch Logs log group. The function runtime sends details about each invocation to CloudWatch Logs. It relays any logs that your function outputs (p. 398) during invocation. If your function returns an error (p. 405), Lambda formats the error and returns it to the invoker.

**Topics**


- AWS Lambda function handler in Java (p. 382)
- Deploy Java Lambda functions with .zip or JAR file archives (p. 386)
- Deploy Java Lambda functions with container images (p. 393)
- AWS Lambda context object in Java (p. 395)
- AWS Lambda function logging in Java (p. 398)
- AWS Lambda function errors in Java (p. 405)
- Instrumenting Java code in AWS Lambda (p. 410)
- Creating a deployment package using Eclipse (p. 416)
- Java sample applications for AWS Lambda (p. 419)

# AWS Lambda function handler in Java

The Lambda function *handler* is the method in your function code that processes events. When your function is invoked, Lambda runs the handler method. When the handler exits or returns a response, it becomes available to handle another event.

In the following example, a class named `Handler` defines a handler method named `handleRequest`. The handler method takes an event and context object as input and returns a string.

**Example Handler.java**

```
package example;
import com.amazonaws.services.lambda.runtime.Context
import com.amazonaws.services.lambda.runtime.RequestHandler
import com.amazonaws.services.lambda.runtime.LambdaLogger
...

// Handler value: example.Handler
public class Handler implements RequestHandler<Map<String,String>, String>{
  Gson gson = new GsonBuilder().setPrettyPrinting().create();
  @Override
  public String handleRequest(Map<String,String> event, Context context)
  {
    LambdaLogger logger = context.getLogger();
    String response = new String("200 OK");
    // log execution details
    logger.log("ENVIRONMENT VARIABLES: " + gson.toJson(System.getenv()));
    logger.log("CONTEXT: " + gson.toJson(context));
    // process event
    logger.log("EVENT: " + gson.toJson(event));
    logger.log("EVENT TYPE: " + event.getClass().toString());
    return response;
  }
}
```

The Lambda runtime (p. 82) receives an event as a JSON-formatted string and converts it into an object. It passes the event object to your function handler along with a context object that provides details about the invocation and the function. You tell the runtime which method to invoke by setting the handler parameter on your function's configuration.

### Handler formats

- *package*`.`*Class*`::`*method* – Full format. For example: `example.Handler::handleRequest`.
- *package*`.`*Class* – Abbreviated format for functions that implement a handler interface (p. 384). For example: `example.Handler`.

You can add initialization code (p. 22) outside of your handler method to reuse resources across multiple invocations. When the runtime loads your handler, it runs static code and the class constructor. Resources that are created during initialization stay in memory between invocations, and can be reused by the handler thousands of times.

In the following example, the logger and the serializer are created when the function serves its first event. Subsequent events served by the same function instance are much faster because those resources already exist.

**Example HandlerS3.java – Initialization code**

```
public class HandlerS3 implements RequestHandler<S3Event, String>{
    private static final Logger logger = LoggerFactory.getLogger(HandlerS3.class);
```

```
    Gson gson = new GsonBuilder().setPrettyPrinting().create();
    @Override
    public String handleRequest(S3Event event, Context context)
    {
      ...
    }
```

The GitHub repo for this guide provides easy-to-deploy sample applications that demonstrate a variety of handler types. For details, see the end of this topic (p. 385).

**Sections**


- Choosing input and output types (p. 383)
- Handler interfaces (p. 384)
- Sample handler code (p. 385)


# Choosing input and output types

You specify the type of object that the event maps to in the handler method's signature. In the preceding example, the Java runtime deserializes the event into a type that implements the `Map<String,String>` interface. String-to-string maps work for flat events like the following:

**Example Event.json – Weather data**

```
{
  "temperatureK": 281,
  "windKmh": -3,
  "humidityPct": 0.55,
  "pressureHPa": 1020
}
```

However, the value of each field must be a string or number. If the event includes a field that has an object as a value, the runtime can't deserialize it and returns an error.

Choose an input type that works with the event data that your function processes. You can use a basic type, a generic type, or a well-defined type.

**Input types**

- `Integer`, `Long`, `Double`, etc. – The event is a number with no additional formatting—for example, `3.5`. The runtime converts the value into an object of the specified type.
- `String` – The event is a JSON string, including quotes—for example, `"My string."`. The runtime converts the value (without quotes) into a `String` object.
- *`Type`*, `Map<String,`*`Type`*`>` etc. – The event is a JSON object. The runtime deserializes it into an object of the specified type or interface.
- `List<Integer>`, `List<String>`, `List<Object>`, etc. – The event is a JSON array. The runtime deserializes it into an object of the specified type or interface.
- `InputStream` – The event is any JSON type. The runtime passes a byte stream of the document to the handler without modification. You deserialize the input and write output to an output stream.
- Library type – For events sent by AWS services, use the types in the aws-lambda-java-events (p. 386) library.

If you define your own input type, it should be a deserializable, mutable plain old Java object (POJO), with a default constructor and properties for each field in the event. Keys in the event that don't map to a property as well as properties that aren't included in the event are dropped without error.

The output type can be an object or `void`. The runtime serializes return values into text. If the output is an object with fields, the runtime serializes it into a JSON document. If it's a type that wraps a primitive value, the runtime returns a text representation of that value.

# Handler interfaces

The aws-lambda-java-core library defines two interfaces for handler methods. Use the provided interfaces to simplify handler configuration and validate the handler method signature at compile time.

- com.amazonaws.services.lambda.runtime.RequestHandler
- com.amazonaws.services.lambda.runtime.RequestStreamHandler

The `RequestHandler` interface is a generic type that takes two parameters: the input type and the output type. Both types must be objects. When you use this interface, the Java runtime deserializes the event into an object with the input type, and serializes the output into text. Use this interface when the built-in serialization works with your input and output types.

**Example Handler.java – Handler interface**

```
// Handler value: example.Handler
public class Handler implements RequestHandler<Map<String,String>, String>{
  @Override
  public String handleRequest(Map<String,String> event, Context context)
```

To use your own serialization, implement the `RequestStreamHandler` interface. With this interface, Lambda passes your handler an input stream and output stream. The handler reads bytes from the input stream, writes to the output stream, and returns void.

The following example uses buffered reader and writer types to work with the input and output streams. It uses the Gson library for serialization and deserialization.

**Example HandlerStream.java**

```
import com.amazonaws.services.lambda.runtime.Context
import com.amazonaws.services.lambda.runtime.RequestStreamHandler
import com.amazonaws.services.lambda.runtime.LambdaLogger
...
// Handler value: example.HandlerStream
public class HandlerStream implements RequestStreamHandler {
  Gson gson = new GsonBuilder().setPrettyPrinting().create();
  @Override
  public void handleRequest(InputStream inputStream, OutputStream outputStream, Context
 context) throws IOException
  {
    LambdaLogger logger = context.getLogger();
    BufferedReader reader = new BufferedReader(new InputStreamReader(inputStream,
 Charset.forName("US-ASCII")));
    PrintWriter writer = new PrintWriter(new BufferedWriter(new
 OutputStreamWriter(outputStream, Charset.forName("US-ASCII"))));
    try
    {
      HashMap event = gson.fromJson(reader, HashMap.class);
      logger.log("STREAM TYPE: " + inputStream.getClass().toString());
      logger.log("EVENT TYPE: " + event.getClass().toString());
      writer.write(gson.toJson(event));
      if (writer.checkError())
      {
        logger.log("WARNING: Writer encountered an error.");
```

```
      }
    }
    catch (IllegalStateException | JsonSyntaxException exception)
    {
      logger.log(exception.toString());
    }
    finally
    {
      reader.close();
      writer.close();
    }
  }
}
```

# Sample handler code

The GitHub repository for this guide includes sample applications that demonstrate the use of various handler types and interfaces. Each sample application includes scripts for easy deployment and cleanup, an AWS SAM template, and supporting resources.

### Sample Lambda applications in Java

- java-basic – A collection of minimal Java functions with unit tests and variable logging configuration.
- java-events – A collection of Java functions that contain skeleton code for how to handle events from various services such as Amazon API Gateway, Amazon SQS, and Amazon Kinesis. These functions use the latest version of the aws-lambda-java-events (p. 386) library (3.0.0 and newer). These examples do not require the AWS SDK as a dependency.
- s3-java – A Java function that processes notification events from Amazon S3 and uses the Java Class Library (JCL) to create thumbnails from uploaded image files.
- Use API Gateway to invoke a Lambda function – A Java function that scans a Amazon DynamoDB table that contains employee information. It then uses Amazon Simple Notification Service to send a text message to employees celebrating their work anniversaries. This example uses API Gateway to invoke the function.

The `java-events` and `s3-java` applications take an AWS service event as input and return a string. The `java-basic` application includes several types of handlers:

- Handler.java – Takes a `Map<String,String>` as input.
- HandlerInteger.java – Takes an `Integer` as input.
- HandlerList.java – Takes a `List<Integer>` as input.
- HandlerStream.java – Takes an `InputStream` and `OutputStream` as input.
- HandlerString.java – Takes a `String` as input.
- HandlerWeatherData.java – Takes a custom type as input.

To test different handler types, just change the handler value in the AWS SAM template. For detailed instructions, see the sample application's readme file.

# Deploy Java Lambda functions with .zip or JAR file archives

Your AWS Lambda function's code consists of scripts or compiled programs and their dependencies. You use a *deployment package* to deploy your function code to Lambda. Lambda supports two types of deployment packages: container images and .zip file archives.

This page describes how to create your deployment package as a .zip file or Jar file, and then use the deployment package to deploy your function code to AWS Lambda using the AWS Command Line Interface (AWS CLI).

**Sections**


- Prerequisites (p. 386)
- Tools and libraries (p. 386)


## Prerequisites

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

## Tools and libraries

Lambda provides the following libraries for Java functions:

- com.amazonaws:aws-lambda-java-core (required) – Defines handler method interfaces and the context object that the runtime passes to the handler. If you define your own input types, this is the only library that you need.
- com.amazonaws:aws-lambda-java-events – Input types for events from services that invoke Lambda functions.
- com.amazonaws:aws-lambda-java-log4j2 – An appender library for Apache Log4j 2 that you can use to add the request ID for the current invocation to your function logs (p. 398).
- AWS SDK for Java 2.0 – The official AWS SDK for the Java programming language.

These libraries are available through Maven Central Repository. Add them to your build definition as follows:

Gradle

```
dependencies {
    implementation 'com.amazonaws:aws-lambda-java-core:1.2.1'
    implementation 'com.amazonaws:aws-lambda-java-events:3.11.0'
    runtimeOnly 'com.amazonaws:aws-lambda-java-log4j2:1.5.1'
}
```

Maven

```
  <dependencies>
```

```
    <dependency>
      <groupId>com.amazonaws</groupId>
      <artifactId>aws-lambda-java-core</artifactId>
      <version>1.2.1</version>
    </dependency>
    <dependency>
      <groupId>com.amazonaws</groupId>
      <artifactId>aws-lambda-java-events</artifactId>
      <version>3.11.0</version>
    </dependency>
    <dependency>
      <groupId>com.amazonaws</groupId>
      <artifactId>aws-lambda-java-log4j2</artifactId>
      <version>1.5.1</version>
    </dependency>
  </dependencies>
```

To create a deployment package, compile your function code and dependencies into a single .zip file or Java Archive (JAR) file. For Gradle, use the `Zip` build type (p. 387). For Apache Maven, use the Maven Shade plugin (p. 388).

> **Note**
> To keep your deployment package size small, package your function's dependencies in layers. Layers enable you to manage your dependencies independently, can be used by multiple functions, and can be shared with other accounts. For more information, see Creating and sharing Lambda layers (p. 156).

You can upload your deployment package by using the Lambda console, the Lambda API, or AWS Serverless Application Model (AWS SAM).

**To upload a deployment package with the Lambda console**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Under **Code source**, choose **Upload from**.
4. Upload the deployment package.
5. Choose **Save**.

**Sections**


- Building a deployment package with Gradle (p. 387)
- Building a deployment package with Maven (p. 388)
- Uploading a deployment package with the Lambda API (p. 390)
- Uploading a deployment package with AWS SAM (p. 391)


# Building a deployment package with Gradle

To create a deployment package with your function's code and dependencies, use the `Zip` build type.

**Example build.gradle – Build task**

```
task buildZip(type: Zip) {
    from compileJava
    from processResources
    into('lib') {
```

```
        from configurations.runtimeClasspath
    }
}
```

This build configuration produces a deployment package in the `build/distributions` directory. The `compileJava` task compiles your function's classes. The `processResources` task copies the Java project resources into their target directory, potentially processing then. The statement `into('lib')` then copies dependency libraries from the build's classpath into a folder named `lib`.

**Example build.gradle – Dependencies**

```
dependencies {
    implementation platform('software.amazon.awssdk:bom:2.10.73')
    implementation 'software.amazon.awssdk:lambda'
    implementation 'com.amazonaws:aws-lambda-java-core:1.2.1'
    implementation 'com.amazonaws:aws-lambda-java-events:3.11.0'
    implementation 'com.google.code.gson:gson:2.8.6'
    implementation 'org.apache.logging.log4j:log4j-api:2.17.1'
    implementation 'org.apache.logging.log4j:log4j-core:2.17.1'
    runtimeOnly 'org.apache.logging.log4j:log4j-slf4j18-impl:2.17.1'
    runtimeOnly 'com.amazonaws:aws-lambda-java-log4j2:1.5.1'
    testImplementation 'org.junit.jupiter:junit-jupiter-api:5.6.0'
    testRuntimeOnly 'org.junit.jupiter:junit-jupiter-engine:5.6.0'
}
```

Lambda loads JAR files in Unicode alphabetical order. If multiple JAR files in the `lib` directory contain the same class, the first one is used. You can use the following shell script to identify duplicate classes:

**Example test-zip.sh**

```
mkdir -p expanded
unzip path/to/my/function.zip -d expanded
find ./expanded/lib -name '*.jar' | xargs -n1 zipinfo -1 | grep '.*.class' | sort | uniq -c
 | sort
```

## Building a deployment package with Maven

To build a deployment package with Maven, use the Maven Shade plugin. The plugin creates a JAR file that contains the compiled function code and all of its dependencies.

**Example pom.xml – Plugin configuration**

```
      <plugin>
        <groupId>org.apache.maven.plugins</groupId>
        <artifactId>maven-shade-plugin</artifactId>
        <version>3.2.2</version>
        <configuration>
          <createDependencyReducedPom>false</createDependencyReducedPom>
        </configuration>
        <executions>
          <execution>
            <phase>package</phase>
            <goals>
              <goal>shade</goal>
            </goals>
          </execution>
        </executions>
      </plugin>
```

To build the deployment package, use the `mvn package` command.

```
[INFO] Scanning for projects...
[INFO] -----------------------< com.example:java-maven >-----------------------
[INFO] Building java-maven-function 1.0-SNAPSHOT
[INFO] --------------------------------[ jar ]---------------------------------
...
[INFO] --- maven-jar-plugin:2.4:jar (default-jar) @ java-maven ---
[INFO] Building jar: target/java-maven-1.0-SNAPSHOT.jar
[INFO]
[INFO] --- maven-shade-plugin:3.2.2:shade (default) @ java-maven ---
[INFO] Including com.amazonaws:aws-lambda-java-core:jar:1.2.1 in the shaded jar.
[INFO] Including com.amazonaws:aws-lambda-java-events:jar:3.11.0 in the shaded jar.
[INFO] Including joda-time:joda-time:jar:2.6 in the shaded jar.
[INFO] Including com.google.code.gson:gson:jar:2.8.6 in the shaded jar.
[INFO] Replacing original artifact with shaded artifact.
[INFO] Replacing target/java-maven-1.0-SNAPSHOT.jar with target/java-maven-1.0-SNAPSHOT-
shaded.jar
[INFO] ------------------------------------------------------------------------
[INFO] BUILD SUCCESS
[INFO] ------------------------------------------------------------------------
[INFO] Total time:  8.321 s
[INFO] Finished at: 2020-03-03T09:07:19Z
[INFO] ------------------------------------------------------------------------
```

This command generates a JAR file in the `target` directory.

If you use the appender library (`aws-lambda-java-log4j2`), you must also configure a transformer for the Maven Shade plugin. The transformer library combines versions of a cache file that appear in both the appender library and in Log4j.

**Example pom.xml – Plugin configuration with Log4j 2 appender**

```
     <plugin>
       <groupId>org.apache.maven.plugins</groupId>
       <artifactId>maven-shade-plugin</artifactId>
       <version>3.2.2</version>
       <configuration>
         <createDependencyReducedPom>false</createDependencyReducedPom>
       </configuration>
       <executions>
         <execution>
           <phase>package</phase>
           <goals>
             <goal>shade</goal>
           </goals>
           <configuration>
             <transformers>
               <transformer
 implementation="com.github.edwgiz.maven_shade_plugin.log4j2_cache_transformer.PluginsCacheFileTransfor
               </transformer>
             </transformers>
           </configuration>
         </execution>
       </executions>
       <dependencies>
         <dependency>
           <groupId>com.github.edwgiz</groupId>
           <artifactId>maven-shade-plugin.log4j2-cachefile-transformer</artifactId>
           <version>2.13.0</version>
         </dependency>
       </dependencies>
     </plugin>
```

## Uploading a deployment package with the Lambda API

To update a function's code with the AWS Command Line Interface (AWS CLI) or AWS SDK, use the UpdateFunctionCode (p. 1088) API operation. For the AWS CLI, use the `update-function-code` command. The following command uploads a deployment package named `my-function.zip` in the current directory:

```
aws lambda update-function-code --function-name my-function --zip-file fileb://my-function.zip
```

You should see the following output:

```
{
    "FunctionName": "my-function",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "Runtime": "java8",
    "Role": "arn:aws:iam::123456789012:role/lambda-role",
    "Handler": "example.Handler",
    "CodeSha256": "Qf0hMc1I2di6YFMi9aXm3JtGTmcDbjniEuiYonYptAk=",
    "Version": "$LATEST",
    "TracingConfig": {
        "Mode": "Active"
    },
    "RevisionId": "983ed1e3-ca8e-434b-8dc1-7d72ebadd83d",
    ...
}
```

If your deployment package is larger than 50 MB, you can't upload it directly. Upload it to an Amazon Simple Storage Service (Amazon S3) bucket and point Lambda to the object. The following example commands upload a deployment package to an S3 bucket named `my-bucket` and use it to update a function's code:

```
aws s3 cp my-function.zip s3://my-bucket
```

You should see the following output:

```
upload: my-function.zip to s3://my-bucket/my-function
```

```
aws lambda update-function-code --function-name my-function \
 --s3-bucket my-bucket --s3-key my-function.zip
```

You should see the following output:

```
{
    "FunctionName": "my-function",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "Runtime": "java8",
    "Role": "arn:aws:iam::123456789012:role/lambda-role",
    "Handler": "example.Handler",
    "CodeSha256": "Qf0hMc1I2di6YFMi9aXm3JtGTmcDbjniEuiYonYptAk=",
    "Version": "$LATEST",
    "TracingConfig": {
        "Mode": "Active"
    },
    "RevisionId": "983ed1e3-ca8e-434b-8dc1-7d72ebadd83d",
    ...
}
```

You can use this method to upload function packages up to 250 MB (decompressed).

## Uploading a deployment package with AWS SAM

You can use AWS SAM to automate deployments of your function code, configuration, and dependencies. AWS SAM is an extension of AWS CloudFormation that provides a simplified syntax for defining serverless applications. The following example template defines a function with a deployment package in the `build/distributions` directory that Gradle uses:

**Example template.yml**

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: 'AWS::Serverless-2016-10-31'
Description: An AWS Lambda application that calls the Lambda API.
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      CodeUri: build/distributions/java-basic.zip
      Handler: example.Handler
      Runtime: java8
      Description: Java function
      MemorySize: 512
      Timeout: 10
      # Function's execution role
      Policies:
        - AWSLambdaBasicExecutionRole
        - AWSLambda_ReadOnlyAccess
        - AWSXrayWriteOnlyAccess
        - AWSLambdaVPCAccessExecutionRole
      Tracing: Active
```

To create the function, use the `package` and `deploy` commands. These commands are customizations to the AWS CLI. They wrap other commands to upload the deployment package to Amazon S3, rewrite the template with the object URI, and update the function's code.

The following example script runs a Gradle build and uploads the deployment package that it creates. It creates an AWS CloudFormation stack the first time you run it. If the stack already exists, the script updates it.

**Example deploy.sh**

```
#!/bin/bash
set -eo pipefail
aws cloudformation package --template-file template.yml --s3-bucket MY_BUCKET --output-
template-file out.yml
aws cloudformation deploy --template-file out.yml --stack-name java-basic --capabilities
 CAPABILITY_NAMED_IAM
```

For a complete working example, see the following sample applications:

**Sample Lambda applications in Java**

- java-basic – A collection of minimal Java functions with unit tests and variable logging configuration.
- java-events – A collection of Java functions that contain skeleton code for how to handle events from various services such as Amazon API Gateway, Amazon SQS, and Amazon Kinesis. These functions use the latest version of the aws-lambda-java-events (p. 386) library (3.0.0 and newer). These examples do not require the AWS SDK as a dependency.

- s3-java – A Java function that processes notification events from Amazon S3 and uses the Java Class Library (JCL) to create thumbnails from uploaded image files.
- Use API Gateway to invoke a Lambda function – A Java function that scans a Amazon DynamoDB table that contains employee information. It then uses Amazon Simple Notification Service to send a text message to employees celebrating their work anniversaries. This example uses API Gateway to invoke the function.

# Deploy Java Lambda functions with container images

You can deploy your Lambda function code as a container image (p. 143). AWS provides the following resources to help you build a container image for your Java function:

- AWS base images for Lambda

  These base images are preloaded with a language runtime and other components that are required to run the image on Lambda. AWS provides a Dockerfile for each of the base images to help with building your container image.
- Open-source runtime interface clients (RIC)

  If you use a community or private enterprise base image, you must add a Runtime interface client (p. 145) to the base image to make it compatible with Lambda.
- Open-source runtime interface emulator (RIE)

  Lambda provides a runtime interface emulator for you to test your function locally. The base images for Lambda and base images for custom runtimes include the RIE. For other base images, you can download the RIE for testing your image (p. 146) locally.

The workflow for a function defined as a container image includes these steps:

1. Build your container image using the resources listed in this topic.
2. Upload the image to your Amazon ECR container registry (p. 153).
3. Create (p. 138) the Lambda function or update the function code (p. 141) to deploy the image to an existing function.

**Topics**

- AWS base images for Java (p. 393)
- Using a Java base image (p. 394)
- Java runtime interface clients (p. 394)
- Deploy the container image (p. 394)

## AWS base images for Java

AWS provides the following base images for Java:

| Tags | Runtime | Operating system | Dockerfile | Deprecation |
|---|---|---|---|---|
| 11 | Java 11 | Amazon Linux 2 | Dockerfile for Java 11 on GitHub | |
| 8.al2 | Java 8 | Amazon Linux 2 | Dockerfile for Java 8 on GitHub | |
| 8 | Java 8 | Amazon Linux | Dockerfile for Java 8 on GitHub | |

Amazon ECR repository: gallery.ecr.aws/lambda/java

# Using a Java base image

For instructions on how to use a Java base image, choose the **usage** tab on Lambda base images for Java in the *Amazon ECR repository*.

# Java runtime interface clients

Install the runtime interface client for Java using the Apache Maven package manager. Add the following to your `pom.xml` file:

```
<dependency>
    <groupId>com.amazonaws</groupId>
    <artifactId>aws-lambda-java-runtime-interface-client</artifactId>
    <version>1.0.0</version>
</dependency>
```

For package details, see Lambda RIC in Maven Central Repository.

You can also view the Java client source code in the AWS Lambda Java Support Libraries repository on GitHub.

After your container image resides in the Amazon ECR container registry, you can create and run (p. 136) the Lambda function.

# Deploy the container image

For a new function, you deploy the Java image when you create the function (p. 138). For an existing function, if you rebuild the container image, you need to redeploy the image by updating the function code (p. 141).

# AWS Lambda context object in Java

When Lambda runs your function, it passes a context object to the handler (p. 382). This object provides methods and properties that provide information about the invocation, function, and execution environment.

### Context methods

- `getRemainingTimeInMillis()` – Returns the number of milliseconds left before the execution times out.
- `getFunctionName()` – Returns the name of the Lambda function.
- `getFunctionVersion()` – Returns the version (p. 173) of the function.
- `getInvokedFunctionArn()` – Returns the Amazon Resource Name (ARN) that's used to invoke the function. Indicates if the invoker specified a version number or alias.
- `getMemoryLimitInMB()` – Returns the amount of memory that's allocated for the function.
- `getAwsRequestId()` – Returns the identifier of the invocation request.
- `getLogGroupName()` – Returns the log group for the function.
- `getLogStreamName()` – Returns the log stream for the function instance.
- `getIdentity()` – (mobile apps) Returns information about the Amazon Cognito identity that authorized the request.
- `getClientContext()` – (mobile apps) Returns the client context that's provided to Lambda by the client application.
- `getLogger()` – Returns the logger object (p. 398) for the function.

The following example shows a function that uses the context object to access the Lambda logger.

### Example Handler.java

```
package example;
import com.amazonaws.services.lambda.runtime.Context
import com.amazonaws.services.lambda.runtime.RequestHandler
import com.amazonaws.services.lambda.runtime.LambdaLogger
...

// Handler value: example.Handler
public class Handler implements RequestHandler<Map<String,String>, String>{
  Gson gson = new GsonBuilder().setPrettyPrinting().create();
  @Override
  public String handleRequest(Map<String,String> event, Context context)
  {
    LambdaLogger logger = context.getLogger();
    String response = new String("200 OK");
    // log execution details
    logger.log("ENVIRONMENT VARIABLES: " + gson.toJson(System.getenv()));
    logger.log("CONTEXT: " + gson.toJson(context));
    // process event
    logger.log("EVENT: " + gson.toJson(event));
    logger.log("EVENT TYPE: " + event.getClass().toString());
    return response;
  }
}
```

The function serializes the context object into JSON and records it in its log stream.

### Example log output

```
START RequestId: 6bc28136-xmpl-4365-b021-0ce6b2e64ab0 Version: $LATEST
...
CONTEXT:
{
    "memoryLimit": 512,
    "awsRequestId": "6bc28136-xmpl-4365-b021-0ce6b2e64ab0",
    "functionName": "java-console",
    ...
}
...
END RequestId: 6bc28136-xmpl-4365-b021-0ce6b2e64ab0
REPORT RequestId: 6bc28136-xmpl-4365-b021-0ce6b2e64ab0 Duration: 198.50 ms Billed Duration:
 200 ms Memory Size: 512 MB Max Memory Used: 90 MB Init Duration: 524.75 ms
```

The interface for the context object is available in the aws-lambda-java-core library. You can implement this interface to create a context class for testing. The following example shows a context class that returns dummy values for most properties and a working test logger.

### Example src/test/java/example/TestContext.java

```
package example;

import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.services.lambda.runtime.CognitoIdentity;
import com.amazonaws.services.lambda.runtime.ClientContext;
import com.amazonaws.services.lambda.runtime.LambdaLogger

public class TestContext implements Context{
  public TestContext() {}
  public String getAwsRequestId(){
    return new String("495b12a8-xmpl-4eca-8168-160484189f99");
  }
  public String getLogGroupName(){
    return new String("/aws/lambda/my-function");
  }
  ...
  public LambdaLogger getLogger(){
    return new TestLogger();
  }

}
```

For more information on logging, see AWS Lambda function logging in Java (p. 398).

# Context in sample applications

The GitHub repository for this guide includes sample applications that demonstrate the use of the context object. Each sample application includes scripts for easy deployment and cleanup, an AWS Serverless Application Model (AWS SAM) template, and supporting resources.

### Sample Lambda applications in Java

- java-basic – A collection of minimal Java functions with unit tests and variable logging configuration.
- java-events – A collection of Java functions that contain skeleton code for how to handle events from various services such as Amazon API Gateway, Amazon SQS, and Amazon Kinesis. These functions use the latest version of the aws-lambda-java-events (p. 386) library (3.0.0 and newer). These examples do not require the AWS SDK as a dependency.

- s3-java – A Java function that processes notification events from Amazon S3 and uses the Java Class Library (JCL) to create thumbnails from uploaded image files.
- Use API Gateway to invoke a Lambda function – A Java function that scans a Amazon DynamoDB table that contains employee information. It then uses Amazon Simple Notification Service to send a text message to employees celebrating their work anniversaries. This example uses API Gateway to invoke the function.

All of the sample applications have a test context class for unit tests. The `java-basic` application shows you how to use the context object to get a logger. It uses SLF4J and Log4J 2 to provide a logger that works for local unit tests.

# AWS Lambda function logging in Java

AWS Lambda automatically monitors Lambda functions on your behalf and sends function metrics to Amazon CloudWatch. Your Lambda function comes with a CloudWatch Logs log group and a log stream for each instance of your function. The Lambda runtime environment sends details about each invocation to the log stream, and relays logs and other output from your function's code.

This page describes how to produce log output from your Lambda function's code, or access logs using the AWS Command Line Interface, the Lambda console, or the CloudWatch console.

**Sections**


- Creating a function that returns logs (p. 398)
- Using the Lambda console (p. 399)
- Using the CloudWatch console (p. 399)
- Using the AWS Command Line Interface (AWS CLI) (p. 400)
- Deleting logs (p. 402)
- Advanced logging with Log4j 2 and SLF4J (p. 402)
- Sample logging code (p. 404)


## Creating a function that returns logs

To output logs from your function code, you can use methods on java.lang.System, or any logging module that writes to `stdout` or `stderr`. The aws-lambda-java-core (p. 386) library provides a logger class named `LambdaLogger` that you can access from the context object. The logger class supports multiline logs.

The following example uses the `LambdaLogger` logger provided by the context object.

**Example Handler.java**

```
// Handler value: example.Handler
public class Handler implements RequestHandler<Object, String>{
  Gson gson = new GsonBuilder().setPrettyPrinting().create();
  @Override
  public String handleRequest(Object event, Context context)
  {
    LambdaLogger logger = context.getLogger();
    String response = new String("SUCCESS");
    // log execution details
    logger.log("ENVIRONMENT VARIABLES: " + gson.toJson(System.getenv()));
    logger.log("CONTEXT: " + gson.toJson(context));
    // process event
    logger.log("EVENT: " + gson.toJson(event));
    return response;
  }
}
```

**Example log format**

```
START RequestId: 6bc28136-xmpl-4365-b021-0ce6b2e64ab0 Version: $LATEST
ENVIRONMENT VARIABLES:
{
    "_HANDLER": "example.Handler",
    "AWS_EXECUTION_ENV": "AWS_Lambda_java8",
```

```
    "AWS_LAMBDA_FUNCTION_MEMORY_SIZE": "512",
    ...
}
CONTEXT:
{
    "memoryLimit": 512,
    "awsRequestId": "6bc28136-xmpl-4365-b021-0ce6b2e64ab0",
    "functionName": "java-console",
    ...
}
EVENT:
{
  "records": [
    {
      "messageId": "19dd0b57-xmpl-4ac1-bd88-01bbb068cb78",
      "receiptHandle": "MessageReceiptHandle",
      "body": "Hello from SQS!",
       ...
    }
  ]
}
END RequestId: 6bc28136-xmpl-4365-b021-0ce6b2e64ab0
REPORT RequestId: 6bc28136-xmpl-4365-b021-0ce6b2e64ab0 Duration: 198.50 ms Billed Duration:
 200 ms Memory Size: 512 MB Max Memory Used: 90 MB Init Duration: 524.75 ms
```

The Java runtime logs the `START`, `END`, and `REPORT` lines for each invocation. The report line provides the following details:

**Report Log**

- **RequestId** – The unique request ID for the invocation.
- **Duration** – The amount of time that your function's handler method spent processing the event.
- **Billed Duration** – The amount of time billed for the invocation.
- **Memory Size** – The amount of memory allocated to the function.
- **Max Memory Used** – The amount of memory used by the function.
- **Init Duration** – For the first request served, the amount of time it took the runtime to load the function and run code outside of the handler method.
- **XRAY TraceId** – For traced requests, the AWS X-Ray trace ID (p. 715).
- **SegmentId** – For traced requests, the X-Ray segment ID.
- **Sampled** – For traced requests, the sampling result.

# Using the Lambda console

You can use the Lambda console to view log output after you invoke a Lambda function. For more information, see Accessing Amazon CloudWatch logs for AWS Lambda (p. 730).

# Using the CloudWatch console

You can use the Amazon CloudWatch console to view logs for all Lambda function invocations.

**To view logs on the CloudWatch console**

1. Open the Log groups page on the CloudWatch console.
2. Choose the log group for your function (**/aws/lambda/*your-function-name***).
3. Choose a log stream.

Each log stream corresponds to an instance of your function (p. 100). A log stream appears when you update your Lambda function, and when additional instances are created to handle multiple concurrent invocations. To find logs for a specific invocation, we recommend instrumenting your function with AWS X-Ray. X-Ray records details about the request and the log stream in the trace.

To use a sample application that correlates logs and traces with X-Ray, see Error processor sample application for AWS Lambda (p. 807).

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

You can use the AWS CLI to retrieve logs for an invocation using the `--log-type` command option. The response contains a `LogResult` field that contains up to 4 KB of base64-encoded logs from the invocation.

### Example retrieve a log ID

The following example shows how to retrieve a *log ID* from the `LogResult` field for a function named `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail
```

You should see the following output:

```
{
    "StatusCode": 200,
    "LogResult":
 "U1RBUlQgUmVxdWVzdElkOiA4N2QwNDRiOC1mMTU0LTExZTgtOGNkYS0yOTc0YzVlNGZiMjEgVmVyc2lvb...",
    "ExecutedVersion": "$LATEST"
}
```

### Example decode the logs

In the same command prompt, use the `base64` utility to decode the logs. The following example shows how to retrieve base64-encoded logs for `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail \
--query 'LogResult' --output text |  base64 -d
```

You should see the following output:

```
START RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8 Version: $LATEST
"AWS_SESSION_TOKEN": "AgoJb3JpZ2luX2VjELj...", "_X_AMZN_TRACE_ID": "Root=1-5d02e5ca-
f5792818b6fe8368e5b51d50;Parent=191db58857df8395;Sampled=0"",ask/lib:/opt/lib",
END RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8
REPORT RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8  Duration: 79.67 ms      Billed
 Duration: 80 ms         Memory Size: 128 MB     Max Memory Used: 73 MB
```

The `base64` utility is available on Linux, macOS, and Ubuntu on Windows. macOS users may need to use `base64 -D`.

### Example get-logs.sh script

In the same command prompt, use the following script to download the last five log events. The script uses `sed` to remove quotes from the output file, and sleeps for 15 seconds to allow time for the logs to become available. The output includes the response from Lambda and the output from the `get-log-events` command.

Copy the contents of the following code sample and save in your Lambda project directory as `get-logs.sh`.

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

```
#!/bin/bash
aws lambda invoke --function-name my-function --cli-binary-format raw-in-base64-out --
payload '{"key": "value"}' out
sed -i'' -e 's/"//g' out
sleep 15
aws logs get-log-events --log-group-name /aws/lambda/my-function --log-stream-name stream1
 --limit 5
```

### Example macOS and Linux (only)

In the same command prompt, macOS and Linux users may need to run the following command to ensure the script is executable.

```
chmod -R 755 get-logs.sh
```

### Example retrieve the last five log events

In the same command prompt, run the following script to get the last five log events.

```
./get-logs.sh
```

You should see the following output:

```
{
    "StatusCode": 200,
    "ExecutedVersion": "$LATEST"
}
{
    "events": [
        {
            "timestamp": 1559763003171,
            "message": "START RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf Version:
 $LATEST\n",
            "ingestionTime": 1559763003309
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tENVIRONMENT VARIABLES\r{\r  \"AWS_LAMBDA_FUNCTION_VERSION\": \"$LATEST\",\r ...",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tEVENT\r{\r  \"key\": \"value\"\r}\n",
```

```
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "END RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\n",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "REPORT RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\tDuration:
 26.73 ms\tBilled Duration: 27 ms \tMemory Size: 128 MB\tMax Memory Used: 75 MB\t\n",
            "ingestionTime": 1559763018353
        }
    ],
    "nextForwardToken": "f/34783877304859518393868359594929986069206639495374241795",
    "nextBackwardToken": "b/34783877303811383369537420289090800615709599058929582080"
}
```

# Deleting logs

Log groups aren't deleted automatically when you delete a function. To avoid storing logs indefinitely, delete the log group, or configure a retention period after which logs are deleted automatically.

# Advanced logging with Log4j 2 and SLF4J

> **Note**
> AWS Lambda does not include Log4j2 in its managed runtimes or base container images. These are therefore not affected by the issues described in CVE-2021-44228, CVE-2021-45046, and CVE-2021-45105.
> For cases where a customer function includes an impacted Log4j2 version, we have applied a change to the Lambda Java managed runtimes (p. 82) and base container images (p. 393) that helps to mitigate the issues in CVE-2021-44228, CVE-2021-45046, and CVE-2021-45105. As a result of this change, customers using Log4J2 may see an additional log entry, similar to "`Transforming org/apache/logging/log4j/core/lookup/JndiLookup (java.net.URLClassLoader@...)`". Any log strings that reference the jndi mapper in the Log4J2 output will be replaced with "`Patched JndiLookup::lookup()`".
> Independent of this change, we strongly encourage all customers whose functions include Log4j2 to update to the latest version. Specifically, customers using the aws-lambda-java-log4j2 library in their functions should update to version 1.5.0 (or later), and redeploy their functions. This version updates the underlying Log4j2 utility dependencies to version 2.17.0 (or later). The updated aws-lambda-java-log4j2 binary is available at the Maven repository and its source code is available in Github.

To customize log output, support logging during unit tests, and log AWS SDK calls, use Apache Log4j 2 with SLF4J. Log4j is a logging library for Java programs that enables you to configure log levels and use appender libraries. SLF4J is a facade library that lets you change which library you use without changing your function code.

To add the request ID to your function's logs, use the appender in the aws-lambda-java-log4j2 (p. 386) library. The following example shows a Log4j 2 configuration file that adds a timestamp and request ID to all logs.

**Example src/main/resources/log4j2.xml – Appender configuration**

```
<Configuration status="WARN">
  <Appenders>
    <Lambda name="Lambda">
      <PatternLayout>
```

```
          <pattern>%d{yyyy-MM-dd HH:mm:ss} %X{AWSRequestId} %-5p %c{1} - %m%n</pattern>
      </PatternLayout>
    </Lambda>
  </Appenders>
  <Loggers>
    <Root level="INFO">
      <AppenderRef ref="Lambda"/>
    </Root>
    <Logger name="software.amazon.awssdk" level="WARN" />
    <Logger name="software.amazon.awssdk.request" level="DEBUG" />
  </Loggers>
</Configuration>
```

With this configuration, each line is prepended with the date, time, request ID, log level, and class name.

### Example log format with appender

```
START RequestId: 6bc28136-xmpl-4365-b021-0ce6b2e64ab0 Version: $LATEST
2020-03-18 08:52:43 6bc28136-xmpl-4365-b021-0ce6b2e64ab0 INFO  Handler - ENVIRONMENT
 VARIABLES:
{
    "_HANDLER": "example.Handler",
    "AWS_EXECUTION_ENV": "AWS_Lambda_java8",
    "AWS_LAMBDA_FUNCTION_MEMORY_SIZE": "512",
    ...
}
2020-03-18 08:52:43 6bc28136-xmpl-4365-b021-0ce6b2e64ab0 INFO  Handler - CONTEXT:
{
    "memoryLimit": 512,
    "awsRequestId": "6bc28136-xmpl-4365-b021-0ce6b2e64ab0",
    "functionName": "java-console",
    ...
}
```

SLF4J is a facade library for logging in Java code. In your function code, you use the SLF4J logger factory to retrieve a logger with methods for log levels like `info()` and `warn()`. In your build configuration, you include the logging library and SLF4J adapter in the classpath. By changing the libraries in the build configuration, you can change the logger type without changing your function code. SLF4J is required to capture logs from the SDK for Java.

In the following example, the handler class uses SLF4J to retrieve a logger.

### Example src/main/java/example/HandlerS3.java – Logging with SLF4J

```
import org.slf4j.Logger;
import org.slf4j.LoggerFactory;

// Handler value: example.Handler
public class HandlerS3 implements RequestHandler<S3Event, String>{
    private static final Logger logger = LoggerFactory.getLogger(HandlerS3.class);
    Gson gson = new GsonBuilder().setPrettyPrinting().create();
    @Override
    public String handleRequest(S3Event event, Context context)
    {
        ...
        logger.info("RECORD: " + record);
        logger.info("SOURCE BUCKET: " + srcBucket);
        logger.info("SOURCE KEY: " + srcKey);
        ...
    }
}
```

The build configuration takes runtime dependencies on the Lambda appender and SLF4J adapter, and implementation dependencies on Log4J 2.

**Example build.gradle – Logging dependencies**

```
dependencies {
    ...
    implementation 'org.apache.logging.log4j:log4j-api:[2.17.1,)'
    implementation 'org.apache.logging.log4j:log4j-core:[2.17.1,)'
    implementation 'org.apache.logging.log4j:log4j-slf4j18-impl:[2.17.1,)'
    ...
}
```

When you run your code locally for tests, the context object with the Lambda logger is not available, and there's no request ID for the Lambda appender to use. For example test configurations, see the sample applications in the next section.

# Sample logging code

The GitHub repository for this guide includes sample applications that demonstrate the use of various logging configurations. Each sample application includes scripts for easy deployment and cleanup, an AWS SAM template, and supporting resources.

### Sample Lambda applications in Java

- java-basic – A collection of minimal Java functions with unit tests and variable logging configuration.
- java-events – A collection of Java functions that contain skeleton code for how to handle events from various services such as Amazon API Gateway, Amazon SQS, and Amazon Kinesis. These functions use the latest version of the aws-lambda-java-events (p. 386) library (3.0.0 and newer). These examples do not require the AWS SDK as a dependency.
- s3-java – A Java function that processes notification events from Amazon S3 and uses the Java Class Library (JCL) to create thumbnails from uploaded image files.
- Use API Gateway to invoke a Lambda function – A Java function that scans a Amazon DynamoDB table that contains employee information. It then uses Amazon Simple Notification Service to send a text message to employees celebrating their work anniversaries. This example uses API Gateway to invoke the function.

The `java-basic` sample application shows a minimal logging configuration that supports logging tests. The handler code uses the `LambdaLogger` logger provided by the context object. For tests, the application uses a custom `TestLogger` class that implements the `LambdaLogger` interface with a Log4j 2 logger. It uses SLF4J as a facade for compatibility with the AWS SDK. Logging libraries are excluded from build output to keep the deployment package small.

# AWS Lambda function errors in Java

When your code raises an error, Lambda generates a JSON representation of the error. This error document appears in the invocation log and, for synchronous invocations, in the output.

This page describes how to view Lambda function invocation errors for the Java runtime using the Lambda console and the AWS CLI.

**Sections**


- Syntax (p. 405)
- How it works (p. 406)
- Creating a function that returns exceptions (p. 406)
- Using the Lambda console (p. 407)
- Using the AWS Command Line Interface (AWS CLI) (p. 408)
- Error handling in other AWS services (p. 408)
- Sample applications (p. 409)
- What's next? (p. 409)


## Syntax

In the following example, the runtime fails to deserialize the event into an object. The input is a valid JSON type, but it doesn't match the type expected by the handler method.

**Example Lambda runtime error**

```
{
  "errorMessage": "An error occurred during JSON parsing",
  "errorType": "java.lang.RuntimeException",
  "stackTrace": [],
  "cause": {
    "errorMessage": "com.fasterxml.jackson.databind.exc.InvalidFormatException: Can not
 construct instance of java.lang.Integer from String value '1000,10': not a valid Integer
 value\n at [Source: lambdainternal.util.NativeMemoryAsInputStream@35fc6dc4; line: 1,
 column: 1] (through reference chain: java.lang.Object[0])",
    "errorType": "java.io.UncheckedIOException",
    "stackTrace": [],
    "cause": {
      "errorMessage": "Can not construct instance of java.lang.Integer
 from String value '1000,10': not a valid Integer value\n at [Source:
 lambdainternal.util.NativeMemoryAsInputStream@35fc6dc4; line: 1, column: 1] (through
 reference chain: java.lang.Object[0])",
      "errorType": "com.fasterxml.jackson.databind.exc.InvalidFormatException",
      "stackTrace": [

 "com.fasterxml.jackson.databind.exc.InvalidFormatException.from(InvalidFormatException.java:55)",

 "com.fasterxml.jackson.databind.DeserializationContext.weirdStringException(DeserializationContext.jav
        ...
      ]
    }
  }
}
```

# How it works

When you invoke a Lambda function, Lambda receives the invocation request and validates the permissions in your execution role, verifies that the event document is a valid JSON document, and checks parameter values.

If the request passes validation, Lambda sends the request to a function instance. The Lambda runtime (p. 82) environment converts the event document into an object, and passes it to your function handler.

If Lambda encounters an error, it returns an exception type, message, and HTTP status code that indicates the cause of the error. The client or service that invoked the Lambda function can handle the error programmatically, or pass it along to an end user. The correct error handling behavior depends on the type of application, the audience, and the source of the error.

The following list describes the range of status codes you can receive from Lambda.

**2xx**

A `2xx` series error with a `X-Amz-Function-Error` header in the response indicates a Lambda runtime or function error. A `2xx` series status code indicates that Lambda accepted the request, but instead of an error code, Lambda indicates the error by including the `X-Amz-Function-Error` header in the response.

**4xx**

A `4xx` series error indicates an error that the invoking client or service can fix by modifying the request, requesting permission, or by retrying the request. `4xx` series errors other than `429` generally indicate an error with the request.

**5xx**

A `5xx` series error indicates an issue with Lambda, or an issue with the function's configuration or resources. `5xx` series errors can indicate a temporary condition that can be resolved without any action by the user. These issues can't be addressed by the invoking client or service, but a Lambda function's owner may be able to fix the issue.

For a complete list of invocation errors, see InvokeFunction errors (p. 995).

# Creating a function that returns exceptions

You can create a Lambda function that displays human-readable error messages to users.

**Note**
To test this code, you need to include InputLengthException.java in your project src folder.

**Example src/main/java/example/HandlerDivide.java – Runtime exception**

```
import java.util.List;

  // Handler value: example.HandlerDivide
  public class HandlerDivide implements RequestHandler<List<Integer>, Integer>{
    Gson gson = new GsonBuilder().setPrettyPrinting().create();
    @Override
    public Integer handleRequest(List<Integer> event, Context context)
    {
      LambdaLogger logger = context.getLogger();
      // process event
      if ( event.size() != 2 )
      {
```

```
        throw new InputLengthException("Input must be a list that contains 2 numbers.");
      }
      int numerator = event.get(0);
      int denominator = event.get(1);
      logger.log("EVENT: " + gson.toJson(event));
      logger.log("EVENT TYPE: " + event.getClass().toString());
      return numerator/denominator;
    }
  }
```

When the function throws `InputLengthException`, the Java runtime serializes it into the following document.

**Example error document (whitespace added)**

```
{
    "errorMessage":"Input must be a list that contains 2 numbers.",
    "errorType":"java.lang.InputLengthException",
    "stackTrace": [
      "example.HandlerDivide.handleRequest(HandlerDivide.java:23)",
      "example.HandlerDivide.handleRequest(HandlerDivide.java:14)"
    ]
  }
```

In this example, InputLengthException is a `RuntimeException`. The `RequestHandler` interface (p. 384) does not allow checked exceptions. The `RequestStreamHandler` interface supports throwing `IOException` errors.

The return statement in the previous example can also throw a runtime exception.

```
    return numerator/denominator;
```

This code can return an arithmetic error.

```
{"errorMessage":"/ by zero","errorType":"java.lang.ArithmeticException","stackTrace":
["example.HandlerDivide.handleRequest(HandlerDivide.java:28)","example.HandlerDivide.handleRequest(Hand
```

# Using the Lambda console

You can invoke your function on the Lambda console by configuring a test event and viewing the output. The output is captured in the function's execution logs and, when active tracing (p. 715) is enabled, in AWS X-Ray.

**To invoke a function on the Lambda console**

1. Open the Functions page of the Lambda console.
2. Choose the function to test, and choose **Test**.
3. Under **Test event**, select **New event**.
4. Select a **Template**.
5. For **Name**, enter a name for the test. In the text entry box, enter the JSON test event.
6. Choose **Save changes**.
7. Choose **Test**.

The Lambda console invokes your function synchronously (p. 225) and displays the result. To see the response, logs, and other information, expand the **Details** section.

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

When you invoke a Lambda function in the AWS CLI, the AWS CLI splits the response into two documents. The AWS CLI response is displayed in your command prompt. If an error has occurred, the response contains a `FunctionError` field. The invocation response or error returned by the function is written to an output file. For example, `output.json` or `output.txt`.

The following invoke command example demonstrates how to invoke a function and write the invocation response to an `output.txt` file.

```
aws lambda invoke   \
  --function-name my-function   \
      --cli-binary-format raw-in-base64-out  \
          --payload '{"key1": "value1", "key2": "value2", "key3": "value3"}' output.txt
```

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

You should see the AWS CLI response in your command prompt:

```
{
    "StatusCode": 200,
    "FunctionError": "Unhandled",
    "ExecutedVersion": "$LATEST"
}
```

You should see the function invocation response in the `output.txt` file. In the same command prompt, you can also view the output in your command prompt using:

```
cat output.txt
```

You should see the invocation response in your command prompt.

```
{"errorMessage":"Input must contain 2
 numbers.","errorType":"java.lang.InputLengthException","stackTrace":
 ["example.HandlerDivide.handleRequest(HandlerDivide.java:23)","example.HandlerDivide.handleRequest(Har
```

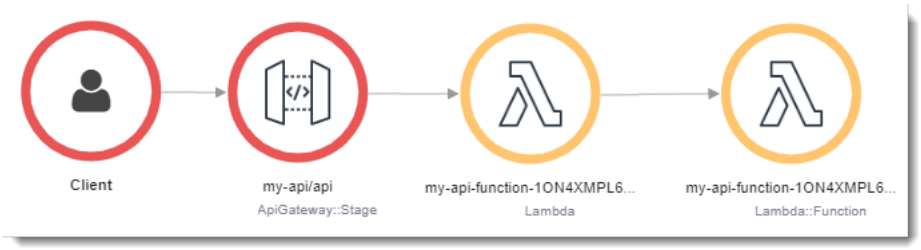
Lambda also records up to 256 KB of the error object in the function's logs. For more information, see AWS Lambda function logging in Java (p. 398).

# Error handling in other AWS services

When another AWS service invokes your function, the service chooses the invocation type and retry behavior. AWS services can invoke your function on a schedule, in response to a lifecycle event on a resource, or to serve a request from a user. Some services invoke functions asynchronously and let Lambda handle errors, while others retry or pass errors back to the user.

For example, API Gateway treats all invocation and function errors as internal errors. If the Lambda API rejects the invocation request, API Gateway returns a `500` error code. If the function runs but returns an error, or returns a response in the wrong format, API Gateway returns a 502 error code. To customize the error response, you must catch errors in your code and format a response in the required format.

We recommend using AWS X-Ray to determine the source of an error and its cause. X-Ray allows you to find out which component encountered an error, and see details about the errors. The following example shows a function error that resulted in a `502` response from API Gateway.




For more information, see Instrumenting Java code in AWS Lambda (p. 410).

# Sample applications

The GitHub repository for this guide includes sample applications that demonstrate the use of the errors. Each sample application includes scripts for easy deployment and cleanup, an AWS Serverless Application Model (AWS SAM) template, and supporting resources.

**Sample Lambda applications in Java**

- java-basic – A collection of minimal Java functions with unit tests and variable logging configuration.
- java-events – A collection of Java functions that contain skeleton code for how to handle events from various services such as Amazon API Gateway, Amazon SQS, and Amazon Kinesis. These functions use the latest version of the aws-lambda-java-events (p. 386) library (3.0.0 and newer). These examples do not require the AWS SDK as a dependency.
- s3-java – A Java function that processes notification events from Amazon S3 and uses the Java Class Library (JCL) to create thumbnails from uploaded image files.
- Use API Gateway to invoke a Lambda function – A Java function that scans a Amazon DynamoDB table that contains employee information. It then uses Amazon Simple Notification Service to send a text message to employees celebrating their work anniversaries. This example uses API Gateway to invoke the function.

The `java-basic` function includes a handler (`HandlerDivide`) that returns a custom runtime exception. The `HandlerStream` handler implements the `RequestStreamHandler` and can throw an `IOException` checked exception.

# What's next?

- Learn how to show logging events for your Lambda function on the the section called "Logging" (p. 398) page.

# Instrumenting Java code in AWS Lambda

Lambda integrates with AWS X-Ray to help you trace, debug, and optimize Lambda applications. You can use X-Ray to trace a request as it traverses resources in your application, which may include Lambda functions and other AWS services.

To send tracing data to X-Ray, you can use one of two SDK libraries:

- AWS Distro for OpenTelemetry (ADOT) – A secure, production-ready, AWS-supported distribution of the OpenTelemetry (OTel) SDK.
- AWS X-Ray SDK for Java – An SDK for generating and sending trace data to X-Ray.

Both ADOT and the X-Ray SDK offer ways to send your telemetry data to the X-Ray service. You can then use X-Ray to view, filter, and gain insights into your application's performance metrics to identify issues and opportunities for optimization.

> **Important**
> **ADOT is the preferred method for instrumenting your Lambda functions**. We recommend using ADOT for all new applications. However, due to the flexibility OpenTelemetry offers, your Lambda function invocations may experience cold start latency increases. If you're optimizing for low-latency and also do not require OpenTelemetry's advanced capabilities such as telemetry correlation and dynamically configurable backend destinations, you may want to use the AWS X-Ray SDK over ADOT.

**Sections**

- Using ADOT to instrument your Java functions (p. 410)
- Using the X-Ray SDK to instrument your Java functions (p. 411)
- Activating tracing with the Lambda console (p. 411)
- Activating tracing with the Lambda API (p. 411)
- Activating tracing with AWS CloudFormation (p. 412)
- Interpreting an X-Ray trace (p. 412)
- Storing runtime dependencies in a layer (X-Ray SDK) (p. 414)
- X-Ray tracing in sample applications (X-Ray SDK) (p. 414)

## Using ADOT to instrument your Java functions

ADOT provides fully managed Lambda layers (p. 14) that package everything you need to collect telemetry data using the OTel SDK. By consuming this layer, you can instrument your Lambda functions without having to modify any function code. You can also configure your layer to do custom initialization of OTel. For more information, see Custom configuration for the ADOT Collector on Lambda in the ADOT documentation.

For Java runtimes, you can choose between two layers to consume:

- **AWS managed Lambda layer for ADOT Java (Auto-instrumentation Agent)** – This layer automatically transforms your function code at startup to collect tracing data. For detailed instructions on how to consume this layer together with the ADOT Java agent, see AWS Distro for OpenTelemetry Lambda Support for Java (Auto-instrumentation Agent) in the ADOT documentation.
- **AWS managed Lambda layer for ADOT Java** – This layer also provides built-in instrumentation for Lambda functions, but it requires a few manual code changes to initialize the OTel SDK. For detailed instructions on how to consume this layer, see AWS Distro for OpenTelemetry Lambda Support for Java in the ADOT documentation.

# Using the X-Ray SDK to instrument your Java functions

To record data about calls that your function makes to other resources and services in your application, you can add the X-Ray SDK for Java to your build configuration. The following example shows a Gradle build configuration that includes the libraries that activate automatic instrumentation of AWS SDK for Java 2.x clients.

**Example build.gradle – Tracing dependencies**

```
dependencies {
    implementation platform('software.amazon.awssdk:bom:2.15.0')
    implementation platform('com.amazonaws:aws-xray-recorder-sdk-bom:2.11.0')
    ...
    implementation 'com.amazonaws:aws-xray-recorder-sdk-core'
    implementation 'com.amazonaws:aws-xray-recorder-sdk-aws-sdk'
    implementation 'com.amazonaws:aws-xray-recorder-sdk-aws-sdk-instrumentor'
    ...
}
```

After you add the correct dependencies and make the necessary code changes, activate tracing in your function's configuration via the Lambda console or the API.

# Activating tracing with the Lambda console

To toggle active tracing on your Lambda function with the console, follow these steps:

**To turn on active tracing**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **Monitoring and operations tools**.
4. Choose **Edit**.
5. Under **X-Ray**, toggle on **Active tracing**.
6. Choose **Save**.

# Activating tracing with the Lambda API

Configure tracing on your Lambda function with the AWS CLI or AWS SDK, use the following API operations:

- UpdateFunctionConfiguration (p. 1098)
- GetFunctionConfiguration (p. 967)
- CreateFunction (p. 904)

The following example AWS CLI command enables active tracing on a function named **my-function**.

```
aws lambda update-function-configuration --function-name my-function \
--tracing-config Mode=Active
```

Tracing mode is part of the version-specific configuration when you publish a version of your function. You can't change the tracing mode on a published version.

# Activating tracing with AWS CloudFormation

To activate tracing on an `AWS::Lambda::Function` resource in an AWS CloudFormation template, use the `TracingConfig` property.

**Example function-inline.yml – Tracing configuration**

```
Resources:
  function:
    Type: AWS::Lambda::Function
    Properties:
      TracingConfig:
        Mode: Active
      ...
```

For an AWS Serverless Application Model (AWS SAM) `AWS::Serverless::Function` resource, use the `Tracing` property.

**Example template.yml – Tracing configuration**

```
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      Tracing: Active
      ...
```

# Interpreting an X-Ray trace

Your function needs permission to upload trace data to X-Ray. When you activate tracing in the Lambda console, Lambda adds the required permissions to your function's execution role (p. 52). Otherwise, add the AWSXRayDaemonWriteAccess policy to the execution role.

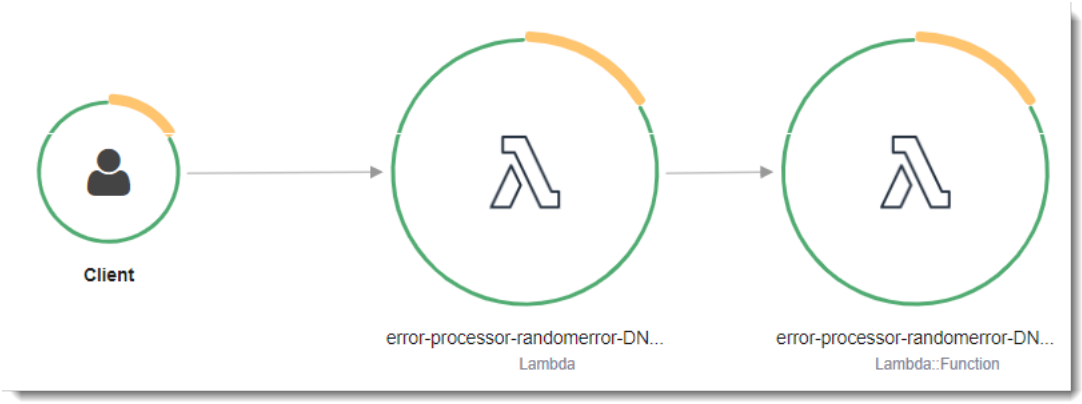
After you've configured active tracing, you can observe specific requests through your application. The X-Ray service graph shows information about your application and all its components. The following example from the error processor (p. 807) sample application shows an application with two functions. The primary function processes events and sometimes returns errors. The second function at the top processes errors that appear in the first's log group and uses the AWS SDK to call X-Ray, Amazon Simple Storage Service (Amazon S3), and Amazon CloudWatch Logs.



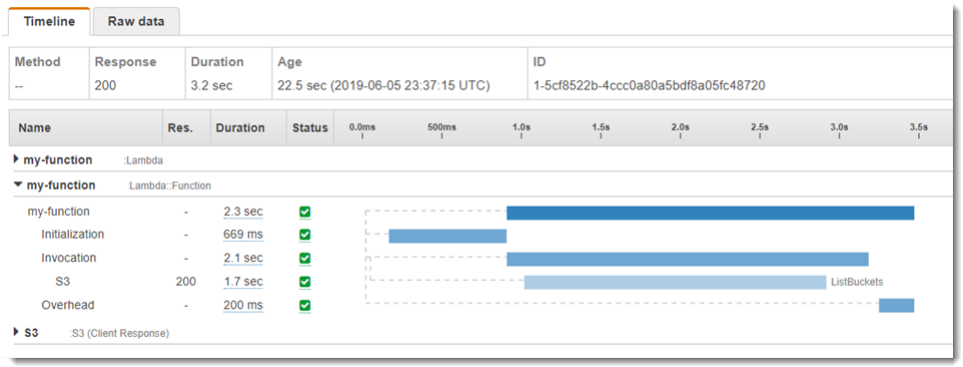
X-Ray doesn't trace all requests to your application. X-Ray applies a sampling algorithm to ensure that tracing is efficient, while still providing a representative sample of all requests. The sampling rate is 1 request per second and 5 percent of additional requests.

> **Note**
> You cannot configure the X-Ray sampling rate for your functions.

When using active tracing, Lambda records 2 segments per trace, which creates two nodes on the service graph. The following image highlights these two nodes for the primary function from the error processor example above.




The first node on the left represents the Lambda service, which receives the invocation request. The second node represents your specific Lambda function. The following example shows a trace with these two segments. Both are named **my-function**, but one has an origin of `AWS::Lambda` and the other has origin `AWS::Lambda::Function`.




This example expands the function segment to show its three subsegments:

- **Initialization** – Represents time spent loading your function and running initialization code (p. 22). This subsegment only appears for the first event that each instance of your function processes.
- **Invocation** – Represents the time spent running your handler code.
- **Overhead** – Represents the time the Lambda runtime spends preparing to handle the next event.

You can also instrument HTTP clients, record SQL queries, and create custom subsegments with annotations and metadata. For more information, see AWS X-Ray SDK for Java in the *AWS X-Ray Developer Guide*.

> **Pricing**
> You can use X-Ray tracing for free each month up to a certain limit as part of the AWS Free Tier. Beyond that threshold, X-Ray charges for trace storage and retrieval. For more information, see AWS X-Ray pricing.

# Storing runtime dependencies in a layer (X-Ray SDK)

If you use the X-Ray SDK to instrument AWS SDK clients your function code, your deployment package can become quite large. To avoid uploading runtime dependencies every time you update your function code, package the X-Ray SDK in a Lambda layer (p. 156).

The following example shows an `AWS::Serverless::LayerVersion` resource that stores the AWS SDK for Java and X-Ray SDK for Java.

**Example template.yml – Dependencies layer**

```
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      CodeUri: build/distributions/blank-java.zip
      Tracing: Active
      Layers:
        - !Ref libs
      ...
  libs:
    Type: AWS::Serverless::LayerVersion
    Properties:
      LayerName: blank-java-lib
      Description: Dependencies for the blank-java sample app.
      ContentUri: build/blank-java-lib.zip
      CompatibleRuntimes:
        - java8
```

With this configuration, you update the library layer only if you change your runtime dependencies. Since the function deployment package contains only your code, this can help reduce upload times.

Creating a layer for dependencies requires build configuration changes to generate the layer archive prior to deployment. For a working example, see the java-basic sample application on GitHub.

# X-Ray tracing in sample applications (X-Ray SDK)

The GitHub repository for this guide includes sample applications that demonstrate the use of X-Ray tracing. Each sample application includes scripts for easy deployment and cleanup, an AWS SAM template, and supporting resources.

### Sample Lambda applications in Java

- java-basic – A collection of minimal Java functions with unit tests and variable logging configuration.
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- s3-java – A Java function that processes notification events from Amazon S3 and uses the Java Class Library (JCL) to create thumbnails from uploaded image files.
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All of the sample applications have active tracing enabled for Lambda functions. For example, the `s3-java` application shows automatic instrumentation of AWS SDK for Java 2.x clients, segment

management for tests, custom subsegments, and the use of Lambda layers to store runtime dependencies.

# Creating a deployment package using Eclipse

This section shows how to package your Java code into a deployment package using Eclipse IDE and Maven plugin for Eclipse.

> **Note**
> The AWS SDK Eclipse Toolkit provides an Eclipse plugin for you to both create a deployment package and also upload it to create a Lambda function. If you can use Eclipse IDE as your development environment, this plugin enables you to author Java code, create and upload a deployment package, and create your Lambda function. For more information, see the AWS Toolkit for Eclipse Getting Started Guide. For an example of using the toolkit for authoring Lambda functions, see Using Lambda with the AWS toolkit for Eclipse.

**Topics**


- Prerequisites (p. 416)
- Create and build a project (p. 416)


## Prerequisites

Install the **Maven** Plugin for Eclipse.

1. Start Eclipse. From the **Help** menu in Eclipse, choose **Install New Software**.
2. In the **Install** window, type **`http://download.eclipse.org/technology/m2e/releases`** in the **Work with:** box, and choose **Add**.
3. Follow the steps to complete the setup.

## Create and build a project

In this step, you start Eclipse and create a Maven project. You will add the necessary dependencies, and build the project. The build will produce a .jar, which is your deployment package.

1. Create a new Maven project in Eclipse.

   a. From the **File** menu, choose **New**, and then choose **Project**.
   b. In the **New Project** window, choose **Maven Project**.
   c. In the **New Maven Project** window, choose **Create a simple project**, and leave other default selections.
   d. In the **New Maven Project**, **Configure project** windows, type the following **Artifact** information:

      - **Group Id**: doc-examples
      - **Artifact Id**: lambda-java-example
      - **Version**: 0.0.1-SNAPSHOT
      - **Packaging**: jar
      - **Name**: lambda-java-example
2. Add the `aws-lambda-java-core` dependency to the `pom.xml` file.

   It provides definitions of the `RequestHandler`, `RequestStreamHandler`, and `Context` interfaces. This allows you to compile code that you can use with AWS Lambda.

   a. Open the context (right-click) menu for the `pom.xml` file, choose **Maven**, and then choose **Add Dependency**.
   b. In the **Add Dependency** windows, type the following values:

**Group Id:** com.amazonaws

**Artifact Id:** aws-lambda-java-core

**Version:** 1.2.1

> **Note**
> If you are following other tutorial topics in this guide, the specific tutorials might require you to add more dependencies. Make sure to add those dependencies as required.

3. Add Java class to the project.

   a. Open the context (right-click) menu for the `src/main/java` subdirectory in the project, choose **New**, and then choose **Class**.

   b. In the **New Java Class** window, type the following values:

   - **Package**: **`example`**
   - **Name**: **`Hello`**

   > **Note**
   > If you are following other tutorial topics in this guide, the specific tutorials might recommend different package name or class name.

   c. Add your Java code. If you are following other tutorial topics in this guide, add the provided code.

4. Build the project.

   Open the context (right-click) menu for the project in **Package Explorer**, choose **Run As**, and then choose **Maven Build ...**. In the **Edit Configuration** window, type **`package`** in the **Goals** box.

   > **Note**
   > The resulting .jar, `lambda-java-example-0.0.1-SNAPSHOT.jar`, is not the final standalone .jar that you can use as your deployment package. In the next step, you add the Apache `maven-shade-plugin` to create the standalone .jar. For more information, go to Apache Maven Shade plugin.

5. Add the `maven-shade-plugin` plugin and rebuild.

   The maven-shade-plugin will take artifacts (jars) produced by the *package* goal (produces customer code .jar), and created a standalone .jar that contains the compiled customer code, and the resolved dependencies from the `pom.xml`.

   a. Open the context (right-click) menu for the `pom.xml` file, choose **Maven**, and then choose **Add Plugin**.

   b. In the **Add Plugin** window, type the following values:

   - **Group Id:** org.apache.maven.plugins
   - **Artifact Id:** maven-shade-plugin
   - **Version:** 3.2.2

   c. Now build again.

   This time we will create the jar as before, and then use the `maven-shade-plugin` to pull in dependencies to make the standalone .jar.

   i. Open the context (right-click) menu for the project, choose **Run As**, and then choose **Maven build ...**.

ii. In the **Edit Configuration** windows, type **`package shade:shade`** in the **Goals** box.

iii. Choose `Run`.

You can find the resulting standalone .jar (that is, your deployment package), in the `/target` subdirectory.

Open the context (right-click) menu for the `/target` subdirectory, choose **Show In**, choose **System Explorer**, and you will find the `lambda-java-example-0.0.1-SNAPSHOT.jar`.

# Java sample applications for AWS Lambda

The GitHub repository for this guide provides sample applications that demonstrate the use of Java in AWS Lambda. Each sample application includes scripts for easy deployment and cleanup, an AWS CloudFormation template, and supporting resources.

### Sample Lambda applications in Java

- java-basic – A collection of minimal Java functions with unit tests and variable logging configuration.
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- s3-java – A Java function that processes notification events from Amazon S3 and uses the Java Class Library (JCL) to create thumbnails from uploaded image files.
- Use API Gateway to invoke a Lambda function – A Java function that scans a Amazon DynamoDB table that contains employee information. It then uses Amazon Simple Notification Service to send a text message to employees celebrating their work anniversaries. This example uses API Gateway to invoke the function.

If you're new to Lambda functions in Java, start with the `java-basic` examples. To get started with Lambda event sources, see the `java-events` examples. Both of these example sets show the use of Lambda's Java libraries, environment variables, the AWS SDK, and the AWS X-Ray SDK. Each example uses a Lambda layer to package its dependencies separately from the function code, which speeds up deployment times. These examples require minimal setup and you can deploy them from the command line in less than a minute.

# Building Lambda functions with Go

The following sections explain how common programming patterns and core concepts apply when authoring Lambda function code in Go.

**Go**

| Name | Identifier | Operating system | Architectures | Deprecation |
|---|---|---|---|---|
| Go 1.x | `go1.x` | Amazon Linux | x86_64 | |

> **Note**
> Runtimes that use the Amazon Linux operating system, such as Go 1.x, do not support the arm64 architecture. To use arm64 architecture, you can run Go with the provided.al2 runtime.

Lambda provides the following tools and libraries for the Go runtime:

### Tools and libraries for Go

- AWS SDK for Go: the official AWS SDK for the Go programming language.
- github.com/aws/aws-lambda-go/lambda: The implementation of the Lambda programming model for Go. This package is used by AWS Lambda to invoke your handler (p. 421).
- github.com/aws/aws-lambda-go/lambdacontext: Helpers for accessing context information from the context object (p. 425).
- github.com/aws/aws-lambda-go/events: This library provides type definitions for common event source integrations.
- github.com/aws/aws-lambda-go/cmd/build-lambda-zip: This tool can be used to create a .zip file archive on Windows.

For more information, see aws-lambda-go on GitHub.

Lambda provides the following sample applications for the Go runtime:

### Sample Lambda applications in Go

- blank-go – A Go function that shows the use of Lambda's Go libraries, logging, environment variables, and the AWS SDK.

**Topics**


- AWS Lambda function handler in Go (p. 421)
- AWS Lambda context object in Go (p. 425)
- Deploy Go Lambda functions with .zip file archives (p. 427)
- Deploy Go Lambda functions with container images (p. 431)
- AWS Lambda function logging in Go (p. 435)
- AWS Lambda function errors in Go (p. 440)
- Instrumenting Go code in AWS Lambda (p. 444)
- Using environment variables (p. 448)

# AWS Lambda function handler in Go

The Lambda function *handler* is the method in your function code that processes events. When your function is invoked, Lambda runs the handler method. When the handler exits or returns a response, it becomes available to handle another event.

A Lambda function written in Go is authored as a Go executable. In your Lambda function code, you need to include the github.com/aws/aws-lambda-go/lambda package, which implements the Lambda programming model for Go. In addition, you need to implement handler function code and a `main()` function.

```
package main

import (
        "fmt"
        "context"
        "github.com/aws/aws-lambda-go/lambda"
)

type MyEvent struct {
        Name string `json:"name"`
}

func HandleRequest(ctx context.Context, name MyEvent) (string, error) {
        return fmt.Sprintf("Hello %s!", name.Name ), nil
}

func main() {
        lambda.Start(HandleRequest)
}
```

Note the following:

- **package main**: In Go, the package containing `func main()` must always be named `main`.
- **import**: Use this to include the libraries your Lambda function requires. In this instance, it includes:
  - **context:** AWS Lambda context object in Go (p. 425).
  - **fmt:** The Go Formatting object used to format the return value of your function.
  - **github.com/aws/aws-lambda-go/lambda:** As mentioned previously, implements the Lambda programming model for Go.
- **func HandleRequest(ctx context.Context, name MyEvent) (string, error)**: This is your Lambda handler signature and includes the code which will be executed. In addition, the parameters included denote the following:
  - **ctx context.Context**: Provides runtime information for your Lambda function invocation. `ctx` is the variable you declare to leverage the information available via AWS Lambda context object in Go (p. 425).
  - **name MyEvent**: An input type with a variable name of `name` whose value will be returned in the `return` statement.
  - **string, error**: Returns two values: string for success and standard error information. For more information on custom error handling, see AWS Lambda function errors in Go (p. 440).
  - **return fmt.Sprintf("Hello %s!", name), nil**: Simply returns a formatted "Hello" greeting with the name you supplied in the input event. `nil` indicates there were no errors and the function executed successfully.
- **func main()**: The entry point that runs your Lambda function code. This is required.

By adding `lambda.Start(HandleRequest)` between `func main(){}` code brackets, your Lambda function will be executed. Per Go language standards, the opening bracket, `{` must be placed directly at end the of the `main` function signature.

# Lambda function handler using structured types

In the example above, the input type was a simple string. But you can also pass in structured events to your function handler:

```
package main

import (
        "fmt"
        "github.com/aws/aws-lambda-go/lambda"
)

type MyEvent struct {
        Name string `json:"What is your name?"`
        Age int     `json:"How old are you?"`
}

type MyResponse struct {
        Message string `json:"Answer:"`
}

func HandleLambdaEvent(event MyEvent) (MyResponse, error) {
        return MyResponse{Message: fmt.Sprintf("%s is %d years old!", event.Name,
 event.Age)}, nil
}

func main() {
        lambda.Start(HandleLambdaEvent)
}
```

Your request would then look like this:

```

# request
{
    "What is your name?": "Jim",
    "How old are you?": 33
}
```

And the response would look like this:

```

# response
{
    "Answer": "Jim is 33 years old!"
}
```

To be exported, field names in the event struct must be capitalized. For more information on handling events from AWS event sources, see aws-lambda-go/events.

## Valid handler signatures

You have several options when building a Lambda function handler in Go, but you must adhere to the following rules:

- The handler must be a function.
- The handler may take between 0 and 2 arguments. If there are two arguments, the first argument must implement `context.Context`.
- The handler may return between 0 and 2 arguments. If there is a single return value, it must implement `error`. If there are two return values, the second value must implement `error`. For more information on implementing error-handling information, see AWS Lambda function errors in Go (p. 440).

The following lists valid handler signatures. `TIn` and `TOut` represent types compatible with the *encoding/json* standard library. For more information, see func Unmarshal to learn how these types are deserialized.

- `func ()`
- `func () error`
- `func (TIn) error`
- `func () (TOut, error)`
- `func (context.Context) error`
- `func (context.Context, TIn) error`
- `func (context.Context) (TOut, error)`
- `func (context.Context, TIn) (TOut, error)`

# Using global state

You can declare and modify global variables that are independent of your Lambda function's handler code. In addition, your handler may declare an `init` function that is executed when your handler is loaded. This behaves the same in AWS Lambda as it does in standard Go programs. A single instance of your Lambda function will never handle multiple events simultaneously.

```
package main

import (
        "log"
        "github.com/aws/aws-lambda-go/lambda"
        "github.com/aws/aws-sdk-go/aws/session"
        "github.com/aws/aws-sdk-go/service/s3"
        "github.com/aws/aws-sdk-go/aws"
)

var invokeCount = 0
var myObjects []*s3.Object
func init() {
        svc := s3.New(session.New())
        input := &s3.ListObjectsV2Input{
                Bucket: aws.String("examplebucket"),
        }
        result, _ := svc.ListObjectsV2(input)
        myObjects = result.Contents
```

```
}

func LambdaHandler() (int, error) {
        invokeCount = invokeCount + 1
        log.Print(myObjects)
        return invokeCount, nil
}

func main() {
        lambda.Start(LambdaHandler)
}
```

# AWS Lambda context object in Go

When Lambda runs your function, it passes a context object to the handler (p. 421). This object provides methods and properties with information about the invocation, function, and execution environment.

The Lambda context library provides the following global variables, methods, and properties.

### Global variables

- `FunctionName` – The name of the Lambda function.
- `FunctionVersion` – The version (p. 173) of the function.
- `MemoryLimitInMB` – The amount of memory that's allocated for the function.
- `LogGroupName` – The log group for the function.
- `LogStreamName` – The log stream for the function instance.

### Context methods

- `Deadline` – Returns the date that the execution times out, in Unix time milliseconds.

### Context properties

- `InvokedFunctionArn` – The Amazon Resource Name (ARN) that's used to invoke the function. Indicates if the invoker specified a version number or alias.
- `AwsRequestID` – The identifier of the invocation request.
- `Identity` – (mobile apps) Information about the Amazon Cognito identity that authorized the request.
- `ClientContext` – (mobile apps) Client context that's provided to Lambda by the client application.

## Accessing invoke context information

Lambda functions have access to metadata about their environment and the invocation request. This can be accessed at Package context. Should your handler include `context.Context` as a parameter, Lambda will insert information about your function into the context's `Value` property. Note that you need to import the `lambdacontext` library to access the contents of the `context.Context` object.

```
package main

import (
        "context"
        "log"
        "github.com/aws/aws-lambda-go/lambda"
        "github.com/aws/aws-lambda-go/lambdacontext"
)

func CognitoHandler(ctx context.Context) {
        lc, _ := lambdacontext.FromContext(ctx)
        log.Print(lc.Identity.CognitoIdentityPoolID)
}

func main() {
        lambda.Start(CognitoHandler)
}
```

In the example above, `lc` is the variable used to consume the information that the context object captured and `log.Print(lc.Identity.CognitoIdentityPoolID)` prints that information, in this case, the CognitoIdentityPoolID.

The following example introduces how to use the context object to monitor how long your Lambda function takes to complete. This allows you to analyze performance expectations and adjust your function code accordingly, if needed.

```
package main

import (
        "context"
        "log"
        "time"
        "github.com/aws/aws-lambda-go/lambda"
)

func LongRunningHandler(ctx context.Context) (string, error) {

        deadline, _ := ctx.Deadline()
        deadline = deadline.Add(-100 * time.Millisecond)
        timeoutChannel := time.After(time.Until(deadline))

        for {

                select {

                case <- timeoutChannel:
                        return "Finished before timing out.", nil

                default:
                        log.Print("hello!")
                        time.Sleep(50 * time.Millisecond)
                }
        }
}

func main() {
        lambda.Start(LongRunningHandler)
}
```

# Deploy Go Lambda functions with .zip file archives

Your AWS Lambda function's code consists of scripts or compiled programs and their dependencies. You use a *deployment package* to deploy your function code to Lambda. Lambda supports two types of deployment packages: container images and .zip file archives.

This page describes how to create a .zip file as your deployment package for the Go runtime, and then use the .zip file to deploy your function code to AWS Lambda using the AWS Command Line Interface (AWS CLI).

**Sections**


- Prerequisites (p. 427)
- Tools and libraries (p. 427)
- Sample applications (p. 427)
- Creating a .zip file on macOS and Linux (p. 428)
- Creating a .zip file on Windows (p. 428)
- Build Go with the provided.al2 runtime (p. 429)


## Prerequisites

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

## Tools and libraries

Lambda provides the following tools and libraries for the Go runtime:

**Tools and libraries for Go**

- AWS SDK for Go: the official AWS SDK for the Go programming language.
- github.com/aws/aws-lambda-go/lambda: The implementation of the Lambda programming model for Go. This package is used by AWS Lambda to invoke your handler (p. 421).
- github.com/aws/aws-lambda-go/lambdacontext: Helpers for accessing context information from the context object (p. 425).
- github.com/aws/aws-lambda-go/events: This library provides type definitions for common event source integrations.
- github.com/aws/aws-lambda-go/cmd/build-lambda-zip: This tool can be used to create a .zip file archive on Windows.

For more information, see aws-lambda-go on GitHub.

## Sample applications

Lambda provides the following sample applications for the Go runtime:

### Sample Lambda applications in Go

- blank-go – A Go function that shows the use of Lambda's Go libraries, logging, environment variables, and the AWS SDK.

# Creating a .zip file on macOS and Linux

The following steps demonstrate how to download the lambda library from GitHub with `go get`, and compile your executable with go build.

1. Download the **lambda** library from GitHub.

```
go get github.com/aws/aws-lambda-go/lambda
```

2. Compile your executable.

```
GOOS=linux go build main.go
```

   Setting `GOOS` to `linux` ensures that the compiled executable is compatible with the Go runtime (p. 82), even if you compile it in a non-Linux environment.

3. (Optional) If your `main` package consists of multiple files, use the following go build command to compile the package:

```
GOOS=linux go build main
```

4. (Optional) You may need to compile packages with `CGO_ENABLED=0` set on Linux:

```
GOOS=linux CGO_ENABLED=0 go build main.go
```

   This command creates a stable binary package for standard C library (`libc`) versions, which may be different on Lambda and other devices.

5. Lambda uses POSIX file permissions, so you may need to set permissions for the deployment package folder before you create the .zip file archive.
6. Create a deployment package by packaging the executable in a .zip file.

```
zip function.zip main
```

7. To upload the package to a Lambda function, use the `update-function-code` command.

```
aws lambda update-function-code --function-name my-function --zip-file
 fileb://function.zip
```

# Creating a .zip file on Windows

The following steps demonstrate how to download the build-lambda-zip tool for Windows from GitHub with `go get`, and compile your executable with go build.

> **Note**
> If you have not already done so, you must install git and then add the `git` executable to your Windows `%PATH%` environment variable.

1. Download the **build-lambda-zip** tool from GitHub:

```
go.exe get -u github.com/aws/aws-lambda-go/cmd/build-lambda-zip
```

2. Use the tool from your `GOPATH` to create a .zip file. If you have a default installation of Go, the tool is typically in `%USERPROFILE%\Go\bin`. Otherwise, navigate to where you installed the Go runtime and do one of the following:

   cmd.exe

   In cmd.exe, run the following:

   ```
   set GOOS=linux
   go build -o main main.go
   %USERPROFILE%\Go\bin\build-lambda-zip.exe -output main.zip main
   ```

   PowerShell

   In PowerShell, run the following:

   ```
   $env:GOOS = "linux"
   $env:CGO_ENABLED = "0"
   $env:GOARCH = "amd64"
   go build -o main main.go
   ~\Go\Bin\build-lambda-zip.exe -output main.zip main
   ```

3. To upload the package to a Lambda function, use the `update-function-code` command.

```
aws lambda update-function-code --function-name my-function --zip-file fileb://main.zip
```

# Build Go with the provided.al2 runtime

Go is implemented differently than other native runtimes. Lambda treats Go as a custom runtime, so you can create a Go function on the provided.al2 runtime. You can use the AWS SAM build command to build the .zip file package.

### Using AWS SAM to build Go for AL2 function

1. Update the AWS SAM template to use the provided.al2 runtime. Also set the BuildMethod to makefile.

   ```
   Resources:
     HelloWorldFunction:
       Type: AWS::Serverless::Function
       Properties:
         CodeUri: hello-world/
         Handler: my.bootstrap.file
         Runtime: provided.al2
         Architectures: [arm64]
       Metadata:
         BuildMethod: makefile
   ```

   Remove the `Architectures` property to build the package for the x86_64 instruction set architecture.

2. Add file makefile to the project folder, with the following contents:

```
GOOS=linux go build -o bootstrap
 cp ./bootstrap $(ARTIFACTS_DIR)/.
```

For an example application, download Go on AL2. The readme file contains the instructions to build and run the application. You can also view the blog post Migrating AWS Lambda functions to Amazon Linux 2.

# Deploy Go Lambda functions with container images

You can deploy your Lambda function code as a container image (p. 143). AWS provides the following resources to help you build a container image for your Go function:

- AWS base images for Lambda

  These base images are preloaded with a language runtime and other components that are required to run the image on Lambda. AWS provides a Dockerfile for each of the base images to help with building your container image.
- Open-source runtime interface clients (RIC)

  If you use a community or private enterprise base image, you must add a Runtime interface client (p. 145) to the base image to make it compatible with Lambda.
- Open-source runtime interface emulator (RIE)

  Lambda provides a runtime interface emulator for you to test your function locally. The base images for Lambda and base images for custom runtimes include the RIE. For other base images, you can download the RIE for testing your image (p. 146) locally.

The workflow for a function defined as a container image includes these steps:

1. Build your container image using the resources listed in this topic.
2. Upload the image to your Amazon ECR container registry (p. 153).
3. Create (p. 138) the Lambda function or update the function code (p. 141) to deploy the image to an existing function.

**Topics**

- AWS base images for Go (p. 431)
- Go runtime interface clients (p. 432)
- Using the Go:1.x base image (p. 432)
- Create a Go image from the provided.al2 base image (p. 432)
- Create a Go image from an alternative base image (p. 433)
- Deploy the container image (p. 434)

## AWS base images for Go

AWS provides the following base image for Go:

| Tags | Runtime | Operating system | Dockerfile | Deprecation |
|---|---|---|---|---|
| 1 | Go 1.x | Amazon Linux | Dockerfile for Go 1.x on GitHub | |

Amazon ECR repository: gallery.ecr.aws/lambda/go

# Go runtime interface clients

AWS does not provide a separate runtime interface client for Go. The `aws-lambda-go/lambda` package includes an implementation of the runtime interface.

# Using the Go:1.x base image

For instructions on how to use the base image for Go:1.x, choose the **usage** tab on Lambda base images for Go in the *Amazon ECR repository*.

# Create a Go image from the `provided.al2` base image

To build a container image for Go that runs on Amazon Linux 2, use the `provided.al2` base image. For more information about this base image, see provided in the Amazon ECR public gallery.

You include the `aws-lambda-go/lambda` package with your Go handler. This package implements the programming model for Go, including the runtime interface client. The `provided.al2` base image also includes the runtime interface emulator.

**To build and deploy a Go function with the `provided.al2` base image.**

Note that the first three steps are identical whether you deploy your function as a .zip file archive or as a container image.

1. On your local machine, create a project directory for your new function.
2. From your project folder, run the following command to install the required Lambda Go libraries.

   ```
   go get github.com/aws/aws-lambda-go
   ```

   For a description of the Lambda Go libraries libraries, see Building Lambda functions with Go (p. 420).
3. Create your Go handler code (p. 421) and include the `aws-lambda-go/lambda` package.
4. Use a text editor to create a Dockerfile in your project directory. The following example Dockerfile uses the AWS `provided.al2` base image.

   ```
   FROM public.ecr.aws/lambda/provided:al2 as build
   # install compiler
   RUN yum install -y golang
   RUN go env -w GOPROXY=direct
   # cache dependencies
   ADD go.mod go.sum ./
   RUN go mod download
   # build
   ADD . .
   RUN go build -o /main
   # copy artifacts to a clean image
   FROM public.ecr.aws/lambda/provided:al2
   COPY --from=build /main /main
   ENTRYPOINT [ "/main" ]
   ```
5. Build your Docker image with the `docker build` command. Enter a name for the image. The following example names the image `hello-world`.

   ```
   docker build -t hello-world .
   ```

6. Authenticate the Docker CLI to your Amazon ECR registry.

```
aws ecr get-login-password --region us-east-1 | docker login --username AWS --password-
stdin 123456789012.dkr.ecr.us-east-1.amazonaws.com
```

7. Tag your image to match your repository name, and deploy the image to Amazon ECR using the `docker push` command.

```
docker tag  hello-world:latest 123456789012.dkr.ecr.us-east-1.amazonaws.com/hello-
world:latest
docker push 123456789012.dkr.ecr.us-east-1.amazonaws.com/hello-world:latest
```

Now that your container image resides in the Amazon ECR container registry, you can create (p. 136) the Lambda function and deploy the image.

# Create a Go image from an alternative base image

You can build a container image for Go from an alternative base image. The following example Dockerfile uses alpine as the base image.

```
FROM alpine as build
# install build tools
RUN apk add go git
RUN go env -w GOPROXY=direct
# cache dependencies
ADD go.mod go.sum ./
RUN go mod download
# build
ADD . .
RUN go build -o /main
# copy artifacts to a clean image
FROM alpine
COPY --from=build /main /main
ENTRYPOINT [ "/main" ]
```

The steps are the same as described for a `provided.al2` base image, with one additional consideration: if you want to add the RIE to your image, you need to follow these additional steps before you run the `docker build` command. For more information about testing your image locally with the RIE, see the section called “Testing images” (p. 146).

**To add RIE to the image**

1. In your Dockerfile, replace the ENTRYPOINT instruction with the following content:

```
# (Optional) Add Lambda Runtime Interface Emulator and use a script in the ENTRYPOINT
 for simpler local runs
ADD https://github.com/aws/aws-lambda-runtime-interface-emulator/releases/latest/
download/aws-lambda-rie /usr/bin/aws-lambda-rie
RUN chmod 755 /usr/bin/aws-lambda-rie
COPY entry.sh /
RUN chmod 755 /entry.sh
ENTRYPOINT [ "/entry.sh" ]
```

2. Use a text editor to create file `entry.sh` in your project directory, containing the following content:

```
#!/bin/sh
if [ -z "${AWS_LAMBDA_RUNTIME_API}" ]; then
  exec /usr/bin/aws-lambda-rie "$@"
```

```
else
  exec "$@"
fi
```

If you do not want to add the RIE to your image, you can test your image locally without adding RIE to the image.

**To test locally without adding RIE to the image**

1. From your project directory, run the following command to download the RIE from GitHub and install it on your local machine.

   ```
   mkdir -p ~/.aws-lambda-rie && curl -Lo ~/.aws-lambda-rie/aws-lambda-rie \
   https://github.com/aws/aws-lambda-runtime-interface-emulator/releases/latest/download/
   aws-lambda-rie \
   && chmod +x ~/.aws-lambda-rie/aws-lambda-rie
   ```

2. Run your Lambda image function using the `docker run` command. In the following example, `/main` is the path to the function entry point.

   ```
   docker run -d -v ~/.aws-lambda-rie:/aws-lambda --entrypoint /aws-lambda/aws-lambda-rie
    -p 9000:8080 myfunction:latest /main
   ```

   This runs the image as a container and starts up an endpoint locally at `localhost:9000/2015-03-31/functions/function/invocations`.

3. Post an event to the following endpoint using a `curl` command:

   ```
   curl -XPOST "http://localhost:9000/2015-03-31/functions/function/invocations" -d '{}'
   ```

   This command invokes the function running in the container image and returns a response.

Now that your container image resides in the Amazon ECR container registry, you can you can create (p. 136) the Lambda function and deploy the image.

# Deploy the container image

For a new function, you deploy the Go image when you create the function (p. 138). For an existing function, if you rebuild the container image, you need to redeploy the image by updating the function code (p. 141).

# AWS Lambda function logging in Go

AWS Lambda automatically monitors Lambda functions on your behalf and sends function metrics to Amazon CloudWatch. Your Lambda function comes with a CloudWatch Logs log group and a log stream for each instance of your function. The Lambda runtime environment sends details about each invocation to the log stream, and relays logs and other output from your function's code.

This page describes how to produce log output from your Lambda function's code, or access logs using the AWS Command Line Interface, the Lambda console, or the CloudWatch console.

**Sections**


- Creating a function that returns logs (p. 435)
- Using the Lambda console (p. 436)
- Using the CloudWatch console (p. 436)
- Using the AWS Command Line Interface (AWS CLI) (p. 436)
- Deleting logs (p. 439)


## Creating a function that returns logs

To output logs from your function code, you can use methods on the fmt package, or any logging library that writes to `stdout` or `stderr`. The following example uses the log package.

**Example main.go – Logging**

```
func handleRequest(ctx context.Context, event events.SQSEvent) (string, error) {
  // event
  eventJson, _ := json.MarshalIndent(event, "", "  ")
  log.Printf("EVENT: %s", eventJson)
  // environment variables
  log.Printf("REGION: %s", os.Getenv("AWS_REGION"))
  log.Println("ALL ENV VARS:")
  for _, element := range os.Environ() {
    log.Println(element)
  }
```

**Example log format**

```
START RequestId: dbda340c-xmpl-4031-8810-11bb609b4c71 Version: $LATEST
2020/03/27 03:40:05 EVENT: {
  "Records": [
    {
      "messageId": "19dd0b57-b21e-4ac1-bd88-01bbb068cb78",
      "receiptHandle": "MessageReceiptHandle",
      "body": "Hello from SQS!",
      "md5OfBody": "7b27xmplb47ff90a553787216d55d91d",
      "md5OfMessageAttributes": "",
      "attributes": {
        "ApproximateFirstReceiveTimestamp": "1523232000001",
        "ApproximateReceiveCount": "1",
        "SenderId": "123456789012",
        "SentTimestamp": "1523232000000"
      },
      ...
2020/03/27 03:40:05 AWS_LAMBDA_LOG_STREAM_NAME=2020/03/27/
[$LATEST]569cxmplc3c34c7489e6a97ad08b4419
2020/03/27 03:40:05 AWS_LAMBDA_FUNCTION_NAME=blank-go-function-9DV3XMPL6XBC
```

```
2020/03/27 03:40:05 AWS_LAMBDA_FUNCTION_MEMORY_SIZE=128
2020/03/27 03:40:05 AWS_LAMBDA_FUNCTION_VERSION=$LATEST
2020/03/27 03:40:05 AWS_EXECUTION_ENV=AWS_Lambda_go1.x
END RequestId: dbda340c-xmpl-4031-8810-11bb609b4c71
REPORT RequestId: dbda340c-xmpl-4031-8810-11bb609b4c71 Duration: 38.66 ms Billed Duration:
 39 ms Memory Size: 128 MB Max Memory Used: 54 MB Init Duration: 203.69 ms
XRAY TraceId: 1-5e7d7595-212fxmpl9ee07c4884191322 SegmentId: 42ffxmpl0645f474 Sampled: true
```

The Go runtime logs the `START`, `END`, and `REPORT` lines for each invocation. The report line provides the following details.

**Report Log**

- **RequestId** – The unique request ID for the invocation.
- **Duration** – The amount of time that your function's handler method spent processing the event.
- **Billed Duration** – The amount of time billed for the invocation.
- **Memory Size** – The amount of memory allocated to the function.
- **Max Memory Used** – The amount of memory used by the function.
- **Init Duration** – For the first request served, the amount of time it took the runtime to load the function and run code outside of the handler method.
- **XRAY TraceId** – For traced requests, the AWS X-Ray trace ID (p. 715).
- **SegmentId** – For traced requests, the X-Ray segment ID.
- **Sampled** – For traced requests, the sampling result.

# Using the Lambda console

You can use the Lambda console to view log output after you invoke a Lambda function. For more information, see Accessing Amazon CloudWatch logs for AWS Lambda (p. 730).

# Using the CloudWatch console

You can use the Amazon CloudWatch console to view logs for all Lambda function invocations.

**To view logs on the CloudWatch console**

1. Open the Log groups page on the CloudWatch console.
2. Choose the log group for your function (**/aws/lambda/*your-function-name***).
3. Choose a log stream.

Each log stream corresponds to an instance of your function (p. 100). A log stream appears when you update your Lambda function, and when additional instances are created to handle multiple concurrent invocations. To find logs for a specific invocation, we recommend instrumenting your function with AWS X-Ray. X-Ray records details about the request and the log stream in the trace.

To use a sample application that correlates logs and traces with X-Ray, see Error processor sample application for AWS Lambda (p. 807).

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2

- AWS CLI – Quick configuration with `aws configure`

You can use the AWS CLI to retrieve logs for an invocation using the `--log-type` command option. The response contains a `LogResult` field that contains up to 4 KB of base64-encoded logs from the invocation.

### Example retrieve a log ID

The following example shows how to retrieve a *log ID* from the `LogResult` field for a function named `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail
```

You should see the following output:

```
{
    "StatusCode": 200,
    "LogResult":
 "U1RBUlQgUmVxdWVzdElkOiA4N2QwNDRiOC1mMTU0LTExZTgtOGNkYS0yOTc0YzVlNGZiMjEgVmVyc2lvb...",
    "ExecutedVersion": "$LATEST"
}
```

### Example decode the logs

In the same command prompt, use the `base64` utility to decode the logs. The following example shows how to retrieve base64-encoded logs for `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail \
--query 'LogResult' --output text |  base64 -d
```

You should see the following output:

```
START RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8 Version: $LATEST
"AWS_SESSION_TOKEN": "AgoJb3JpZ2luX2VjELj...", "_X_AMZN_TRACE_ID": "Root=1-5d02e5ca-
f5792818b6fe8368e5b51d50;Parent=191db58857df8395;Sampled=0"",ask/lib:/opt/lib",
END RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8
REPORT RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8  Duration: 79.67 ms      Billed
 Duration: 80 ms         Memory Size: 128 MB     Max Memory Used: 73 MB
```

The `base64` utility is available on Linux, macOS, and Ubuntu on Windows. macOS users may need to use `base64 -D`.

### Example get-logs.sh script

In the same command prompt, use the following script to download the last five log events. The script uses `sed` to remove quotes from the output file, and sleeps for 15 seconds to allow time for the logs to become available. The output includes the response from Lambda and the output from the `get-log-events` command.

Copy the contents of the following code sample and save in your Lambda project directory as `get-logs.sh`.

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

```
#!/bin/bash
```

```
aws lambda invoke --function-name my-function --cli-binary-format raw-in-base64-out --
payload '{"key": "value"}' out
sed -i'' -e 's/"//g' out
sleep 15
aws logs get-log-events --log-group-name /aws/lambda/my-function --log-stream-name stream1
 --limit 5
```

### Example macOS and Linux (only)

In the same command prompt, macOS and Linux users may need to run the following command to ensure the script is executable.

```
chmod -R 755 get-logs.sh
```

### Example retrieve the last five log events

In the same command prompt, run the following script to get the last five log events.

```
./get-logs.sh
```

You should see the following output:

```
{
    "StatusCode": 200,
    "ExecutedVersion": "$LATEST"
}
{
    "events": [
        {
            "timestamp": 1559763003171,
            "message": "START RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf Version:
 $LATEST\n",
            "ingestionTime": 1559763003309
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tENVIRONMENT VARIABLES\r{\r  \"AWS_LAMBDA_FUNCTION_VERSION\": \"$LATEST\",\r ...",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tEVENT\r{\r  \"key\": \"value\"\r}\n",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "END RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\n",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "REPORT RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\tDuration:
 26.73 ms\tBilled Duration: 27 ms \tMemory Size: 128 MB\tMax Memory Used: 75 MB\t\n",
            "ingestionTime": 1559763018353
        }
    ],
    "nextForwardToken": "f/34783877304859518393868359594929986069206639495374241795",
    "nextBackwardToken": "b/34783877303811383369537420289090800615709599058929582080"
}
```

# Deleting logs

Log groups aren't deleted automatically when you delete a function. To avoid storing logs indefinitely, delete the log group, or configure a retention period after which logs are deleted automatically.

# AWS Lambda function errors in Go

When your code raises an error, Lambda generates a JSON representation of the error. This error document appears in the invocation log and, for synchronous invocations, in the output.

This page describes how to view Lambda function invocation errors for the Go runtime using the Lambda console and the AWS CLI.

**Sections**


- Creating a function that returns exceptions (p. 440)
- How it works (p. 440)
- Using the Lambda console (p. 441)
- Using the AWS Command Line Interface (AWS CLI) (p. 441)
- Error handling in other AWS services (p. 442)
- What's next? (p. 443)


## Creating a function that returns exceptions

The following code sample demonstrates custom error handling that raises an exception directly from a Lambda function and handles it directly. Note that custom errors in Go must import the `errors` module.

```
package main

import (
        "errors"
        "github.com/aws/aws-lambda-go/lambda"
)

func OnlyErrors() error {
        return errors.New("something went wrong!")
}

func main() {
        lambda.Start(OnlyErrors)
}
```

Which returns the following:

```
{
  "errorMessage": "something went wrong!",
  "errorType": "errorString"
}
```

## How it works

When you invoke a Lambda function, Lambda receives the invocation request and validates the permissions in your execution role, verifies that the event document is a valid JSON document, and checks parameter values.

If the request passes validation, Lambda sends the request to a function instance. The Lambda runtime (p. 82) environment converts the event document into an object, and passes it to your function handler.

If Lambda encounters an error, it returns an exception type, message, and HTTP status code that indicates the cause of the error. The client or service that invoked the Lambda function can handle the

error programmatically, or pass it along to an end user. The correct error handling behavior depends on the type of application, the audience, and the source of the error.

The following list describes the range of status codes you can receive from Lambda.

**`2xx`**

A `2xx` series error with a `X-Amz-Function-Error` header in the response indicates a Lambda runtime or function error. A `2xx` series status code indicates that Lambda accepted the request, but instead of an error code, Lambda indicates the error by including the `X-Amz-Function-Error` header in the response.

**`4xx`**

A `4xx` series error indicates an error that the invoking client or service can fix by modifying the request, requesting permission, or by retrying the request. `4xx` series errors other than `429` generally indicate an error with the request.

**`5xx`**

A `5xx` series error indicates an issue with Lambda, or an issue with the function's configuration or resources. `5xx` series errors can indicate a temporary condition that can be resolved without any action by the user. These issues can't be addressed by the invoking client or service, but a Lambda function's owner may be able to fix the issue.

For a complete list of invocation errors, see InvokeFunction errors (p. 995).

# Using the Lambda console

You can invoke your function on the Lambda console by configuring a test event and viewing the output. The output is captured in the function's execution logs and, when active tracing (p. 715) is enabled, in AWS X-Ray.

**To invoke a function on the Lambda console**

1. Open the Functions page of the Lambda console.
2. Choose the function to test, and choose **Test**.
3. Under **Test event**, select **New event**.
4. Select a **Template**.
5. For **Name**, enter a name for the test. In the text entry box, enter the JSON test event.
6. Choose **Save changes**.
7. Choose **Test**.

The Lambda console invokes your function synchronously (p. 225) and displays the result. To see the response, logs, and other information, expand the **Details** section.

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

When you invoke a Lambda function in the AWS CLI, the AWS CLI splits the response into two documents. The AWS CLI response is displayed in your command prompt. If an error has occurred, the

response contains a `FunctionError` field. The invocation response or error returned by the function is written to an output file. For example, `output.json` or `output.txt`.

The following invoke command example demonstrates how to invoke a function and write the invocation response to an `output.txt` file.

```
aws lambda invoke   \
  --function-name my-function   \
      --cli-binary-format raw-in-base64-out  \
          --payload '{"key1": "value1", "key2": "value2", "key3": "value3"}' output.txt
```

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

You should see the AWS CLI response in your command prompt:

```
{
    "StatusCode": 200,
    "FunctionError": "Unhandled",
    "ExecutedVersion": "$LATEST"
}
```

You should see the function invocation response in the `output.txt` file. In the same command prompt, you can also view the output in your command prompt using:

```
cat output.txt
```

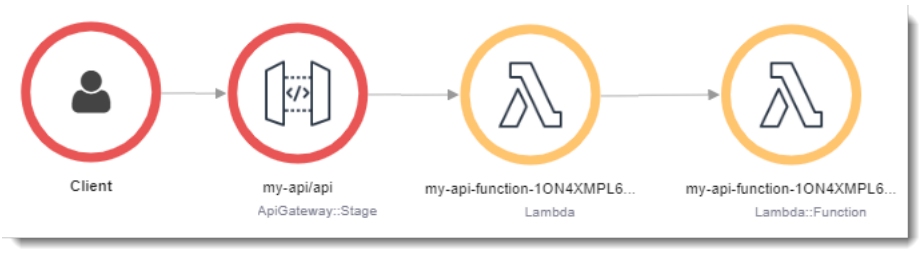
You should see the invocation response in your command prompt.

# Error handling in other AWS services

When another AWS service invokes your function, the service chooses the invocation type and retry behavior. AWS services can invoke your function on a schedule, in response to a lifecycle event on a resource, or to serve a request from a user. Some services invoke functions asynchronously and let Lambda handle errors, while others retry or pass errors back to the user.

For example, API Gateway treats all invocation and function errors as internal errors. If the Lambda API rejects the invocation request, API Gateway returns a `500` error code. If the function runs but returns an error, or returns a response in the wrong format, API Gateway returns a 502 error code. To customize the error response, you must catch errors in your code and format a response in the required format.

We recommend using AWS X-Ray to determine the source of an error and its cause. X-Ray allows you to find out which component encountered an error, and see details about the errors. The following example shows a function error that resulted in a `502` response from API Gateway.




For more information, see Instrumenting Go code in AWS Lambda (p. 444).

# What's next?

- Learn how to show logging events for your Lambda function on the the section called "Logging" (p. 435) page.

# Instrumenting Go code in AWS Lambda

Lambda integrates with AWS X-Ray to help you trace, debug, and optimize Lambda applications. You can use X-Ray to trace a request as it traverses resources in your application, which may include Lambda functions and other AWS services.

To send tracing data to X-Ray, you can use one of two SDK libraries:

- AWS Distro for OpenTelemetry (ADOT) – A secure, production-ready, AWS-supported distribution of the OpenTelemetry (OTel) SDK.
- AWS X-Ray SDK for Go – An SDK for generating and sending trace data to X-Ray.

Both ADOT and the X-Ray SDK offer ways to send your telemetry data to the X-Ray service. You can then use X-Ray to view, filter, and gain insights into your application's performance metrics to identify issues and opportunities for optimization.

> **Important**
> **ADOT is the preferred method for instrumenting your Lambda functions**. We recommend using ADOT for all new applications. However, due to the flexibility OpenTelemetry offers, your Lambda function invocations may experience cold start latency increases. If you're optimizing for low-latency and also do not require OpenTelemetry's advanced capabilities such as telemetry correlation and dynamically configurable backend destinations, you may want to use the AWS X-Ray SDK over ADOT.

**Sections**

- Using ADOT to instrument your Go functions (p. 444)
- Using the X-Ray SDK to instrument your Go functions (p. 444)
- Activating tracing with the Lambda console (p. 445)
- Activating tracing with the Lambda API (p. 445)
- Activating tracing with AWS CloudFormation (p. 445)
- Interpreting an X-Ray trace (p. 446)

## Using ADOT to instrument your Go functions

ADOT provides fully managed Lambda layers (p. 14) that package everything you need to collect telemetry data using the OTel SDK. By consuming this layer, you can instrument your Lambda functions without having to modify any function code. You can also configure your layer to do custom initialization of OTel. For more information, see Custom configuration for the ADOT Collector on Lambda in the ADOT documentation.

For Go runtimes, you can add the **AWS managed Lambda layer for ADOT Go** to automatically instrument your functions. For detailed instructions on how to add this layer, see AWS Distro for OpenTelemetry Lambda Support for Go in the ADOT documentation.

## Using the X-Ray SDK to instrument your Go functions

To record details about calls that your Lambda function makes to other resources in your application, you can also use the AWS X-Ray SDK for Go. To get the SDK, download the SDK from its GitHub repository with `go get`:

```
go get github.com/aws/aws-xray-sdk-go
```

To instrument AWS SDK clients, pass the client to the `xray.AWS()` method. You can then trace calls by using the `WithContext` version of the method.

```
svc := s3.New(session.New())
xray.AWS(svc.Client)
...
svc.ListBucketsWithContext(ctx aws.Context, input *ListBucketsInput)
```

After you add the correct dependencies and make the necessary code changes, activate tracing in your function's configuration via the Lambda console or the API.

# Activating tracing with the Lambda console

To toggle active tracing on your Lambda function with the console, follow these steps:

**To turn on active tracing**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **Monitoring and operations tools**.
4. Choose **Edit**.
5. Under **X-Ray**, toggle on **Active tracing**.
6. Choose **Save**.

# Activating tracing with the Lambda API

Configure tracing on your Lambda function with the AWS CLI or AWS SDK, use the following API operations:

- UpdateFunctionConfiguration (p. 1098)
- GetFunctionConfiguration (p. 967)
- CreateFunction (p. 904)

The following example AWS CLI command enables active tracing on a function named **my-function**.

```
aws lambda update-function-configuration --function-name my-function \
--tracing-config Mode=Active
```

Tracing mode is part of the version-specific configuration when you publish a version of your function. You can't change the tracing mode on a published version.

# Activating tracing with AWS CloudFormation

To activate tracing on an `AWS::Lambda::Function` resource in an AWS CloudFormation template, use the `TracingConfig` property.

**Example function-inline.yml – Tracing configuration**

```
Resources:
```

```
  function:
    Type: AWS::Lambda::Function
    Properties:
      TracingConfig:
        Mode: Active
      ...
```

For an AWS Serverless Application Model (AWS SAM) `AWS::Serverless::Function` resource, use the `Tracing` property.

**Example template.yml – Tracing configuration**

```
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      Tracing: Active
      ...
```

# Interpreting an X-Ray trace

Your function needs permission to upload trace data to X-Ray. When you activate tracing in the Lambda console, Lambda adds the required permissions to your function's execution role (p. 52). Otherwise, add the AWSXRayDaemonWriteAccess policy to the execution role.

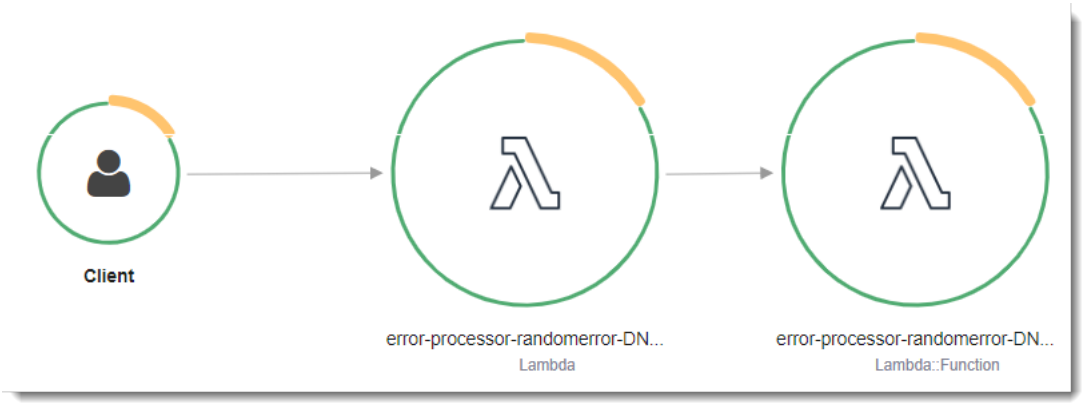
After you've configured active tracing, you can observe specific requests through your application. The X-Ray service graph shows information about your application and all its components. The following example from the error processor (p. 807) sample application shows an application with two functions. The primary function processes events and sometimes returns errors. The second function at the top processes errors that appear in the first's log group and uses the AWS SDK to call X-Ray, Amazon Simple Storage Service (Amazon S3), and Amazon CloudWatch Logs.



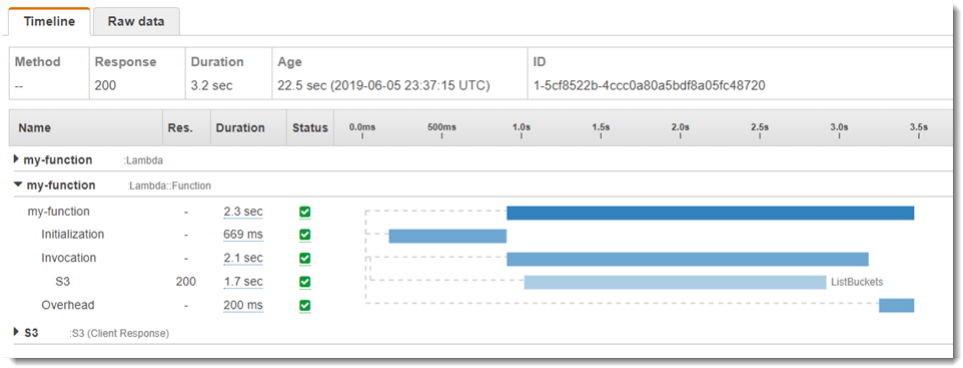

X-Ray doesn't trace all requests to your application. X-Ray applies a sampling algorithm to ensure that tracing is efficient, while still providing a representative sample of all requests. The sampling rate is 1 request per second and 5 percent of additional requests.

> **Note**
> You cannot configure the X-Ray sampling rate for your functions.

When using active tracing, Lambda records 2 segments per trace, which creates two nodes on the service graph. The following image highlights these two nodes for the primary function from the error processor example above.




The first node on the left represents the Lambda service, which receives the invocation request. The second node represents your specific Lambda function. The following example shows a trace with these two segments. Both are named **my-function**, but one has an origin of `AWS::Lambda` and the other has origin `AWS::Lambda::Function`.




This example expands the function segment to show its three subsegments:

- **Initialization** – Represents time spent loading your function and running initialization code (p. 22). This subsegment only appears for the first event that each instance of your function processes.
- **Invocation** – Represents the time spent running your handler code.
- **Overhead** – Represents the time the Lambda runtime spends preparing to handle the next event.

You can also instrument HTTP clients, record SQL queries, and create custom subsegments with annotations and metadata. For more information, see the AWS X-Ray SDK for Go in the *AWS X-Ray Developer Guide*.

### Pricing

You can use X-Ray tracing for free each month up to a certain limit as part of the AWS Free Tier. Beyond that threshold, X-Ray charges for trace storage and retrieval. For more information, see AWS X-Ray pricing.

# Using environment variables

To access environment variables (p. 166) in Go, use the Getenv function.

The following explains how to do this. Note that the function imports the fmt package to format the printed results and the os package, a platform-independent system interface that allows you to access environment variables.

```
package main

import (
 "fmt"
 "os"
 "github.com/aws/aws-lambda-go/lambda"
)

func main() {
 fmt.Printf("%s is %s. years old\n", os.Getenv("NAME"), os.Getenv("AGE"))

}
```

For a list of environment variables that are set by the Lambda runtime, see Defined runtime environment variables (p. 169).

# Building Lambda functions with C#

The following sections explain how common programming patterns and core concepts apply when authoring Lambda function code in C#.

AWS Lambda provides the following libraries for C# functions:

- **Amazon.Lambda.Core** – This library provides a static Lambda logger, serialization interfaces and a context object. The `Context` object (AWS Lambda context object in C# (p. 465)) provides runtime information about your Lambda function.
- **Amazon.Lambda.Serialization.Json** – This is an implementation of the serialization interface in **Amazon.Lambda.Core**.
- **Amazon.Lambda.Logging.AspNetCore** – This provides a library for logging from ASP.NET.
- Event objects (POCOs) for several AWS services, including:
  - **Amazon.Lambda.APIGatewayEvents**
  - **Amazon.Lambda.CognitoEvents**
  - **Amazon.Lambda.ConfigEvents**
  - **Amazon.Lambda.DynamoDBEvents**
  - **Amazon.Lambda.KinesisEvents**
  - **Amazon.Lambda.S3Events**
  - **Amazon.Lambda.SQSEvents**
  - **Amazon.Lambda.SNSEvents**

These packages are available at Nuget packages.

### .NET

| Name | Identifier | Operating system | Architectures | Deprecation |
|---|---|---|---|---|
| .NET Core 3.1 | `dotnetcore3.1` | Amazon Linux 2 | x86_64, arm64 | Jan 20, 2023 |
| .NET 6 | `dotnet6` | Amazon Linux 2 | x86_64, arm64 | |
| .NET 5 | `dotnet5.0` | Amazon Linux 2 | x86_64 | |

> **Note**
> For end of support information about .NET Core 2.1, see the section called "Runtime deprecation policy" (p. 83).

To get started with application development in your local environment, deploy one of the sample applications available in this guide's GitHub repository.

### Sample Lambda applications in C#

- blank-csharp – A C# function that shows the use of Lambda's .NET libraries, logging, environment variables, AWS X-Ray tracing, unit tests, and the AWS SDK.
- ec2-spot – A function that manages spot instance requests in Amazon EC2.

### Topics

- Lambda function handler in C# (p. 451)
- Deploy C# Lambda functions with .zip file archives (p. 458)
- Deploy .NET Lambda functions with container images (p. 463)
- AWS Lambda context object in C# (p. 465)
- Lambda function logging in C# (p. 466)
- AWS Lambda function errors in C# (p. 471)
- Instrumenting C# code in AWS Lambda (p. 476)

# Lambda function handler in C#

The Lambda function *handler* is the method in your function code that processes events. When your function is invoked, Lambda runs the handler method. When the handler exits or returns a response, it becomes available to handle another event.

You define a Lambda function handler as an instance or static method in a class. For access to the Lambda context object, you can define a method parameter of type *ILambdaContext*. You can use this to access information about the current invocation, such as the name of the function, memory limit, remaining execution time, and logging.

```
returnType handler-name(inputType input, ILambdaContext context) {
   ...
}
```

In the syntax, note the following:

- *inputType* – The first handler parameter is the input to the handler. This can be event data (that an event source publishes) or custom input that you provide, such as a string or any custom data object.
- *returnType* – If you plan to invoke the Lambda function synchronously (using the `RequestResponse` invocation type), you can return the output of your function using any of the supported data types. For example, if you use a Lambda function as a mobile application backend, you are invoking it synchronously. Your output data type is serialized into JSON.

  If you plan to invoke the Lambda function asynchronously (using the `Event` invocation type), the `returnType` should be `void`. For example, if you use Lambda with event sources such as Amazon Simple Storage Service (Amazon S3) or Amazon Simple Notification Service (Amazon SNS), these event sources invoke the Lambda function using the `Event` invocation type.
- `ILambdaContext context` – The second argument in the handler signature is optional. It provides access to the context object (p. 465), which has information about the function and request.

## Handling streams

By default, Lambda supports only the `System.IO.Stream` type as an input parameter.

For example, consider the following C# example code.

```
using System.IO;

namespace Example
{
  public class Hello
  {
    public Stream MyHandler(Stream stream)
    {
       //function logic
    }
  }
}
```

In the example C# code, the first handler parameter is the input to the handler (MyHandler). This can be event data (published by an event source such as Amazon S3) or custom input that you provide, such as a `Stream` (as in this example) or any custom data object. The output is of type `Stream`.

# Handling standard data types

All the following other types require you to specify a serializer:

- Primitive .NET types (such as string or int)
- Collections and maps – IList, IEnumerable, IList<T>, Array, IDictionary, IDictionary<TKey, TValue>
- POCO types (Plain old CLR objects)
- Predefined AWS event types
- For asynchronous invocations, Lambda ignores the return type. In such cases, the return type may be set to void.
- If you are using .NET asynchronous programming, the return type can be Task and Task<T> types and use `async` and `await` keywords. For more information, see Using async in C# functions with Lambda (p. 456).

Unless your function input and output parameters are of type `System.IO.Stream`, you must serialize them. Lambda provides default serializers that can be applied at the assembly or method level of your application, or you can define your own by implementing the `ILambdaSerializer` interface provided by the `Amazon.Lambda.Core` library. For more information, see Deploy C# Lambda functions with .zip file archives (p. 458).

To add the default serializer attribute to a method, first add a dependency on `Amazon.Lambda.Serialization.SystemTextJson` in your `.csproj` file.

```
<Project Sdk="Microsoft.NET.Sdk">

      <PropertyGroup>
        <TargetFramework>net6.0</TargetFramework>
        <ImplicitUsings>enable</ImplicitUsings>
        <Nullable>enable</Nullable>
        <GenerateRuntimeConfigurationFiles>true</GenerateRuntimeConfigurationFiles>
        <AWSProjectType>Lambda</AWSProjectType>
        <!-- Makes the build directory similar to a publish directory and helps the
 AWS .NET Lambda Mock Test Tool find project dependencies. -->
        <CopyLocalLockFileAssemblies>true</CopyLocalLockFileAssemblies>
        <!-- Generate ready to run images during publishing to improve cold start time. -->
        <PublishReadyToRun>true</PublishReadyToRun>
      </PropertyGroup>

      <ItemGroup>
        <PackageReference Include="Amazon.Lambda.Core" Version="2.1.0 " />
        <PackageReference Include="Amazon.Lambda.Serialization.SystemTextJson"
 Version="2.2.0" />
      </ItemGroup>

    </Project>
```

The example below illustrates the flexibility you can leverage by specifying the default System.Text.Json serializer on one method and another of your choosing on a different method:

```
public class ProductService
      {

 [LambdaSerializer(typeof(Amazon.Lambda.Serialization.SystemTextJson.DefaultLambdaJsonSerializer))]
      public Product DescribeProduct(DescribeProductRequest request)
      {
        return catalogService.DescribeProduct(request.Id);
      }
```

```
    [LambdaSerializer(typeof(MyJsonSerializer))]
    public Customer DescribeCustomer(DescribeCustomerRequest request)
    {
       return customerService.DescribeCustomer(request.Id);
    }
}
```

## Source generation for JSON serialization

C# 9 provides source generators that allow code generation during compilation. Starting with .NET 6, the native JSON library `System.Text.Json` can use source generators, allowing JSON parsing without the need for reflection APIs. This can help improve cold start performance.

**To use the source generator**

1. In your project, define an empty, partial class that derives from `System.Text.Json.Serialization.JsonSerializerContext`.
2. Add the `JsonSerializable` attribute for each .NET type that the source generator must generate serialization code for.

**Example API Gateway integration leveraging source generation**

```
using System.Collections.Generic;
using System.Net;
using System.Text.Json.Serialization;

using Amazon.Lambda.Core;
using Amazon.Lambda.APIGatewayEvents;
using Amazon.Lambda.Serialization.SystemTextJson;

[assembly:
LambdaSerializer(typeof(SourceGeneratorLambdaJsonSerializer<SourceGeneratorExa
mple.HttpApiJsonSerializerContext>))]

namespace SourceGeneratorExample;

[JsonSerializable(typeof(APIGatewayHttpApiV2ProxyRequest))]
[JsonSerializable(typeof(APIGatewayHttpApiV2ProxyResponse))]
public partial class HttpApiJsonSerializerContext : JsonSerializerContext
{
}

public class Functions
{
    public APIGatewayProxyResponse Get(APIGatewayHttpApiV2ProxyRequest
request, ILambdaContext context)
    {
        context.Logger.LogInformation("Get Request");
        var response = new APIGatewayHttpApiV2ProxyResponse
        {
            StatusCode = (int)HttpStatusCode.OK,
            Body = "Hello AWS Serverless",
            Headers = new Dictionary<string, string> { { "Content-Type",
"text/plain" } }
            };

            return response;
    }
}
```

When you invoke your function, Lambda uses the source-generated JSON serialization code to handle the serialization of Lambda events and responses.

# Handler signatures

When creating Lambda functions, you have to provide a handler string that tells Lambda where to look for the code to invoke. In C#, the format is:

*ASSEMBLY::TYPE::METHOD* where:

- *ASSEMBLY* is the name of the .NET assembly file for your application. When using the .NET Core CLI to build your application, if you haven't set the assembly name using the `AssemblyName` property in the .csproj file, the *ASSEMBLY* name is the .csproj file name. For more information, see .NET Core CLI (p. 458). In this case, let's assume that the .csproj file is `HelloWorldApp.csproj`.
- *TYPE* is the full name of the handler type, which consists of the *Namespace* and the *ClassName*. In this case `Example.Hello`.
- *METHOD* is name of the function handler, in this case `MyHandler`.

Ultimately, the signature is of this format: *Assembly::Namespace.ClassName::MethodName*

Consider the following example:

```
using System.IO;

namespace Example
{
  public class Hello
  {
    public Stream MyHandler(Stream stream)
    {
       //function logic
    }
  }
}
```

The handler string would be: `HelloWorldApp::Example.Hello::MyHandler`

> **Important**
> If the method specified in your handler string is overloaded, you must provide the exact signature of the method that Lambda should invoke. If the resolution would require selecting among multiple (overloaded) signatures, Lambda will reject an otherwise valid signature.

# Using top-level statements

Starting with .NET 6, you can write functions using *top-level statements*. Top-level statements remove some of the boilerplate code required for .NET projects, reducing the number of lines of code that you write. For example, you can rewrite the previous example using top-level statements:

```
using Amazon.Lambda.RuntimeSupport;

var handler = (Stream stream) =>
{
  //function logic
};

await LambdaBootstrapBuilder.Create(handler).Build().RunAsync();
```

When using top-level statements, you only include the `ASSEMBLY` name when providing the handler signature. Continuing from the previous example, the handler string would be `HelloWorldApp`.

By setting the handler to the assembly name Lambda will treat the assembly as an executable and execute it at startup. You must add the NuGet package `Amazon.Lambda.RuntimeSupport` to the project so that the executable that runs at startup starts the Lambda runtime client.

# Serializing Lambda functions

For any Lambda functions that use input or output types other than a `Stream` object, you must add a serialization library to your application. You can do this in the following ways:

- Use the `Amazon.Lambda.Serialization.SystemTextJson` NuGet package. This library uses the native .NET Core JSON serializer to handle serialization. This package provides a performance improvement over `Amazon.Lambda.Serialization.Json`, but note the limitations described in the Microsoft documentation. This library is available for .NET Core 3.1 and later runtimes.
- Use the `Amazon.Lambda.Serialization.Json` NuGet package. This library uses JSON.NET to handle serialization.
- Create your own serialization library by implementing the `ILambdaSerializer` interface, which is available as part of the `Amazon.Lambda.Core` library. The interface defines two methods:
  - `T Deserialize<T>(Stream requestStream);`

    You implement this method to deserialize the request payload from the `Invoke` API into the object that is passed to the Lambda function handler.
  - `T Serialize<T>(T response, Stream responseStream);`.

    You implement this method to serialize the result returned from the Lambda function handler into the response payload that the `Invoke` API operation returns.

To use the serializer, you must add a dependency to your `MyProject.csproj` file.

```
...
 <ItemGroup>
    <PackageReference Include="Amazon.Lambda.Serialization.SystemTextJson"
 Version="2.1.0" />
    <!-- or -->
    <PackageReference Include="Amazon.Lambda.Serialization.Json" Version="2.0.0" />
  </ItemGroup>
```

Next, you must define the serializer. The following example defines the `Amazon.Lambda.Serialization.SystemTextJson` serializer in the AssemblyInfo.cs file.

```
[assembly: LambdaSerializer(typeof(DefaultLambdaJsonSerializer))]
```

The following example defines the `Amazon.Lambda.Serialization.Json` serializer in the AssemblyInfo.cs file.

```
[assembly: LambdaSerializer(typeof(JsonSerializer))]
```

You can define a custom serialization attribute at the method level, which overrides the default serializer specified at the assembly level.

```
public class ProductService{
```

```
    [LambdaSerializer(typeof(JsonSerializer))]
    public Product DescribeProduct(DescribeProductRequest request)
    {
      return catalogService.DescribeProduct(request.Id);
    }

   [LambdaSerializer(typeof(MyJsonSerializer))]
   public Customer DescribeCustomer(DescribeCustomerRequest request)
   {
      return customerService.DescribeCustomer(request.Id);
   }
}
```

# Lambda function handler restrictions

Note that there are some restrictions on the handler signature.

- It may not be `unsafe` and use pointer types in the handler signature, though you can use `unsafe` context inside the handler method and its dependencies. For more information, see unsafe (C# Reference) on the Microsoft Docs website.
- It may not pass a variable number of parameters using the `params` keyword, or use `ArgIterator` as an input or a return parameter, which is used to support a variable number of parameters.
- The handler may not be a generic method, for example, IList<T> Sort<T>(IList<T> input).
- Async handlers with signature `async void` are not supported.

# Using async in C# functions with Lambda

If you know that your Lambda function will require a long-running process, such as uploading large files to Amazon S3 or reading a large stream of records from Amazon DynamoDB, you can take advantage of the async/await pattern. When you use this signature, Lambda invokes the function synchronously and waits for the function to return a response or for execution to time out.

```
public async Task<Response> ProcessS3ImageResizeAsync(SimpleS3Event input)
{
   var response = await client.DoAsyncWork(input);
   return response;
}
```

If you use this pattern, consider the following:

- Lambda does not support `async void` methods.
- If you create an async Lambda function without implementing the `await` operator, .NET will issue a compiler warning and you will observe unexpected behavior. For example, some async actions will run while others won't. Or some async actions won't complete before the function invocation completes.

  ```
  public async Task ProcessS3ImageResizeAsync(SimpleS3Event event) // Compiler warning
  {
      client.DoAsyncWork(input);
  }
  ```

- Your Lambda function can include multiple async calls, which can be invoked in parallel. You can use the `Task.WhenAll` and `Task.WhenAny` methods to work with multiple tasks. To use the `Task.WhenAll` method, you pass a list of the operations as an array to the method. Note that in the following example, if you neglect to include any operation to the array, that call may return before its operation completes.

```
public async Task DoesNotWaitForAllTasks1()
{
   // In Lambda, Console.WriteLine goes to CloudWatch Logs.
   var task1 = Task.Run(() => Console.WriteLine("Test1"));
   var task2 = Task.Run(() => Console.WriteLine("Test2"));
   var task3 = Task.Run(() => Console.WriteLine("Test3"));

   // Lambda may return before printing "Test2" since we never wait on task2.
   await Task.WhenAll(task1, task3);
}
```

To use the `Task.WhenAny` method, you again pass a list of operations as an array to the method. The call returns as soon as the first operation completes, even if the others are still running.

```
public async Task DoesNotWaitForAllTasks2()
{
  // In Lambda, Console.WriteLine goes to CloudWatch Logs.
  var task1 = Task.Run(() => Console.WriteLine("Test1"));
  var task2 = Task.Run(() => Console.WriteLine("Test2"));
  var task3 = Task.Run(() => Console.WriteLine("Test3"));

  // Lambda may return before printing all tests since we're waiting for only one to
 finish.
  await Task.WhenAny(task1, task2, task3);
}
```

# Deploy C# Lambda functions with .zip file archives

A .NET Core deployment package (.zip file archive) contains your function's compiled assembly along with all of its assembly dependencies. The package also contains a *proj*`.deps.json` file. This signals to the .NET Core runtime all of your function's dependencies and a *proj*`.runtimeconfig.json` file, which is used to configure the runtime. The .NET command line interface (CLI) `publish` command can create a folder with all of these files. By default, the *proj*`.runtimeconfig.json` is not included because a Lambda project is typically configured to be a class library. To force the *proj*`.runtimeconfig.json` to be written as part of the `publish` process, pass in the command line argument `/p:GenerateRuntimeConfigurationFiles=true` to the `publish` command.

Although it is possible to create the deployment package with the `dotnet publish` command, we recommend that you create the deployment package with either the .NET Core CLI (p. 458) or the AWS Toolkit for Visual Studio (p. 461). These are tools optimized specifically for Lambda to ensure that the *lambda-project*`.runtimeconfig.json` file exists and optimizes the package bundle, including the removal of any non-Linux-based dependencies.

**Topics**


- .NET Core CLI (p. 458)
- AWS Toolkit for Visual Studio (p. 461)


## .NET Core CLI

The .NET Core CLI offers a cross-platform way for you to create .NET-based Lambda applications. This section assumes that you have installed the .NET Core CLI. If you haven't, see Download .NET on the Microsoft website.

In the .NET CLI, you use the `new` command to create .NET projects from a command line. This is useful if you want to create a project outside of Visual Studio. To view a list of the available project types, open a command line, navigate to where you installed the .NET Core runtime, and then run the following command:

```
dotnet new -all
Usage: new [options]
...
Templates                                         Short Name         Language          Tags

----------------------------------------------------------------------------------------------------
Console Application                               console            [C#], F#, VB
 Common/Console
Class library                                     classlib           [C#], F#, VB
 Common/Library
Unit Test Project                                 mstest             [C#], F#, VB
 Test/MSTest
xUnit Test Project                                xunit              [C#], F#, VB
 Test/xUnit
...
Examples:
    dotnet new mvc --auth Individual
    dotnet new viewstart
    dotnet new --help
```

Lambda offers additional templates via the Amazon.Lambda.Templates NuGet package. To install this package, run the following command:

```
dotnet new -i Amazon.Lambda.Templates
```

Once the install is complete, the Lambda templates show up as part of `dotnet new`. To examine details about a template, use the `help` option.

```
dotnet new lambda.EmptyFunction --help
```

The `lambda.EmptyFunction` template supports the following options:

- `--name` – The name of the function
- `--profile` – The name of a profile in your AWS SDK for .NET credentials file
- `--region` – The AWS Region to create the function in

These options are saved to a file named `aws-lambda-tools-defaults.json`.

Create a function project with the `lambda.EmptyFunction` template.

```
dotnet new lambda.EmptyFunction --name MyFunction
```

Under the `src/myfunction` directory, examine the following files:

- **aws-lambda-tools-defaults.json**: This is where you specify the command line options when deploying your Lambda function. For example:

```
  "profile" : "default",
  "region" : "us-east-2",
  "configuration" : "Release",
  "function-runtime":"dotnet6",
  "function-memory-size" : 256,
  "function-timeout" : 30,
  "function-handler" : "MyFunction::MyFunction.Function::FunctionHandler"
```

- **Function.cs**: Your Lambda handler function code. It's a C# template that includes the default `Amazon.Lambda.Core` library and a default `LambdaSerializer` attribute. For more information on serialization requirements and options, see Serializing Lambda functions (p. 455). It also includes a sample function that you can edit to apply your Lambda function code.

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Threading.Tasks;

using Amazon.Lambda.Core;

// Assembly attribute to enable the Lambda function's JSON input to be converted into
 a .NET class.
[assembly:
 LambdaSerializer(typeof(Amazon.Lambda.Serialization.SystemTextJson.DefaultLambdaJsonSerializer))]

namespace MyFunction
{
    public class Function
    {

        public string FunctionHandler(string input, ILambdaContext context)
        {
            return input.ToUpper();
        }
    }
}
```

- **MyFunction.csproj**: An MSBuild file that lists the files and assemblies that comprise your application.

```
<Project Sdk="Microsoft.NET.Sdk">

  <PropertyGroup>
    <TargetFramework>net6.0</TargetFramework>
    <ImplicitUsings>enable</ImplicitUsings>
    <Nullable>enable</Nullable>
    <GenerateRuntimeConfigurationFiles>true</GenerateRuntimeConfigurationFiles>
    <AWSProjectType>Lambda</AWSProjectType>
    <!-- Makes the build directory similar to a publish directory and helps the AWS .NET
 Lambda Mock Test Tool find project dependencies. -->
    <CopyLocalLockFileAssemblies>true</CopyLocalLockFileAssemblies>
    <!-- Generate ready to run images during publishing to improve cold start time. -->
    <PublishReadyToRun>true</PublishReadyToRun>
  </PropertyGroup>

  <ItemGroup>
    <PackageReference Include="Amazon.Lambda.Core" Version="2.1.0 " />
    <PackageReference Include="Amazon.Lambda.Serialization.SystemTextJson"
 Version="2.2.0" />
  </ItemGroup>

</Project>
```

- **Readme**: Use this file to document your Lambda function.

Under the `myfunction/test` directory, examine the following files:

- **myFunction.Tests.csproj**: As noted previously, this is an MSBuild file that lists the files and assemblies that comprise your test project. Note also that it includes the `Amazon.Lambda.Core` library, so you can seamlessly integrate any Lambda templates required to test your function.

```
<Project Sdk="Microsoft.NET.Sdk">
   ...

    <PackageReference Include="Amazon.Lambda.Core" Version="2.1.0 " />
   ...
```

- **FunctionTest.cs**: The same C# code template file that it is included in the `src` directory. Edit this file to mirror your function's production code and test it before uploading your Lambda function to a production environment.

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Threading.Tasks;

using Xunit;
using Amazon.Lambda.Core;
using Amazon.Lambda.TestUtilities;

using MyFunction;

namespace MyFunction.Tests
{
    public class FunctionTest
    {
        [Fact]
        public void TestToUpperFunction()
        {
```

```
            // Invoke the lambda function and confirm the string was upper cased.
            var function = new Function();
            var context = new TestLambdaContext();
            var upperCase = function.FunctionHandler("hello world", context);

            Assert.Equal("HELLO WORLD", upperCase);
        }
    }
}
```

Once your function has passed its tests, you can build and deploy using the Amazon.Lambda.Tools .NET Core Global Tool. To install the .NET Core Global Tool, run the following command:

```
dotnet tool install -g Amazon.Lambda.Tools
```

If you already have the tool installed, you can make sure that it is the latest version using the following command:

```
dotnet tool update -g Amazon.Lambda.Tools
```

For more information about the Amazon.Lambda.Tools .NET Core Global Tool, see the AWS Extensions for .NET CLI repository on GitHub.

With the Amazon.Lambda.Tools installed, you can deploy your function using the following command:

```
dotnet lambda deploy-function MyFunction --function-role role
```

After deployment, you can re-test it in a production environment using the following command, and pass in a different value to your Lambda function handler:

```
dotnet lambda invoke-function MyFunction --payload "Just Checking If Everything is OK"
```

If everything is successful, you see the following:

```
dotnet lambda invoke-function MyFunction --payload "Just Checking If Everything is OK"
Payload:
"JUST CHECKING IF EVERYTHING IS OK"

Log Tail:
START RequestId: id Version: $LATEST
END RequestId: id
REPORT RequestId: id  Duration: 0.99 ms       Billed Duration: 1 ms         Memory Size:
 256 MB     Max Memory Used: 12 MB
```

# AWS Toolkit for Visual Studio

You can build .NET-based Lambda applications using the Lambda plugin for the AWS Toolkit for Visual Studio. The toolkit is available as a Visual Studio extension.

1. Launch Microsoft Visual Studio and choose **New project**.

   a. From the **File** menu, choose **New**, and then choose **Project**.
   b. In the **New Project** window, choose **Lambda Project (.NET Core)**, and then choose **OK**.
   c. In the **Select Blueprint** window, select from the list of sample applications with sample code to help you get started with creating a .NET-based Lambda application.

d. To create a Lambda application from scratch, choose **Empty Function**, and then choose **Finish**.

2. Review the `aws-lambda-tools-defaults.json` file, which is created as part of your project. You can set the options in this file, which the Lambda tooling reads by default. The project templates created in Visual Studio set many of these fields with default values. Note the following fields:

   - **profile** – The name of a profile in your AWS SDK for .NET credentials file
   - **function-handler** – The field where you specify the `function handler`. (This is why you don't have to set it in the wizard.) However, whenever you rename the *`Assembly`*, *`Namespace`*, *`Class`*, or *`Function`* in your function code, you must update the corresponding fields in the `aws-lambda-tools-defaults.json` file.

   ```
   {
     "profile":"default",
     "region" : "us-east-2",
     "configuration" : "Release",
     "function-runtime":"dotnet6",
     "function-memory-size" : 256,
     "function-timeout" : 30,
     "function-handler" : "Assembly::Namespace.Class::Function"
   }
   ```

3. Open the **Function.cs** file. You are provided with a template to implement your Lambda function handler code.
4. After writing the code that represents your Lambda function, upload it by opening the context (right-click) menu for the **Project** node in your application and then choosing **Publish to AWS Lambda**.
5. In the **Upload Lambda Function** window, enter a name for the function, or select a previously published function to republish. Then choose **Next**.
6. In the **Advanced Function Details** window, configure the following options:

   - **Role Name** (required) – The AWS Identity and Access Management (IAM) role (p. 52) that Lambda assumes when it runs your function.
   - **Environment** – Key-value pairs that Lambda sets in the execution environment. To extend your function's configuration outside of code, use environment variables (p. 166).
   - **Memory** – The amount of memory available to the function at runtime. Choose an amount between 128 MB and 10,240 MB (p. 796) in 1-MB increments.
   - **Timeout** – The amount of time that Lambda allows a function to run before stopping it. The default is three seconds. The maximum allowed value is 900 seconds.
   - **VPC** – If your function needs network access to resources that are not available over the internet, configure it to connect to a virtual private cloud (VPC) (p. 191).
   - **DLQ** – If your function is invoked asynchronously, choose a dead-letter queue (p. 234) to receive failed invocations.
   - **Enable active tracing** – Sample incoming requests and trace sampled requests with AWS X-Ray (p. 715).

7. Choose **Next**, and then choose **Upload** to deploy your application.

For more information, see Deploying an AWS Lambda Project with the .NET Core CLI.

# Deploy .NET Lambda functions with container images

You can deploy your Lambda function code as a container image (p. 143).

AWS provides the following resources to help you build a container image for your .NET function:

AWS provides base images for the x86_64 architecture for all supported .NET runtimes, and for the arm64 architecture for the .NET Core 3.1 and .NET 6.0 runtimes.

- AWS base images for Lambda

  These base images are preloaded with a language runtime and other components that are required to run the image on Lambda. AWS provides a Dockerfile for each of the base images to help with building your container image.
- Open-source runtime interface clients (RIC)

  If you use a community or private enterprise base image, you must add a Runtime interface client (p. 145) to the base image to make it compatible with Lambda.
- Open-source runtime interface emulator (RIE)

  Lambda provides a runtime interface emulator for you to test your function locally. The base images for Lambda and base images for custom runtimes include the RIE. For other base images, you can download the RIE for testing your image (p. 146) locally.

The workflow for a function defined as a container image includes these steps:

1. Build your container image using the resources listed in this topic.
2. Upload the image to your Amazon ECR container registry (p. 153).
3. Create (p. 138) the Lambda function or update the function code (p. 141) to deploy the image to an existing function.

**Topics**

- AWS base images for .NET (p. 463)
- Using a .NET base image (p. 464)
- .NET runtime interface clients (p. 464)
- Deploy the container image (p. 464)

# AWS base images for .NET

AWS provides the following base images for .NET:

| Tags | Runtime | Operating system | Dockerfile | Deprecation |
|---|---|---|---|---|
| core3.1 | .NET Core 3.1 | Amazon Linux 2 | Dockerfile for .NET Core 3.1 on GitHub | Jan 20, 2023 |
| 6 | .NET 6 | Amazon Linux 2 | Dockerfile for .NET 6 on GitHub | |

| Tags | Runtime | Operating system | Dockerfile | Deprecation |
|---|---|---|---|---|
| 5.0 | .NET 5 | Amazon Linux 2 | Dockerfile for .NET 5 on GitHub | |

Amazon ECR repository: gallery.ecr.aws/lambda/dotnet

# Using a .NET base image

For instructions on how to use a .NET base image, choose the **usage** tab on AWS Lambda base images for .NET in the *Amazon ECR repository*.

# .NET runtime interface clients

Download the .NET runtime interface client from the AWS Lambda for .NET Core repository on GitHub.

# Deploy the container image

For a new function, you deploy the container image when you create the function (p. 138). For an existing function, if you rebuild the container image, you need to redeploy the image by updating the function code (p. 141).

# AWS Lambda context object in C#

When Lambda runs your function, it passes a context object to the handler (p. 451). This object provides properties with information about the invocation, function, and execution environment.

### Context properties

- `FunctionName` – The name of the Lambda function.
- `FunctionVersion` – The version (p. 173) of the function.
- `InvokedFunctionArn` – The Amazon Resource Name (ARN) that's used to invoke the function. Indicates if the invoker specified a version number or alias.
- `MemoryLimitInMB` – The amount of memory that's allocated for the function.
- `AwsRequestId` – The identifier of the invocation request.
- `LogGroupName` – The log group for the function.
- `LogStreamName` – The log stream for the function instance.
- `RemainingTime` (`TimeSpan`) – The number of milliseconds left before the execution times out.
- `Identity` – (mobile apps) Information about the Amazon Cognito identity that authorized the request.
- `ClientContext` – (mobile apps) Client context that's provided to Lambda by the client application.
- `Logger` The logger object (p. 466) for the function.

The following C# code snippet shows a simple handler function that prints some of the context information.

```
public async Task Handler(ILambdaContext context)
{
    Console.WriteLine("Function name: " + context.FunctionName);
    Console.WriteLine("RemainingTime: " + context.RemainingTime);
    await Task.Delay(TimeSpan.FromSeconds(0.42));
    Console.WriteLine("RemainingTime after sleep: " + context.RemainingTime);
}
```

# Lambda function logging in C#

AWS Lambda automatically monitors Lambda functions on your behalf and sends function metrics to Amazon CloudWatch. Your Lambda function comes with a CloudWatch Logs log group and a log stream for each instance of your function. The Lambda runtime environment sends details about each invocation to the log stream, and relays logs and other output from your function's code.

This page describes how to produce log output from your Lambda function's code, or access logs using the AWS Command Line Interface, the Lambda console, or the CloudWatch console.

**Sections**


- Creating a function that returns logs (p. 466)
- Using log levels (p. 467)
- Using the Lambda console (p. 468)
- Using the CloudWatch console (p. 468)
- Using the AWS Command Line Interface (AWS CLI) (p. 468)
- Deleting logs (p. 470)


## Creating a function that returns logs

To output logs from your function code, you can use methods on the Console class, or any logging library that writes to `stdout` or `stderr`. The following example uses the `LambdaLogger` class from the Amazon.Lambda.Core (p. 449) library.

**Example src/blank-csharp/Function.cs – Logging**

```
public async Task<AccountUsage> FunctionHandler(SQSEvent invocationEvent, ILambdaContext
 context)
  {
    GetAccountSettingsResponse accountSettings;
    try
    {
      accountSettings = await callLambda();
    }
    catch (AmazonLambdaException ex)
    {
      throw ex;
    }
    AccountUsage accountUsage = accountSettings.AccountUsage;
    LambdaLogger.Log("ENVIRONMENT VARIABLES: " +
 JsonConvert.SerializeObject(System.Environment.GetEnvironmentVariables()));
    LambdaLogger.Log("CONTEXT: " + JsonConvert.SerializeObject(context));
    LambdaLogger.Log("EVENT: " + JsonConvert.SerializeObject(invocationEvent));
    return accountUsage;
  }
```

**Example log format**

```
START RequestId: d1cf0ccb-xmpl-46e6-950d-04c96c9b1c5d Version: $LATEST
ENVIRONMENT VARIABLES:
{
  "AWS_EXECUTION_ENV": "AWS_Lambda_dotnet6",
  "AWS_LAMBDA_FUNCTION_MEMORY_SIZE": "256",
  "AWS_LAMBDA_LOG_GROUP_NAME": "/aws/lambda/blank-csharp-function-WU56XMPLV2XA",
  "AWS_LAMBDA_FUNCTION_VERSION": "$LATEST",
  "AWS_LAMBDA_LOG_STREAM_NAME": "2020/03/27/[$LATEST]5296xmpl084f411d9fb73b258393f30c",
```

```
  "AWS_LAMBDA_FUNCTION_NAME": "blank-csharp-function-WU56XMPLV2XA",
  ...
EVENT:
{
  "Records": [
      {
          "MessageId": "19dd0b57-b21e-4ac1-bd88-01bbb068cb78",
          "ReceiptHandle": "MessageReceiptHandle",
          "Body": "Hello from SQS!",
          "Md5OfBody": "7b270e59b47ff90a553787216d55d91d",
          "Md5OfMessageAttributes": null,
          "EventSourceArn": "arn:aws:sqs:us-west-2:123456789012:MyQueue",
          "EventSource": "aws:sqs",
          "AwsRegion": "us-west-2",
          "Attributes": {
              "ApproximateReceiveCount": "1",
              "SentTimestamp": "1523232000000",
              "SenderId": "123456789012",
              "ApproximateFirstReceiveTimestamp": "1523232000001"
          },
          ...
END RequestId: d1cf0ccb-xmpl-46e6-950d-04c96c9b1c5d
REPORT RequestId: d1cf0ccb-xmpl-46e6-950d-04c96c9b1c5d Duration: 4157.16 ms Billed
 Duration: 4200 ms Memory Size: 256 MB Max Memory Used: 99 MB Init Duration: 841.60 ms
XRAY TraceId: 1-5e7e8131-7ff0xmpl32bfb31045d0a3bb SegmentId: 0152xmpl6016310f Sampled: true
```

The .NET runtime logs the `START`, `END`, and `REPORT` lines for each invocation. The report line provides the following details.

**Report Log**

- **RequestId** – The unique request ID for the invocation.
- **Duration** – The amount of time that your function's handler method spent processing the event.
- **Billed Duration** – The amount of time billed for the invocation.
- **Memory Size** – The amount of memory allocated to the function.
- **Max Memory Used** – The amount of memory used by the function.
- **Init Duration** – For the first request served, the amount of time it took the runtime to load the function and run code outside of the handler method.
- **XRAY TraceId** – For traced requests, the AWS X-Ray trace ID (p. 715).
- **SegmentId** – For traced requests, the X-Ray segment ID.
- **Sampled** – For traced requests, the sampling result.

# Using log levels

Starting with .NET 6, you can use log levels for additional logging from Lambda functions. Log levels provide filtering and categorization for the logs that your function writes to Amazon EventBridge (CloudWatch Events).

The log levels available are:

- `LogCritical`
- `LogError`
- `LogWarning`
- `LogInformation`
- `LogDebug`
- `LogTrace`

By default, Lambda writes `LogInformation` level logs and above to CloudWatch. You can adjust the level of logs that Lambda writes using the `AWS_LAMBDA_HANDLER_LOG_LEVEL` environment variable. Set the value of the environment variable to the string enum value for the level desired, as outlined in the LogLevel enum. For example, if you set `AWS_LAMBDA_HANDLER_LOG_LEVEL` to `Error`, Lambda writes `LogError` and `LogCritical` messages to CloudWatch.

Lambda writes `Console.WriteLine` calls as info level messages, and `Console.Error.WriteLine` calls as error level messages.

If you prefer the previous style of logging in .NET, set `AWS_LAMBDA_HANDLER_LOG_FORMAT` to `Unformatted`.

# Using the Lambda console

You can use the Lambda console to view log output after you invoke a Lambda function. For more information, see Accessing Amazon CloudWatch logs for AWS Lambda (p. 730).

# Using the CloudWatch console

You can use the Amazon CloudWatch console to view logs for all Lambda function invocations.

**To view logs on the CloudWatch console**

1. Open the Log groups page on the CloudWatch console.
2. Choose the log group for your function (**/aws/lambda/*your-function-name***).
3. Choose a log stream.

Each log stream corresponds to an instance of your function (p. 100). A log stream appears when you update your Lambda function, and when additional instances are created to handle multiple concurrent invocations. To find logs for a specific invocation, we recommend instrumenting your function with AWS X-Ray. X-Ray records details about the request and the log stream in the trace.

To use a sample application that correlates logs and traces with X-Ray, see Error processor sample application for AWS Lambda (p. 807).

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

You can use the AWS CLI to retrieve logs for an invocation using the `--log-type` command option. The response contains a `LogResult` field that contains up to 4 KB of base64-encoded logs from the invocation.

**Example retrieve a log ID**

The following example shows how to retrieve a *log ID* from the `LogResult` field for a function named `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail
```

You should see the following output:

```
{
    "StatusCode": 200,
    "LogResult":
 "U1RBUlQgUmVxdWVzdElkOiA4N2QwNDRiOC1mMTU0LTExZTgtOGNkYS0yOTc0YzVlNGZiMjEgVmVyc2lvb...",
    "ExecutedVersion": "$LATEST"
}
```

### Example decode the logs

In the same command prompt, use the `base64` utility to decode the logs. The following example shows how to retrieve base64-encoded logs for `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail \
--query 'LogResult' --output text |  base64 -d
```

You should see the following output:

```
START RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8 Version: $LATEST
"AWS_SESSION_TOKEN": "AgoJb3JpZ2luX2VjELj...", "_X_AMZN_TRACE_ID": "Root=1-5d02e5ca-
f5792818b6fe8368e5b51d50;Parent=191db58857df8395;Sampled=0"",ask/lib:/opt/lib",
END RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8
REPORT RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8  Duration: 79.67 ms      Billed
 Duration: 80 ms         Memory Size: 128 MB     Max Memory Used: 73 MB
```

The `base64` utility is available on Linux, macOS, and Ubuntu on Windows. macOS users may need to use `base64 -D`.

### Example get-logs.sh script

In the same command prompt, use the following script to download the last five log events. The script uses `sed` to remove quotes from the output file, and sleeps for 15 seconds to allow time for the logs to become available. The output includes the response from Lambda and the output from the `get-log-events` command.

Copy the contents of the following code sample and save in your Lambda project directory as `get-logs.sh`.

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

```
#!/bin/bash
aws lambda invoke --function-name my-function --cli-binary-format raw-in-base64-out --
payload '{"key": "value"}' out
sed -i'' -e 's/"//g' out
sleep 15
aws logs get-log-events --log-group-name /aws/lambda/my-function --log-stream-name stream1
 --limit 5
```

### Example macOS and Linux (only)

In the same command prompt, macOS and Linux users may need to run the following command to ensure the script is executable.

```
chmod -R 755 get-logs.sh
```

### Example retrieve the last five log events

In the same command prompt, run the following script to get the last five log events.

```
./get-logs.sh
```

You should see the following output:

```
{
    "StatusCode": 200,
    "ExecutedVersion": "$LATEST"
}
{
    "events": [
        {
            "timestamp": 1559763003171,
            "message": "START RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf Version:
 $LATEST\n",
            "ingestionTime": 1559763003309
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tENVIRONMENT VARIABLES\r{\r  \"AWS_LAMBDA_FUNCTION_VERSION\": \"$LATEST\",\r ...",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tEVENT\r{\r  \"key\": \"value\"\r}\n",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "END RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\n",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "REPORT RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\tDuration:
 26.73 ms\tBilled Duration: 27 ms \tMemory Size: 128 MB\tMax Memory Used: 75 MB\t\n",
            "ingestionTime": 1559763018353
        }
    ],
    "nextForwardToken": "f/34783877304859518393868359594929986069206639495374241795",
    "nextBackwardToken": "b/34783877303811383369537420289090800615709599058929582080"
}
```

# Deleting logs

Log groups aren't deleted automatically when you delete a function. To avoid storing logs indefinitely, delete the log group, or configure a retention period after which logs are deleted automatically.

# AWS Lambda function errors in C#

When your code raises an error, Lambda generates a JSON representation of the error. This error document appears in the invocation log and, for synchronous invocations, in the output.

This page describes how to view Lambda function invocation errors for the C# runtime using the Lambda console and the AWS CLI.

**Sections**


- Syntax (p. 471)
- How it works (p. 473)
- Using the Lambda console (p. 474)
- Using the AWS Command Line Interface (AWS CLI) (p. 474)
- Error handling in other AWS services (p. 475)
- What's next? (p. 475)


## Syntax

In the initialization phase, exceptions can be thrown for invalid handler strings, a rule-breaking type or method (see Lambda function handler restrictions (p. 456)), or any other validation method (such as forgetting the serializer attribute and having a POCO as your input or output type). These exceptions are of type `LambdaException`. For example:

```
{
  "errorType": "LambdaException",
  "errorMessage": "Invalid lambda function handler: 'http://this.is.not.a.valid.handler/'.
  The valid format is 'ASSEMBLY::TYPE::METHOD'."
}
```

If your constructor throws an exception, the error type is also of type `LambdaException`, but the exception thrown during construction is provided in the `cause` property, which is itself a modeled exception object:

```
{
  "errorType": "LambdaException",
  "errorMessage": "An exception was thrown when the constructor for type
 'LambdaExceptionTestFunction.ThrowExceptionInConstructor'
   was invoked. Check inner exception for more details.",
  "cause":   {
    "errorType": "TargetInvocationException",
    "errorMessage": "Exception has been thrown by the target of an invocation.",
    "stackTrace": [
      "at System.RuntimeTypeHandle.CreateInstance(RuntimeType type, Boolean publicOnly,
 Boolean noCheck, Boolean&canBeCached,
      RuntimeMethodHandleInternal&ctor, Boolean& bNeedSecurityCheck)",
      "at System.RuntimeType.CreateInstanceSlow(Boolean publicOnly, Boolean skipCheckThis,
 Boolean fillCache, StackCrawlMark& stackMark)",
      "at System.Activator.CreateInstance(Type type, Boolean nonPublic)",
      "at System.Activator.CreateInstance(Type type)"
    ],
    "cause":     {
      "errorType": "ArithmeticException",
      "errorMessage": "Sorry, 2 + 2 = 5",
      "stackTrace": [
        "at LambdaExceptionTestFunction.ThrowExceptionInConstructor..ctor()"
      ]
    }
```

```
  }
}
```

As the example shows, the inner exceptions are always preserved (as the `cause` property), and can be deeply nested.

Exceptions can also occur during invocation. In this case, the exception type is preserved and the exception is returned directly as the payload and in the CloudWatch logs. For example:

```
{
  "errorType": "AggregateException",
  "errorMessage": "One or more errors occurred. (An unknown web exception occurred!)",
  "stackTrace": [
    "at System.Threading.Tasks.Task.ThrowIfExceptional(Boolean
 includeTaskCanceledExceptions)",
    "at System.Threading.Tasks.Task`1.GetResultCore(Boolean waitCompletionNotification)",
    "at lambda_method(Closure , Stream , Stream , ContextInfo )"
  ],
  "cause":   {
    "errorType": "UnknownWebException",
    "errorMessage": "An unknown web exception occurred!",
    "stackTrace": [
      "at LambdaDemo107.LambdaEntryPoint.<GetUriResponse>d__1.MoveNext()",
      "--- End of stack trace from previous location where exception was thrown ---",
      "at System.Runtime.CompilerServices.TaskAwaiter.ThrowForNonSuccess(Task task)",
      "at
 System.Runtime.CompilerServices.TaskAwaiter.HandleNonSuccessAndDebuggerNotification(Task
 task)",
      "at System.Runtime.CompilerServices.TaskAwaiter`1.GetResult()",
      "at LambdaDemo107.LambdaEntryPoint.<CheckWebsiteStatus>d__0.MoveNext()"
    ],
    "cause":     {
      "errorType": "WebException",
      "errorMessage": "An error occurred while sending the request. SSL peer certificate or
 SSH remote key was not OK",
      "stackTrace": [
        "at System.Net.HttpWebRequest.EndGetResponse(IAsyncResult asyncResult)",
        "at System.Threading.Tasks.TaskFactory`1.FromAsyncCoreLogic(IAsyncResult iar,
 Func`2 endFunction, Action`1 endAction, Task`1 promise, Boolean requiresSynchronization)",
        "--- End of stack trace from previous location where exception was thrown ---",
        "at System.Runtime.CompilerServices.TaskAwaiter.ThrowForNonSuccess(Task task)",
        "at
 System.Runtime.CompilerServices.TaskAwaiter.HandleNonSuccessAndDebuggerNotification(Task
 task)",
        "at System.Runtime.CompilerServices.TaskAwaiter`1.GetResult()",
        "at LambdaDemo107.LambdaEntryPoint.<GetUriResponse>d__1.MoveNext()"
      ],
      "cause":       {
        "errorType": "HttpRequestException",
        "errorMessage": "An error occurred while sending the request.",
        "stackTrace": [
          "at System.Runtime.CompilerServices.TaskAwaiter.ThrowForNonSuccess(Task task)",
          "at
 System.Runtime.CompilerServices.TaskAwaiter.HandleNonSuccessAndDebuggerNotification(Task
 task)",
          "at System.Net.Http.HttpClient.<FinishSendAsync>d__58.MoveNext()",
          "--- End of stack trace from previous location where exception was thrown ---",
          "at System.Runtime.CompilerServices.TaskAwaiter.ThrowForNonSuccess(Task task)",
          "at
 System.Runtime.CompilerServices.TaskAwaiter.HandleNonSuccessAndDebuggerNotification(Task
 task)",
          "at System.Net.HttpWebRequest.<SendRequest>d__63.MoveNext()",
          "--- End of stack trace from previous location where exception was thrown ---",
          "at System.Runtime.CompilerServices.TaskAwaiter.ThrowForNonSuccess(Task task)",
```

```
          "at
 System.Runtime.CompilerServices.TaskAwaiter.HandleNonSuccessAndDebuggerNotification(Task
 task)",
          "at System.Net.HttpWebRequest.EndGetResponse(IAsyncResult asyncResult)"
        ],
        "cause":         {
          "errorType": "CurlException",
          "errorMessage": "SSL peer certificate or SSH remote key was not OK",
          "stackTrace": [
            "at System.Net.Http.CurlHandler.ThrowIfCURLEError(CURLcode error)",
            "at
 System.Net.Http.CurlHandler.MultiAgent.FinishRequest(StrongToWeakReference`1 easyWrapper,
 CURLcode messageResult)"
          ]
        }
      }
    }
  }
}
```

The method in which error information is conveyed depends on the invocation type:

- `RequestResponse` invocation type (that is, synchronous execution): In this case, you get the error message back.

  For example, if you invoke a Lambda function using the Lambda console, the `RequestResponse` is always the invocation type and the console displays the error information returned by AWS Lambda in the **Execution result** section of the console.
- `Event` invocation type (that is, asynchronous execution): In this case AWS Lambda does not return anything. Instead, it logs the error information in CloudWatch Logs and CloudWatch metrics.

# How it works

When you invoke a Lambda function, Lambda receives the invocation request and validates the permissions in your execution role, verifies that the event document is a valid JSON document, and checks parameter values.

If the request passes validation, Lambda sends the request to a function instance. The Lambda runtime (p. 82) environment converts the event document into an object, and passes it to your function handler.

If Lambda encounters an error, it returns an exception type, message, and HTTP status code that indicates the cause of the error. The client or service that invoked the Lambda function can handle the error programmatically, or pass it along to an end user. The correct error handling behavior depends on the type of application, the audience, and the source of the error.

The following list describes the range of status codes you can receive from Lambda.

**`2xx`**

A `2xx` series error with a `X-Amz-Function-Error` header in the response indicates a Lambda runtime or function error. A `2xx` series status code indicates that Lambda accepted the request, but instead of an error code, Lambda indicates the error by including the `X-Amz-Function-Error` header in the response.

**`4xx`**

A `4xx` series error indicates an error that the invoking client or service can fix by modifying the request, requesting permission, or by retrying the request. `4xx` series errors other than `429` generally indicate an error with the request.

**5xx**

A 5xx series error indicates an issue with Lambda, or an issue with the function's configuration or resources. 5xx series errors can indicate a temporary condition that can be resolved without any action by the user. These issues can't be addressed by the invoking client or service, but a Lambda function's owner may be able to fix the issue.

For a complete list of invocation errors, see InvokeFunction errors (p. 995).

# Using the Lambda console

You can invoke your function on the Lambda console by configuring a test event and viewing the output. The output is captured in the function's execution logs and, when active tracing (p. 715) is enabled, in AWS X-Ray.

### To invoke a function on the Lambda console

1. Open the Functions page of the Lambda console.
2. Choose the function to test, and choose **Test**.
3. Under **Test event**, select **New event**.
4. Select a **Template**.
5. For **Name**, enter a name for the test. In the text entry box, enter the JSON test event.
6. Choose **Save changes**.
7. Choose **Test**.

The Lambda console invokes your function synchronously (p. 225) and displays the result. To see the response, logs, and other information, expand the **Details** section.

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

When you invoke a Lambda function in the AWS CLI, the AWS CLI splits the response into two documents. The AWS CLI response is displayed in your command prompt. If an error has occurred, the response contains a `FunctionError` field. The invocation response or error returned by the function is written to an output file. For example, `output.json` or `output.txt`.

The following invoke command example demonstrates how to invoke a function and write the invocation response to an `output.txt` file.

```
aws lambda invoke   \
  --function-name my-function   \
      --cli-binary-format raw-in-base64-out  \
          --payload '{"key1": "value1", "key2": "value2", "key3": "value3"}' output.txt
```

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

You should see the AWS CLI response in your command prompt:

```
{
    "StatusCode": 200,
    "FunctionError": "Unhandled",
    "ExecutedVersion": "$LATEST"
}
```

You should see the function invocation response in the `output.txt` file. In the same command prompt, you can also view the output in your command prompt using:

```
cat output.txt
```

You should see the invocation response in your command prompt.

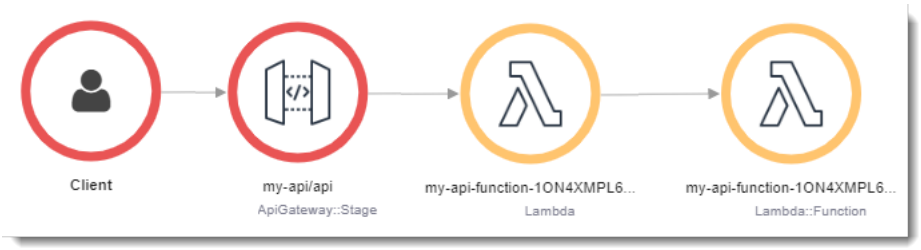
Lambda also records up to 256 KB of the error object in the function's logs. For more information, see Lambda function logging in C# (p. 466).

# Error handling in other AWS services

When another AWS service invokes your function, the service chooses the invocation type and retry behavior. AWS services can invoke your function on a schedule, in response to a lifecycle event on a resource, or to serve a request from a user. Some services invoke functions asynchronously and let Lambda handle errors, while others retry or pass errors back to the user.

For example, API Gateway treats all invocation and function errors as internal errors. If the Lambda API rejects the invocation request, API Gateway returns a `500` error code. If the function runs but returns an error, or returns a response in the wrong format, API Gateway returns a 502 error code. To customize the error response, you must catch errors in your code and format a response in the required format.

We recommend using AWS X-Ray to determine the source of an error and its cause. X-Ray allows you to find out which component encountered an error, and see details about the errors. The following example shows a function error that resulted in a `502` response from API Gateway.




For more information, see Instrumenting C# code in AWS Lambda (p. 476).

# What's next?

- Learn how to show logging events for your Lambda function on the the section called “Logging” (p. 466) page.

# Instrumenting C# code in AWS Lambda

Lambda integrates with AWS X-Ray to enable you to trace, debug, and optimize Lambda applications. You can use X-Ray to trace a request as it traverses resources in your application, from the frontend API to storage and database on the backend. By simply adding the X-Ray SDK library to your build configuration, you can record errors and latency for any call that your function makes to an AWS service.

After you've configured active tracing, you can observe specific requests through your application. The X-Ray service graph shows information about your application and all its components. The following example from the error processor (p. 807) sample application shows an application with two functions. The primary function processes events and sometimes returns errors. The second function at the top processes errors that appear in the first's log group and uses the AWS SDK to call X-Ray, Amazon Simple Storage Service (Amazon S3), and Amazon CloudWatch Logs.




To toggle active tracing on your Lambda function with the console, follow these steps:

### To turn on active tracing

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **Monitoring and operations tools**.
4. Choose **Edit**.
5. Under **X-Ray**, toggle on **Active tracing**.
6. Choose **Save**.

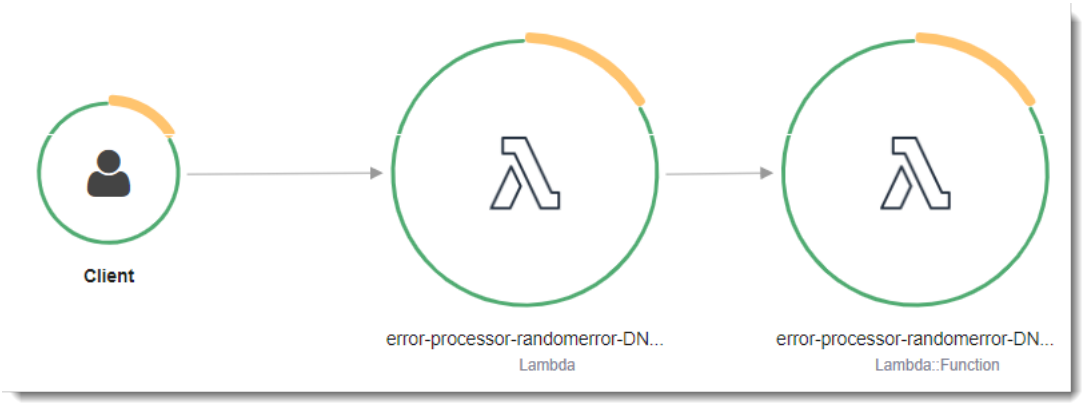
> **Pricing**
> You can use X-Ray tracing for free each month up to a certain limit as part of the AWS Free Tier. Beyond that threshold, X-Ray charges for trace storage and retrieval. For more information, see AWS X-Ray pricing.

Your function needs permission to upload trace data to X-Ray. When you activate tracing in the Lambda console, Lambda adds the required permissions to your function's execution role (p. 52). Otherwise, add the AWSXRayDaemonWriteAccess policy to the execution role.

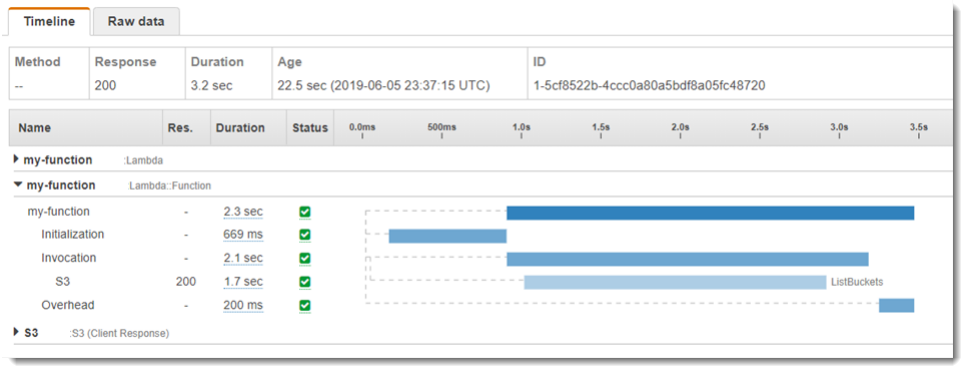
X-Ray doesn't trace all requests to your application. X-Ray applies a sampling algorithm to ensure that tracing is efficient, while still providing a representative sample of all requests. The sampling rate is 1 request per second and 5 percent of additional requests.

> **Note**
> You cannot configure the X-Ray sampling rate for your functions.

When using active tracing, Lambda records 2 segments per trace, which creates two nodes on the service graph. The following image highlights these two nodes for the primary function from the error processor example above.




The first node on the left represents the Lambda service, which receives the invocation request. The second node represents your specific Lambda function. The following example shows a trace with these two segments. Both are named **my-function**, but one has an origin of `AWS::Lambda` and the other has origin `AWS::Lambda::Function`.




This example expands the function segment to show its three subsegments:

- **Initialization** – Represents time spent loading your function and running initialization code (p. 22). This subsegment only appears for the first event that each instance of your function processes.
- **Invocation** – Represents the time spent running your handler code.
- **Overhead** – Represents the time the Lambda runtime spends preparing to handle the next event.

You can instrument your function code to record metadata and trace downstream calls. To record detail about calls that your function makes to other resources and services, use the X-Ray SDK for .NET. To get the SDK, add the `AWSXRayRecorder` packages to your project file.

**Example src/blank-csharp/blank-csharp.csproj**

```
<Project Sdk="Microsoft.NET.Sdk">
  <PropertyGroup>
    <TargetFramework>netcoreapp3.1</TargetFramework>
    <GenerateRuntimeConfigurationFiles>true</GenerateRuntimeConfigurationFiles>
    <AWSProjectType>Lambda</AWSProjectType>
  </PropertyGroup>
  <ItemGroup>
    <PackageReference Include="Newtonsoft.Json" Version="12.0.3" />
```

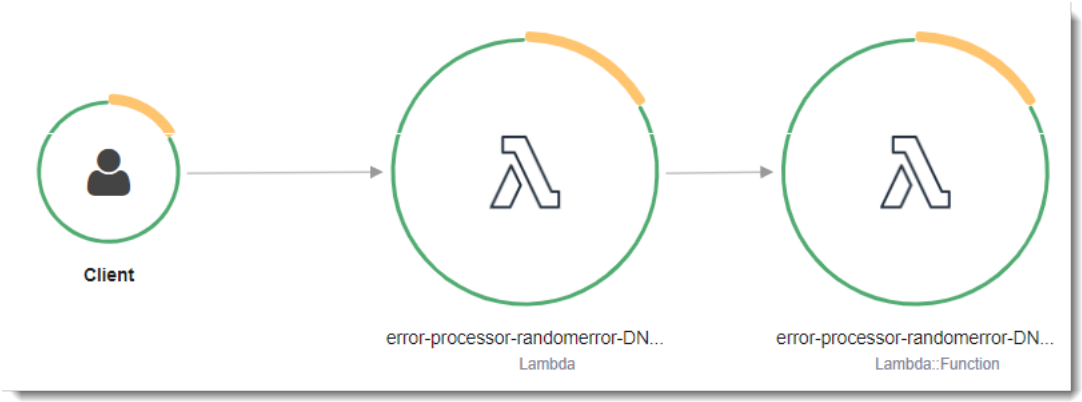
```
    <PackageReference Include="Amazon.Lambda.Core" Version="1.1.0" />
    <PackageReference Include="Amazon.Lambda.SQSEvents" Version="1.1.0" />
    <PackageReference Include="Amazon.Lambda.Serialization.Json" Version="1.7.0" />
    <PackageReference Include="AWSSDK.Core" Version="3.3.104.38" />
    <PackageReference Include="AWSSDK.Lambda" Version="3.3.108.11" />
    <PackageReference Include="AWSXRayRecorder.Core" Version="2.6.2" />
    <PackageReference Include="AWSXRayRecorder.Handlers.AwsSdk" Version="2.7.2" />
  </ItemGroup>
</Project>
```

To instrument AWS SDK clients, call the `RegisterXRayForAllServices` method in your initialization code.

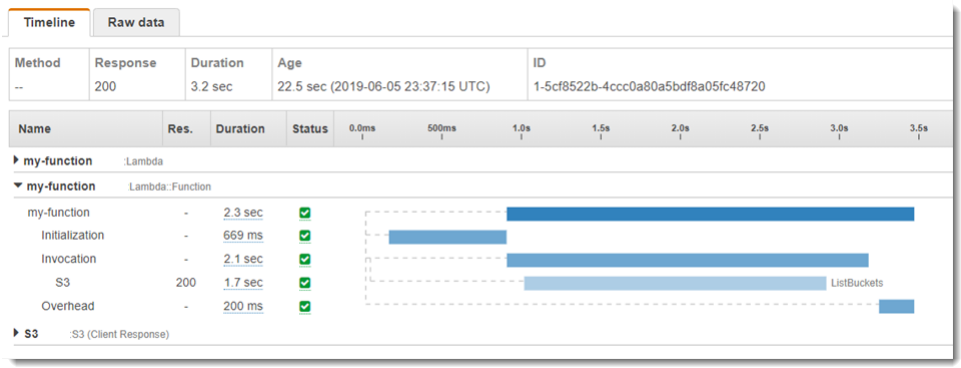
**Example src/blank-csharp/Function.cs – Initialize X-Ray**

```
    static async void initialize() {
      AWSSDKHandler.RegisterXRayForAllServices();
      lambdaClient = new AmazonLambdaClient();
      await callLambda();
    }
```

When using active tracing, Lambda records 2 segments per trace, which creates two nodes on the service graph. The following image highlights these two nodes for the primary function from the error processor example above.




The first node on the left represents the Lambda service, which receives the invocation request. The second node represents your specific Lambda function. The following example shows a trace with these two segments. Both are named **my-function**, but one has an origin of `AWS::Lambda` and the other has origin `AWS::Lambda::Function`.




This example expands the function segment to show its three subsegments:

- **Initialization** – Represents time spent loading your function and running initialization code (p. 22). This subsegment only appears for the first event that each instance of your function processes.
- **Invocation** – Represents the time spent running your handler code.
- **Overhead** – Represents the time the Lambda runtime spends preparing to handle the next event.

You can also instrument HTTP clients, record SQL queries, and create custom subsegments with annotations and metadata. For more information, see The X-Ray SDK for .NET in the AWS X-Ray Developer Guide.

**Sections**

- Enabling active tracing with the Lambda API (p. 479)
- Enabling active tracing with AWS CloudFormation (p. 479)

# Enabling active tracing with the Lambda API

To manage tracing configuration with the AWS CLI or AWS SDK, use the following API operations:

- UpdateFunctionConfiguration (p. 1098)
- GetFunctionConfiguration (p. 967)
- CreateFunction (p. 904)

The following example AWS CLI command enables active tracing on a function named **my-function**.

```
aws lambda update-function-configuration --function-name my-function \
--tracing-config Mode=Active
```

Tracing mode is part of the version-specific configuration when you publish a version of your function. You can't change the tracing mode on a published version.

# Enabling active tracing with AWS CloudFormation

To activate tracing on an `AWS::Lambda::Function` resource in an AWS CloudFormation template, use the `TracingConfig` property.

**Example function-inline.yml – Tracing configuration**

```
Resources:
  function:
    Type: AWS::Lambda::Function
    Properties:
      TracingConfig:
        Mode: Active
      ...
```

For an AWS Serverless Application Model (AWS SAM) `AWS::Serverless::Function` resource, use the `Tracing` property.

**Example template.yml – Tracing configuration**

```
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
```

```
      Tracing: Active
      ...
```

# Building Lambda functions with PowerShell

The following sections explain how common programming patterns and core concepts apply when you author Lambda function code in PowerShell.

**.NET**

| Name | Identifier | Operating system | Architectures | Deprecation |
|---|---|---|---|---|
| .NET Core 3.1 | `dotnetcore3.1` | Amazon Linux 2 | x86_64, arm64 | Jan 20, 2023 |
| .NET 6 | `dotnet6` | Amazon Linux 2 | x86_64, arm64 | |
| .NET 5 | `dotnet5.0` | Amazon Linux 2 | x86_64 | |

Lambda provides the following sample applications for the PowerShell runtime:

- blank-powershell – A PowerShell function that shows the use of logging, environment variables, and the AWS SDK.

Before you get started, you must first set up a PowerShell development environment. For instructions on how to do this, see Setting Up a PowerShell Development Environment (p. 482).

To learn about how to use the AWSLambdaPSCore module to download sample PowerShell projects from templates, create PowerShell deployment packages, and deploy PowerShell functions to the AWS Cloud, see Deploy PowerShell Lambda functions with .zip file archives (p. 483).

**Topics**


- Setting Up a PowerShell Development Environment (p. 482)
- Deploy PowerShell Lambda functions with .zip file archives (p. 483)
- AWS Lambda function handler in PowerShell (p. 485)
- AWS Lambda context object in PowerShell (p. 486)
- AWS Lambda function logging in PowerShell (p. 487)
- AWS Lambda function errors in PowerShell (p. 492)

# Setting Up a PowerShell Development Environment

Lambda provides a set of tools and libraries for the PowerShell runtime. For installation instructions, see Lambda tools for PowerShell on GitHub.

The AWSLambdaPSCore module includes the following cmdlets to help author and publish PowerShell Lambda functions:

- **Get-AWSPowerShellLambdaTemplate** – Returns a list of getting started templates.
- **New-AWSPowerShellLambda** – Creates an initial PowerShell script based on a template.
- **Publish-AWSPowerShellLambda** – Publishes a given PowerShell script to Lambda.
- **New-AWSPowerShellLambdaPackage** – Creates a Lambda deployment package that you can use in a CI/CD system for deployment.

# Deploy PowerShell Lambda functions with .zip file archives

A deployment package for the PowerShell runtime contains your PowerShell script, PowerShell modules that are required for your PowerShell script, and the assemblies needed to host PowerShell Core.

## Creating the Lambda function

To get started writing and invoking a PowerShell script with Lambda, you can use the `New-AWSPowerShellLambda` cmdlet to create a starter script based on a template. You can use the `Publish-AWSPowerShellLambda` cmdlet to deploy your script to Lambda. Then you can test your script either through the command line or the Lambda console.

To create a new PowerShell script, upload it, and test it, do the following:

1. To view the list of available templates, run the following command:

```
PS C:\> Get-AWSPowerShellLambdaTemplate

Template               Description
--------               -----------
Basic                  Bare bones script
CodeCommitTrigger      Script to process AWS CodeCommit Triggers
...
```

2. To create a sample script based on the `Basic` template, run the following command:

```
New-AWSPowerShellLambda -ScriptName MyFirstPSScript -Template Basic
```

   A new file named `MyFirstPSScript.ps1` is created in a new subdirectory of the current directory. The name of the directory is based on the `-ScriptName` parameter. You can use the `-Directory` parameter to choose an alternative directory.

   You can see that the new file has the following contents:

```
# PowerShell script file to run as a Lambda function
#
# When executing in Lambda the following variables are predefined.
#   $LambdaInput - A PSObject that contains the Lambda function input data.
#   $LambdaContext - An Amazon.Lambda.Core.ILambdaContext object that contains
 information about the currently running Lambda environment.
#
# The last item in the PowerShell pipeline is returned as the result of the Lambda
 function.
#
# To include PowerShell modules with your Lambda function, like the
 AWSPowerShell.NetCore module, add a "#Requires" statement
# indicating the module and version.

#Requires -Modules @{ModuleName='AWSPowerShell.NetCore';ModuleVersion='3.3.618.0'}

# Uncomment to send the input to CloudWatch Logs
# Write-Host (ConvertTo-Json -InputObject $LambdaInput -Compress -Depth 5)
```

3. To see how log messages from your PowerShell script are sent to Amazon CloudWatch Logs, uncomment the `Write-Host` line of the sample script.

To demonstrate how you can return data back from your Lambda functions, add a new line at the end of the script with `$PSVersionTable`. This adds the `$PSVersionTable` to the PowerShell pipeline. After the PowerShell script is complete, the last object in the PowerShell pipeline is the return data for the Lambda function. `$PSVersionTable` is a PowerShell global variable that also provides information about the running environment.

After making these changes, the last two lines of the sample script look like this:

```
Write-Host (ConvertTo-Json -InputObject $LambdaInput -Compress -Depth 5)
$PSVersionTable
```

4. After editing the `MyFirstPSScript.ps1` file, change the directory to the script's location. Then run the following command to publish the script to Lambda:

```
Publish-AWSPowerShellLambda -ScriptPath .\MyFirstPSScript.ps1 -Name  MyFirstPSScript -
Region us-east-2
```

Note that the `-Name` parameter specifies the Lambda function name, which appears in the Lambda console. You can use this function to invoke your script manually.

5. Invoke your function using the AWS Command Line Interface (AWS CLI) `invoke` command.

```
> aws lambda invoke --function-name MyFirstPSScript out
```

# AWS Lambda function handler in PowerShell

When a Lambda function is invoked, the Lambda handler invokes the PowerShell script.

When the PowerShell script is invoked, the following variables are predefined:

- *$LambdaInput* – A PSObject that contains the input to the handler. This input can be event data (published by an event source) or custom input that you provide, such as a string or any custom data object.
- *$LambdaContext* – An Amazon.Lambda.Core.ILambdaContext object that you can use to access information about the current invocation—such as the name of the current function, the memory limit, execution time remaining, and logging.

For example, consider the following PowerShell example code.

```
#Requires -Modules @{ModuleName='AWSPowerShell.NetCore';ModuleVersion='3.3.618.0'}
Write-Host 'Function Name:' $LambdaContext.FunctionName
```

This script returns the FunctionName property that's obtained from the $LambdaContext variable.

> **Note**
> You're required to use the `#Requires` statement within your PowerShell scripts to indicate the modules that your scripts depend on. This statement performs two important tasks. 1) It communicates to other developers which modules the script uses, and 2) it identifies the dependent modules that AWS PowerShell tools need to package with the script, as part of the deployment. For more information about the `#Requires` statement in PowerShell, see About requires. For more information about PowerShell deployment packages, see Deploy PowerShell Lambda functions with .zip file archives (p. 483).
> When your PowerShell Lambda function uses the AWS PowerShell cmdlets, be sure to set a `#Requires` statement that references the `AWSPowerShell.NetCore` module, which supports PowerShell Core—and not the `AWSPowerShell` module, which only supports Windows PowerShell. Also, be sure to use version 3.3.270.0 or newer of `AWSPowerShell.NetCore` which optimizes the cmdlet import process. If you use an older version, you'll experience longer cold starts. For more information, see AWS Tools for PowerShell.

## Returning data

Some Lambda invocations are meant to return data back to their caller. For example, if an invocation was in response to a web request coming from API Gateway, then our Lambda function needs to return back the response. For PowerShell Lambda, the last object that's added to the PowerShell pipeline is the return data from the Lambda invocation. If the object is a string, the data is returned as is. Otherwise the object is converted to JSON by using the `ConvertTo-Json` cmdlet.

For example, consider the following PowerShell statement, which adds `$PSVersionTable` to the PowerShell pipeline:

```
$PSVersionTable
```

After the PowerShell script is finished, the last object in the PowerShell pipeline is the return data for the Lambda function. `$PSVersionTable` is a PowerShell global variable that also provides information about the running environment.

# AWS Lambda context object in PowerShell

When Lambda runs your function, it passes context information by making a `$LambdaContext` variable available to the handler (p. 485). This variable provides methods and properties with information about the invocation, function, and execution environment.

### Context properties

- `FunctionName` – The name of the Lambda function.
- `FunctionVersion` – The version (p. 173) of the function.
- `InvokedFunctionArn` – The Amazon Resource Name (ARN) that's used to invoke the function. Indicates if the invoker specified a version number or alias.
- `MemoryLimitInMB` – The amount of memory that's allocated for the function.
- `AwsRequestId` – The identifier of the invocation request.
- `LogGroupName` – The log group for the function.
- `LogStreamName` – The log stream for the function instance.
- `RemainingTime` – The number of milliseconds left before the execution times out.
- `Identity` – (mobile apps) Information about the Amazon Cognito identity that authorized the request.
- `ClientContext` – (mobile apps) Client context that's provided to Lambda by the client application.
- `Logger` – The logger object (p. 487) for the function.

The following PowerShell code snippet shows a simple handler function that prints some of the context information.

```
#Requires -Modules @{ModuleName='AWSPowerShell.NetCore';ModuleVersion='3.3.618.0'}
Write-Host 'Function name:' $LambdaContext.FunctionName
Write-Host 'Remaining milliseconds:' $LambdaContext.RemainingTime.TotalMilliseconds
Write-Host 'Log group name:' $LambdaContext.LogGroupName
Write-Host 'Log stream name:' $LambdaContext.LogStreamName
```

# AWS Lambda function logging in PowerShell

AWS Lambda automatically monitors Lambda functions on your behalf and sends function metrics to Amazon CloudWatch. Your Lambda function comes with a CloudWatch Logs log group and a log stream for each instance of your function. The Lambda runtime environment sends details about each invocation to the log stream, and relays logs and other output from your function's code.

This page describes how to produce log output from your Lambda function's code, or access logs using the AWS Command Line Interface, the Lambda console, or the CloudWatch console.

**Sections**


- Creating a function that returns logs (p. 487)
- Using the Lambda console (p. 488)
- Using the CloudWatch console (p. 488)
- Using the AWS Command Line Interface (AWS CLI) (p. 488)
- Deleting logs (p. 491)


## Creating a function that returns logs

To output logs from your function code, you can use cmdlets on Microsoft.PowerShell.Utility , or any logging module that writes to `stdout` or `stderr`. The following example uses `Write-Host`.

**Example function/Handler.ps1 – Logging**

```
#Requires -Modules @{ModuleName='AWSPowerShell.NetCore';ModuleVersion='3.3.618.0'}
Write-Host `## Environment variables
Write-Host AWS_LAMBDA_FUNCTION_VERSION=$Env:AWS_LAMBDA_FUNCTION_VERSION
Write-Host AWS_LAMBDA_LOG_GROUP_NAME=$Env:AWS_LAMBDA_LOG_GROUP_NAME
Write-Host AWS_LAMBDA_LOG_STREAM_NAME=$Env:AWS_LAMBDA_LOG_STREAM_NAME
Write-Host AWS_EXECUTION_ENV=$Env:AWS_EXECUTION_ENV
Write-Host AWS_LAMBDA_FUNCTION_NAME=$Env:AWS_LAMBDA_FUNCTION_NAME
Write-Host PATH=$Env:PATH
Write-Host `## Event
Write-Host (ConvertTo-Json -InputObject $LambdaInput -Compress -Depth 3)
```

**Example log format**

```
START RequestId: 56639408-xmpl-435f-9041-ac47ae25ceed Version: $LATEST
Importing module ./Modules/AWSPowerShell.NetCore/3.3.618.0/AWSPowerShell.NetCore.psd1
[Information] - ## Environment variables
[Information] - AWS_LAMBDA_FUNCTION_VERSION=$LATEST
[Information] - AWS_LAMBDA_LOG_GROUP_NAME=/aws/lambda/blank-powershell-
function-18CIXMPLHFAJJ
[Information] - AWS_LAMBDA_LOG_STREAM_NAME=2020/04/01/
[$LATEST]53c5xmpl52d64ed3a744724d9c201089
[Information] - AWS_EXECUTION_ENV=AWS_Lambda_dotnet6_powershell_1.0.0
[Information] - AWS_LAMBDA_FUNCTION_NAME=blank-powershell-function-18CIXMPLHFAJJ
[Information] - PATH=/var/lang/bin:/usr/local/bin:/usr/bin/:/bin:/opt/bin
[Information] - ## Event
[Information] -
{
    "Records": [
        {
            "messageId": "19dd0b57-b21e-4ac1-bd88-01bbb068cb78",
            "receiptHandle": "MessageReceiptHandle",
            "body": "Hello from SQS!",
            "attributes": {
```

```
                "ApproximateReceiveCount": "1",
                "SentTimestamp": "1523232000000",
                "SenderId": "123456789012",
                "ApproximateFirstReceiveTimestamp": "1523232000001"
            },
            ...
END RequestId: 56639408-xmpl-435f-9041-ac47ae25ceed
REPORT RequestId: 56639408-xmpl-435f-9041-ac47ae25ceed Duration: 3906.38 ms Billed
 Duration: 4000 ms Memory Size: 512 MB Max Memory Used: 367 MB Init Duration: 5960.19 ms
XRAY TraceId: 1-5e843da6-733cxmple7d0c3c020510040 SegmentId: 3913xmpl20999446 Sampled: true
```

The .NET runtime logs the `START`, `END`, and `REPORT` lines for each invocation. The report line provides the following details.

**Report Log**

- **RequestId** – The unique request ID for the invocation.
- **Duration** – The amount of time that your function's handler method spent processing the event.
- **Billed Duration** – The amount of time billed for the invocation.
- **Memory Size** – The amount of memory allocated to the function.
- **Max Memory Used** – The amount of memory used by the function.
- **Init Duration** – For the first request served, the amount of time it took the runtime to load the function and run code outside of the handler method.
- **XRAY TraceId** – For traced requests, the AWS X-Ray trace ID (p. 715).
- **SegmentId** – For traced requests, the X-Ray segment ID.
- **Sampled** – For traced requests, the sampling result.

# Using the Lambda console

You can use the Lambda console to view log output after you invoke a Lambda function. For more information, see Accessing Amazon CloudWatch logs for AWS Lambda (p. 730).

# Using the CloudWatch console

You can use the Amazon CloudWatch console to view logs for all Lambda function invocations.

**To view logs on the CloudWatch console**

1. Open the Log groups page on the CloudWatch console.
2. Choose the log group for your function (**/aws/lambda/*your-function-name***).
3. Choose a log stream.

Each log stream corresponds to an instance of your function (p. 100). A log stream appears when you update your Lambda function, and when additional instances are created to handle multiple concurrent invocations. To find logs for a specific invocation, we recommend instrumenting your function with AWS X-Ray. X-Ray records details about the request and the log stream in the trace.

To use a sample application that correlates logs and traces with X-Ray, see Error processor sample application for AWS Lambda (p. 807).

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

You can use the AWS CLI to retrieve logs for an invocation using the `--log-type` command option. The response contains a `LogResult` field that contains up to 4 KB of base64-encoded logs from the invocation.

### Example retrieve a log ID

The following example shows how to retrieve a *log ID* from the `LogResult` field for a function named `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail
```

You should see the following output:

```
{
    "StatusCode": 200,
    "LogResult":
 "U1RBUlQgUmVxdWVzdElkOiA4N2QwNDRiOC1mMTU0LTExZTgtOGNkYS0yOTc0YzVlNGZiMjEgVmVyc2lvb...",
    "ExecutedVersion": "$LATEST"
}
```

### Example decode the logs

In the same command prompt, use the `base64` utility to decode the logs. The following example shows how to retrieve base64-encoded logs for `my-function`.

```
aws lambda invoke --function-name my-function out --log-type Tail \
--query 'LogResult' --output text |  base64 -d
```

You should see the following output:

```
START RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8 Version: $LATEST
"AWS_SESSION_TOKEN": "AgoJb3JpZ2luX2VjELj...", "_X_AMZN_TRACE_ID": "Root=1-5d02e5ca-
f5792818b6fe8368e5b51d50;Parent=191db58857df8395;Sampled=0"",ask/lib:/opt/lib",
END RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8
REPORT RequestId: 57f231fb-1730-4395-85cb-4f71bd2b87b8  Duration: 79.67 ms      Billed
 Duration: 80 ms         Memory Size: 128 MB     Max Memory Used: 73 MB
```

The `base64` utility is available on Linux, macOS, and Ubuntu on Windows. macOS users may need to use `base64 -D`.

### Example get-logs.sh script

In the same command prompt, use the following script to download the last five log events. The script uses `sed` to remove quotes from the output file, and sleeps for 15 seconds to allow time for the logs to become available. The output includes the response from Lambda and the output from the `get-log-events` command.

Copy the contents of the following code sample and save in your Lambda project directory as `get-logs.sh`.

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

```
#!/bin/bash
aws lambda invoke --function-name my-function --cli-binary-format raw-in-base64-out --
payload '{"key": "value"}' out
sed -i'' -e 's/"//g' out
sleep 15
aws logs get-log-events --log-group-name /aws/lambda/my-function --log-stream-name stream1
 --limit 5
```

### Example macOS and Linux (only)

In the same command prompt, macOS and Linux users may need to run the following command to ensure the script is executable.

```
chmod -R 755 get-logs.sh
```

### Example retrieve the last five log events

In the same command prompt, run the following script to get the last five log events.

```
./get-logs.sh
```

You should see the following output:

```
{
    "StatusCode": 200,
    "ExecutedVersion": "$LATEST"
}
{
    "events": [
        {
            "timestamp": 1559763003171,
            "message": "START RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf Version:
 $LATEST\n",
            "ingestionTime": 1559763003309
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tENVIRONMENT VARIABLES\r{\r  \"AWS_LAMBDA_FUNCTION_VERSION\": \"$LATEST\",\r ...",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003173,
            "message": "2019-06-05T19:30:03.173Z\t4ce9340a-b765-490f-ad8a-02ab3415e2bf
\tINFO\tEVENT\r{\r  \"key\": \"value\"\r}\n",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "END RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\n",
            "ingestionTime": 1559763018353
        },
        {
            "timestamp": 1559763003218,
            "message": "REPORT RequestId: 4ce9340a-b765-490f-ad8a-02ab3415e2bf\tDuration:
 26.73 ms\tBilled Duration: 27 ms \tMemory Size: 128 MB\tMax Memory Used: 75 MB\t\n",
            "ingestionTime": 1559763018353
        }
    ],
    "nextForwardToken": "f/34783877304859518393868359594929986069206639495374241795",
    "nextBackwardToken": "b/34783877303811383369537420289090800615709599058929582080"
```

```
}
```

# Deleting logs

Log groups aren't deleted automatically when you delete a function. To avoid storing logs indefinitely, delete the log group, or configure a retention period after which logs are deleted automatically.

# AWS Lambda function errors in PowerShell

When your code raises an error, Lambda generates a JSON representation of the error. This error document appears in the invocation log and, for synchronous invocations, in the output.

This page describes how to view Lambda function invocation errors for the PowerShell runtime using the Lambda console and the AWS CLI.

**Sections**


- Syntax (p. 492)
- How it works (p. 493)
- Using the Lambda console (p. 493)
- Using the AWS Command Line Interface (AWS CLI) (p. 494)
- Error handling in other AWS services (p. 494)
- What's next? (p. 495)


## Syntax

Consider the following PowerShell script example statement:

```
throw 'The Account is not found'
```

When you invoke this Lambda function, it throws a terminating error, and AWS Lambda returns the following error message:

```
{
  "errorMessage": "The Account is not found",
  "errorType": "RuntimeException"
}
```

Note the `errorType` is `RuntimeException`, which is the default exception thrown by PowerShell. You can use custom error types by throwing the error like this:

```
throw @{'Exception'='AccountNotFound';'Message'='The Account is not found'}
```

The error message is serialized with `errorType` set to `AccountNotFound`:

```
{
  "errorMessage": "The Account is not found",
  "errorType": "AccountNotFound"
}
```

If you don't need an error message, you can throw a string in the format of an error code. The error code format requires that the string starts with a character and only contain letters and digits afterwards, with no spaces or symbols.

For example, if your Lambda function contains the following:

```
throw 'AccountNotFound'
```

The error is serialized like this:

```
{
  "errorMessage": "AccountNotFound",
  "errorType": "AccountNotFound"
}
```

# How it works

When you invoke a Lambda function, Lambda receives the invocation request and validates the permissions in your execution role, verifies that the event document is a valid JSON document, and checks parameter values.

If the request passes validation, Lambda sends the request to a function instance. The Lambda runtime (p. 82) environment converts the event document into an object, and passes it to your function handler.

If Lambda encounters an error, it returns an exception type, message, and HTTP status code that indicates the cause of the error. The client or service that invoked the Lambda function can handle the error programmatically, or pass it along to an end user. The correct error handling behavior depends on the type of application, the audience, and the source of the error.

The following list describes the range of status codes you can receive from Lambda.

**2xx**

A `2xx` series error with a `X-Amz-Function-Error` header in the response indicates a Lambda runtime or function error. A `2xx` series status code indicates that Lambda accepted the request, but instead of an error code, Lambda indicates the error by including the `X-Amz-Function-Error` header in the response.

**4xx**

A `4xx` series error indicates an error that the invoking client or service can fix by modifying the request, requesting permission, or by retrying the request. `4xx` series errors other than `429` generally indicate an error with the request.

**5xx**

A `5xx` series error indicates an issue with Lambda, or an issue with the function's configuration or resources. `5xx` series errors can indicate a temporary condition that can be resolved without any action by the user. These issues can't be addressed by the invoking client or service, but a Lambda function's owner may be able to fix the issue.

For a complete list of invocation errors, see InvokeFunction errors (p. 995).

# Using the Lambda console

You can invoke your function on the Lambda console by configuring a test event and viewing the output. The output is captured in the function's execution logs and, when active tracing (p. 715) is enabled, in AWS X-Ray.

### To invoke a function on the Lambda console

1. Open the Functions page of the Lambda console.
2. Choose the function to test, and choose **Test**.
3. Under **Test event**, select **New event**.
4. Select a **Template**.

5. For **Name**, enter a name for the test. In the text entry box, enter the JSON test event.
6. Choose **Save changes**.
7. Choose **Test**.

The Lambda console invokes your function synchronously (p. 225) and displays the result. To see the response, logs, and other information, expand the **Details** section.

# Using the AWS Command Line Interface (AWS CLI)

The AWS CLI is an open-source tool that enables you to interact with AWS services using commands in your command line shell. To complete the steps in this section, you must have the following:

- AWS CLI – Install version 2
- AWS CLI – Quick configuration with `aws configure`

When you invoke a Lambda function in the AWS CLI, the AWS CLI splits the response into two documents. The AWS CLI response is displayed in your command prompt. If an error has occurred, the response contains a `FunctionError` field. The invocation response or error returned by the function is written to an output file. For example, `output.json` or `output.txt`.

The following invoke command example demonstrates how to invoke a function and write the invocation response to an `output.txt` file.

```
aws lambda invoke   \
  --function-name my-function   \
      --cli-binary-format raw-in-base64-out  \
          --payload '{"key1": "value1", "key2": "value2", "key3": "value3"}' output.txt
```

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

You should see the AWS CLI response in your command prompt:

```
{
    "StatusCode": 200,
    "FunctionError": "Unhandled",
    "ExecutedVersion": "$LATEST"
}
```

You should see the function invocation response in the `output.txt` file. In the same command prompt, you can also view the output in your command prompt using:

```
cat output.txt
```

You should see the invocation response in your command prompt.

Lambda also records up to 256 KB of the error object in the function's logs. For more information, see AWS Lambda function logging in PowerShell (p. 487).

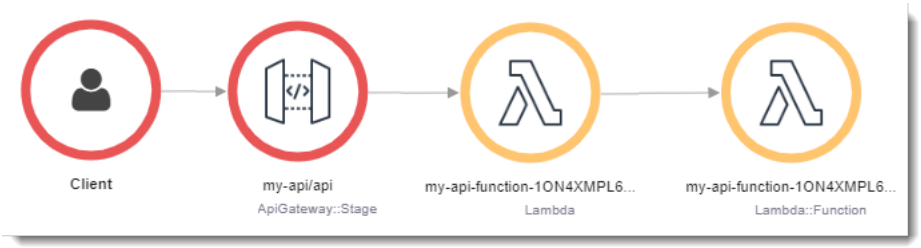
# Error handling in other AWS services

When another AWS service invokes your function, the service chooses the invocation type and retry behavior. AWS services can invoke your function on a schedule, in response to a lifecycle event on a

resource, or to serve a request from a user. Some services invoke functions asynchronously and let Lambda handle errors, while others retry or pass errors back to the user.

For example, API Gateway treats all invocation and function errors as internal errors. If the Lambda API rejects the invocation request, API Gateway returns a `500` error code. If the function runs but returns an error, or returns a response in the wrong format, API Gateway returns a 502 error code. To customize the error response, you must catch errors in your code and format a response in the required format.

We recommend using AWS X-Ray to determine the source of an error and its cause. X-Ray allows you to find out which component encountered an error, and see details about the errors. The following example shows a function error that resulted in a `502` response from API Gateway.




For more information, see Using AWS Lambda with AWS X-Ray (p. 715).

# What's next?

- Learn how to show logging events for your Lambda function on the the section called "Logging" (p. 487) page.

# Using AWS Lambda with other services

AWS Lambda integrates with other AWS services to invoke functions or take other actions. These are some common use cases:

- Invoke a function in response to resource lifecycle events, such as with Amazon Simple Storage Service (Amazon S3). For more information, see Using AWS Lambda with Amazon S3 (p. 663).
- Respond to incoming HTTP requests. For more information, see Tutorial: Using Lambda with API Gateway (p. 508).
- Consume events from a queue. For more information, see Using Lambda with Amazon SQS (p. 697).
- Run a function on a schedule. For more information, see Using AWS Lambda with Amazon EventBridge (CloudWatch Events) (p. 535).

Depending on which service you're using with Lambda, the invocation generally works in one of two ways. An event drives the invocation or Lambda polls a queue or data stream and invokes the function in response to activity in the queue or data stream. Lambda integrates with Amazon Elastic File System and AWS X-Ray in a way that doesn't involve invoking functions.

For more information, see Event-driven invocation (p. 498) and Lambda polling (p. 498). Or, look up the service that you want to work with in the following section to find a link to information about using that service with Lambda.

## Listing of services and links to more information

Find the service that you want to work with in the following table, to determine which method of invocation you should use. Follow the link from the service name to find information about how to set up the integration between the services. These topics also include example events that you can use to test your function.

**Tip**
Entries in this table are alphabetical by service name, excluding the "Amazon" or "AWS" prefix. You can also use your browser's search functionality to find your service in the list.

| Service | Method of invocation |
| --- | --- |
| Amazon Alexa (p. 501) | Event-driven; synchronous invocation |
| Amazon Managed Streaming for Apache Kafka (p. 646) | Lambda polling |
| Self-managed Apache Kafka (p. 600) | Lambda polling |
| Amazon API Gateway (p. 502) | Event-driven; synchronous invocation |
| AWS CloudFormation (p. 542) | Event-driven; asynchronous invocation |
| Amazon CloudFront (Lambda@Edge) (p. 544) | Event-driven; synchronous invocation |

| Service | Method of invocation |
| --- | --- |
| Amazon EventBridge (CloudWatch Events) (p. 535) | Event-driven; asynchronous invocation |
| Amazon CloudWatch Logs (p. 541) | Event-driven; asynchronous invocation |
| AWS CodeCommit (p. 546) | Event-driven; asynchronous invocation |
| AWS CodePipeline (p. 547) | Event-driven; asynchronous invocation |
| Amazon Cognito (p. 556) | Event-driven; synchronous invocation |
| AWS Config (p. 557) | Event-driven; asynchronous invocation |
| Amazon Connect (p. 558) | Event-driven; synchronous invocation |
| Amazon DynamoDB (p. 559) | Lambda polling |
| Amazon Elastic File System (p. 595) | Special integration |
| Elastic Load Balancing (Application Load Balancer) (p. 593) | Event-driven; synchronous invocation |
| AWS IoT (p. 597) | Event-driven; asynchronous invocation |
| AWS IoT Events (p. 598) | Event-driven; asynchronous invocation |
| Amazon Kinesis (p. 613) | Lambda polling |
| Amazon Kinesis Data Firehose (p. 612) | Event-driven; synchronous invocation |
| Amazon Lex (p. 635) | Event-driven; synchronous invocation |
| Amazon MQ (p. 638) | Lambda polling |
| Amazon Simple Email Service (p. 687) | Event-driven; asynchronous invocation |
| Amazon Simple Notification Service (p. 689) | Event-driven; asynchronous invocation |
| Amazon Simple Queue Service (p. 697) | Lambda polling |
| Amazon Simple Storage Service (Amazon S3) (p. 663) | Event-driven; asynchronous invocation |
| Amazon Simple Storage Service Batch (p. 683) | Event-driven; synchronous invocation |
| Secrets Manager (p. 686) | Event-driven; synchronous invocation |
| AWS X-Ray (p. 715) | Special integration |

# Event-driven invocation

Some services generate events that can invoke your Lambda function. For more information about designing these types of architectures , see Event driven architectures in the *Lambda operator guide*.

When you implement an event-driven architecture, you grant the event-generating service permission to invoke your function in the function's resource-based policy (p. 68). Then you configure that service to generate events that invoke your function.

The events are data structured in JSON format. The JSON structure varies depending on the service that generates it and the event type, but they all contain the data that the function needs to process the event.

Lambda converts the event document into an object and passes it to your function handler (p. 12). For compiled languages, Lambda provides definitions for event types in a library. For more information, see the topic about building functions with your language: Building Lambda functions with C# (p. 449), Building Lambda functions with Go (p. 420), Building Lambda functions with Java (p. 379), or Building Lambda functions with PowerShell (p. 481).

Depending on the service, the event-driven invocation can be synchronous or asynchronous.

- For synchronous invocation, the service that generates the event waits for the response from your function. That service defines the data that the function needs to return in the response. The service controls the error strategy, such as whether to retry on errors. For more information, see the section called “Synchronous invocation” (p. 225).
- For asynchronous invocation, Lambda queues the event before passing it to your function. When Lambda queues the event, it immediately sends a success response to the service that generated the event. After the function processes the event, Lambda doesn’t return a response to the event-generating service. For more information, see the section called “Asynchronous invocation” (p. 228).

For more information about how Lambda manages error handling for synchronously and asychronously invoked functions, see the section called “Error handling” (p. 250).

# Lambda polling

For services that generate a queue or data stream, you set up an event source mapping (p. 236) in Lambda to have Lambda poll the queue or a data stream.

When you implement a Lambda polling architecture, you grant Lambda permission to access the other service in the function's execution role (p. 52). Lambda reads data from the other service, creates an event, and invokes your function.

# Common Lambda application types and use cases

Lambda functions and triggers are the core components of building applications on AWS Lambda. A Lambda function is the code and runtime that process events, while a trigger is the AWS service or application that invokes the function. To illustrate, consider the following scenarios:

- **File processing** – Suppose you have a photo sharing application. People use your application to upload photos, and the application stores these user photos in an Amazon S3 bucket. Then, your application creates a thumbnail version of each user's photos and displays them on the user's profile page. In this scenario, you may choose to create a Lambda function that creates a thumbnail automatically. Amazon S3 is one of the supported AWS event sources that can publish *object-created events* and invoke your Lambda function. Your Lambda function code can read the photo object from the S3 bucket, create a thumbnail version, and then save it in another S3 bucket.
- **Data and analytics** – Suppose you are building an analytics application and storing raw data in a DynamoDB table. When you write, update, or delete items in a table, DynamoDB streams can publish item update events to a stream associated with the table. In this case, the event data provides the item key, event name (such as insert, update, and delete), and other relevant details. You can write a Lambda function to generate custom metrics by aggregating raw data.
- **Websites** – Suppose you are creating a website and you want to host the backend logic on Lambda. You can invoke your Lambda function over HTTP using Amazon API Gateway as the HTTP endpoint. Now, your web client can invoke the API, and then API Gateway can route the request to Lambda.
- **Mobile applications** – Suppose you have a custom mobile application that produces events. You can create a Lambda function to process events published by your custom application. For example, you can configure a Lambda function to process the clicks within your custom mobile application.

AWS Lambda supports many AWS services as event sources. For more information, see Using AWS Lambda with other services (p. 496). When you configure these event sources to trigger a Lambda function, the Lambda function is invoked automatically when events occur. You define *event source mapping*, which is how you identify what events to track and which Lambda function to invoke.

The following are introductory examples of event sources and how the end-to-end experience works.

## Example 1: Amazon S3 pushes events and invokes a Lambda function

Amazon S3 can publish events of different types, such as PUT, POST, COPY, and DELETE object events on a bucket. Using the bucket notification feature, you can configure an event source mapping that directs Amazon S3 to invoke a Lambda function when a specific type of event occurs.

The following is a typical sequence:

1. The user creates an object in a bucket.
2. Amazon S3 detects the object created event.
3. Amazon S3 invokes your Lambda function using the permissions provided by the execution role (p. 52).
4. AWS Lambda runs the Lambda function, specifying the event as a parameter.

You configure Amazon S3 to invoke your function as a bucket notification action. To grant Amazon S3 permission to invoke the function, update the function's resource-based policy (p. 68).

# Example 2: AWS Lambda pulls events from a Kinesis stream and invokes a Lambda function

For poll-based event sources, AWS Lambda polls the source and then invokes the Lambda function when records are detected on that source.

- CreateEventSourceMapping (p. 893)
- UpdateEventSourceMapping (p. 1078)

The following steps describe how a custom application writes records to a Kinesis stream:

1. The custom application writes records to a Kinesis stream.
2. AWS Lambda continuously polls the stream, and invokes the Lambda function when the service detects new records on the stream. AWS Lambda knows which stream to poll and which Lambda function to invoke based on the event source mapping you create in Lambda.
3. The Lambda function is invoked with the incoming event.

When working with stream-based event sources, you create event source mappings in AWS Lambda. Lambda reads items from the stream and invokes the function synchronously. You don't need to grant Lambda permission to invoke the function, but it does need permission to read from the stream.

# Using AWS Lambda with Alexa

You can use Lambda functions to build services that give new skills to Alexa, the Voice assistant on Amazon Echo. The Alexa Skills Kit provides the APIs, tools, and documentation to create these new skills, powered by your own services running as Lambda functions. Amazon Echo users can access these new skills by asking Alexa questions or making requests.

The Alexa Skills Kit is available on GitHub.

- Alexa Skills Kit SDK for Java
- Alexa Skills Kit SDK for Node.js
- Alexa Skills Kit SDK for Python

### Example Alexa smart home event

```
{
  "header": {
    "payloadVersion": "1",
    "namespace": "Control",
    "name": "SwitchOnOffRequest"
  },
  "payload": {
    "switchControlAction": "TURN_ON",
    "appliance": {
      "additionalApplianceDetails": {
        "key2": "value2",
        "key1": "value1"
      },
      "applianceId": "sampleId"
    },
    "accessToken": "sampleAccessToken"
  }
}
```

For more information, see Host a custom skill as an AWS Lambda Function in the *Build Skills with the Alexa Skills Kit* guide.

# Using AWS Lambda with Amazon API Gateway

You can create a web API with an HTTP endpoint for your Lambda function by using Amazon API Gateway. API Gateway provides tools for creating and documenting web APIs that route HTTP requests to Lambda functions. You can secure access to your API with authentication and authorization controls. Your APIs can serve traffic over the internet or can be accessible only within your VPC.

Resources in your API define one or more methods, such as GET or POST. Methods have an integration that routes requests to a Lambda function or another integration type. You can define each resource and method individually, or use special resource and method types to match all requests that fit a pattern. A *proxy resource* catches all paths beneath a resource. The `ANY` method catches all HTTP methods.

**Sections**


- Adding an endpoint to your Lambda function (p. 502)
- Proxy integration (p. 502)
- Event format (p. 503)
- Response format (p. 504)
- Permissions (p. 504)
- Handling errors with an API Gateway API (p. 506)
- Choosing an API type (p. 506)
- Sample applications (p. 508)
- Tutorial: Using Lambda with API Gateway (p. 508)
- Sample function code (p. 517)
- Create a simple microservice using Lambda and API Gateway (p. 520)
- AWS SAM template for an API Gateway application (p. 521)


## Adding an endpoint to your Lambda function

**To add a public endpoint to your Lambda function**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Under **Function overview**, choose **Add trigger**.
4. Select **API Gateway**.
5. Choose **Create an API** or **Use an existing API**.
   a. **New API:** For **API type**, choose **HTTP API**. For more information, see API types (p. 506).
   b. **Existing API:** Select the API from the dropdown menu or enter the API ID (for example, r3pmxmplak).
6. For **Security**, choose **Open**.
7. Choose **Add**.

## Proxy integration

API Gateway APIs are comprised of stages, resources, methods, and integrations. The stage and resource determine the path of the endpoint:

### API path format

- `/prod/` – The `prod` stage and root resource.
- `/prod/user` – The `prod` stage and `user` resource.
- `/dev/{proxy+}` – Any route in the `dev` stage.
- `/` – (HTTP APIs) The default stage and root resource.

A Lambda integration maps a path and HTTP method combination to a Lambda function. You can configure API Gateway to pass the body of the HTTP request as-is (custom integration), or to encapsulate the request body in a document that includes all of the request information including headers, resource, path, and method.

# Event format

Amazon API Gateway invokes your function synchronously (p. 225) with an event that contains a JSON representation of the HTTP request. For a custom integration, the event is the body of the request. For a proxy integration, the event has a defined structure. The following example shows a proxy event from an API Gateway REST API.

**Example event.json API Gateway proxy event (REST API)**

```
{
      "resource": "/",
      "path": "/",
      "httpMethod": "GET",
      "requestContext": {
          "resourcePath": "/",
          "httpMethod": "GET",
          "path": "/Prod/",
          ...
      },
      "headers": {
          "accept": "text/html,application/xhtml+xml,application/xml;q=0.9,image/
webp,image/apng,*/*;q=0.8,application/signed-exchange;v=b3;q=0.9",
          "accept-encoding": "gzip, deflate, br",
          "Host": "70ixmpl4fl.execute-api.us-east-2.amazonaws.com",
          "User-Agent": "Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36
 (KHTML, like Gecko) Chrome/80.0.3987.132 Safari/537.36",
          "X-Amzn-Trace-Id": "Root=1-5e66d96f-7491f09xmpl79d18acf3d050",
          ...
      },
      "multiValueHeaders": {
          "accept": [
              "text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,image/
apng,*/*;q=0.8,application/signed-exchange;v=b3;q=0.9"
          ],
          "accept-encoding": [
              "gzip, deflate, br"
          ],
          ...
      },
      "queryStringParameters": null,
      "multiValueQueryStringParameters": null,
      "pathParameters": null,
      "stageVariables": null,
      "body": null,
      "isBase64Encoded": false
  }
```

# Response format

API Gateway waits for a response from your function and relays the result to the caller. For a custom integration, you define an integration response and a method response to convert the output from the function to an HTTP response. For a proxy integration, the function must respond with a representation of the response in a specific format.

The following example shows a response object from a Node.js function. The response object represents a successful HTTP response that contains a JSON document.

**Example index.js – Proxy integration response object (Node.js)**

```
var response = {
      "statusCode": 200,
      "headers": {
        "Content-Type": "application/json"
      },
      "isBase64Encoded": false,
      "multiValueHeaders": {
        "X-Custom-Header": ["My value", "My other value"],
      },
      "body": "{\n  \"TotalCodeSize\": 104330022,\n  \"FunctionCount\": 26\n}"
    }
```

The Lambda runtime serializes the response object into JSON and sends it to the API. The API parses the response and uses it to create an HTTP response, which it then sends to the client that made the original request.

**Example HTTP response**

```
< HTTP/1.1 200 OK
  < Content-Type: application/json
  < Content-Length: 55
  < Connection: keep-alive
  < x-amzn-RequestId: 32998fea-xmpl-4268-8c72-16138d629356
  < X-Custom-Header: My value
  < X-Custom-Header: My other value
  < X-Amzn-Trace-Id: Root=1-5e6aa925-ccecxmplbae116148e52f036
  <
  {
    "TotalCodeSize": 104330022,
    "FunctionCount": 26
  }
```

# Permissions

Amazon API Gateway gets permission to invoke your function from the function's resource-based policy (p. 68). You can grant invoke permission to an entire API, or grant limited access to a stage, resource, or method.

When you add an API to your function by using the Lambda console, using the API Gateway console, or in an AWS SAM template, the function's resource-based policy is updated automatically. The following is an example function policy.

**Example function policy**

```
{
  "Version": "2012-10-17",
  "Id": "default",
  "Statement": [
```

```
    {
      "Sid": "nodejs-apig-functiongetEndpointPermissionProd-BWDBXMPLXE2F",
      "Effect": "Allow",
      "Principal": {
        "Service": "apigateway.amazonaws.com"
      },
      "Action": "lambda:InvokeFunction",
      "Resource": "arn:aws:lambda:us-east-2:111122223333:function:nodejs-apig-
function-1G3MXMPLXVXYI",
      "Condition": {
        "StringEquals": {
          "aws:SourceAccount": "111122223333"
        },
        "ArnLike": {
          "aws:SourceArn": "arn:aws:execute-api:us-east-2:111122223333:ktyvxmpls1/*/GET/"
        }
      }
    }
  ]
}
```

You can manage function policy permissions manually with the following API operations:

- AddPermission (p. 881)
- RemovePermission (p. 1065)
- GetPolicy (p. 988)

To grant invocation permission to an existing API, use the `add-permission` command.

```
aws lambda add-permission --function-name my-function \
--statement-id apigateway-get --action lambda:InvokeFunction \
--principal apigateway.amazonaws.com \
--source-arn "arn:aws:execute-api:us-east-2:123456789012:mnh1xmpli7/default/GET/"
```

You should see the following output:

```
{
    "Statement": "{\"Sid\":\"apigateway-test-2\",\"Effect\":\"Allow\",\"Principal\":
{\"Service\":\"apigateway.amazonaws.com\"},\"Action\":\"lambda:InvokeFunction\",\"Resource
\":\"arn:aws:lambda:us-east-2:123456789012:function:my-function\",\"Condition\":{\"ArnLike
\":{\"AWS:SourceArn\":\"arn:aws:execute-api:us-east-2:123456789012:mnh1xmpli7/default/GET
\"}}}"
}
```

**Note**
If your function and API are in different regions, the region identifier in the source ARN must match the region of the function, not the region of the API. When API Gateway invokes a function, it uses a resource ARN that is based on the ARN of the API, but modified to match the function's region.

The source ARN in this example grants permission to an integration on the GET method of the root resource in the default stage of an API, with ID `mnh1xmpli7`. You can use an asterisk in the source ARN to grant permissions to multiple stages, methods, or resources.

### Resource patterns

- `mnh1xmpli7/*/GET/*` – GET method on all resources in all stages.
- `mnh1xmpli7/prod/ANY/user` – ANY method on the `user` resource in the `prod` stage.
- `mnh1xmpli7/*/*/*` – Any method on all resources in all stages.

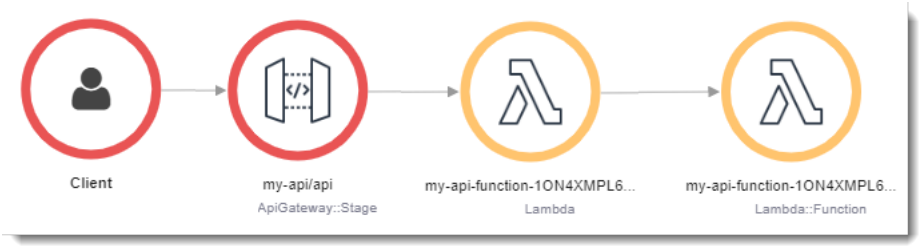
For details on viewing the policy and removing statements, see Cleaning up resource-based policies (p. 72).

# Handling errors with an API Gateway API

API Gateway treats all invocation and function errors as internal errors. If the Lambda API rejects the invocation request, API Gateway returns a 500 error code. If the function runs but returns an error, or returns a response in the wrong format, API Gateway returns a 502. In both cases, the body of the response from API Gateway is `{"message": "Internal server error"}`.

> **Note**
> API Gateway does not retry any Lambda invocations. If Lambda returns an error, API Gateway returns an error response to the client.

The following example shows an X-Ray trace map for a request that resulted in a function error and a 502 from API Gateway. The client receives the generic error message.

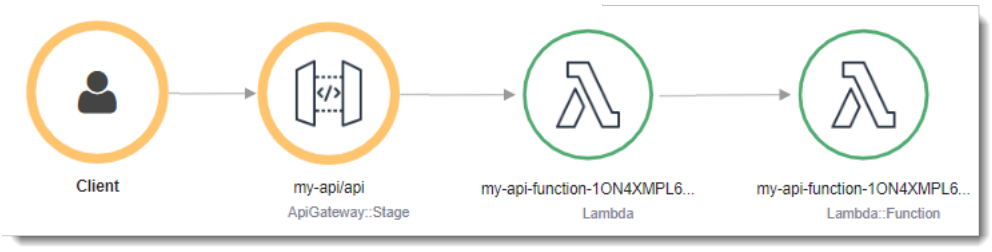



To customize the error response, you must catch errors in your code and format a response in the required format.

**Example index.js – Error formatting**

```
var formatError = function(error){
  var response = {
    "statusCode": error.statusCode,
    "headers": {
      "Content-Type": "text/plain",
      "x-amzn-ErrorType": error.code
    },
    "isBase64Encoded": false,
    "body": error.code + ": " + error.message
  }
  return response
}
```

API Gateway converts this response into an HTTP error with a custom status code and body. In the trace map, the function node is green because it handled the error.




# Choosing an API type

API Gateway supports three types of APIs that invoke Lambda functions:

- **HTTP API** – A lightweight, low-latency RESTful API.
- **REST API** – A customizable, feature-rich RESTful API.
- **WebSocket API** – A web API that maintains persistent connections with clients for full-duplex communication.

HTTP APIs and REST APIs are both RESTful APIs that process HTTP requests and return responses. HTTP APIs are newer and are built with the API Gateway version 2 API. The following features are new for HTTP APIs:

### HTTP API features

- **Automatic deployments** – When you modify routes or integrations, changes deploy automatically to stages that have automatic deployment enabled.
- **Default stage** – You can create a default stage (`$default`) to serve requests at the root path of your API's URL. For named stages, you must include the stage name at the beginning of the path.
- **CORS configuration** – You can configure your API to add CORS headers to outgoing responses, instead of adding them manually in your function code.

REST APIs are the classic RESTful APIs that API Gateway has supported since launch. REST APIs currently have more customization, integration, and management features.

### REST API features

- **Integration types** – REST APIs support custom Lambda integrations. With a custom integration, you can send just the body of the request to the function, or apply a transform template to the request body before sending it to the function.
- **Access control** – REST APIs support more options for authentication and authorization.
- **Monitoring and tracing** – REST APIs support AWS X-Ray tracing and additional logging options.

For a detailed comparison, see Choosing between HTTP APIs and REST APIs in the *API Gateway Developer Guide*.

WebSocket APIs also use the API Gateway version 2 API and support a similar feature set. Use a WebSocket API for applications that benefit from a persistent connection between the client and API. WebSocket APIs provide full-duplex communication, which means that both the client and the API can send messages continuously without waiting for a response.

HTTP APIs support a simplified event format (version 2.0). The following example shows an event from an HTTP API.

**Example event-v2.json – API Gateway proxy event (HTTP API)**

```
{
    "version": "2.0",
    "routeKey": "ANY /nodejs-apig-function-1G3XMPLZXVXYI",
    "rawPath": "/default/nodejs-apig-function-1G3XMPLZXVXYI",
    "rawQueryString": "",
    "cookies": [
        "s_fid=7AABXMPL1AFD9BBF-0643XMPL09956DE2",
        "regStatus=pre-register"
    ],
    "headers": {
        "accept": "text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,image/
apng,*/*;q=0.8,application/signed-exchange;v=b3;q=0.9",
        "accept-encoding": "gzip, deflate, br",
```

```
        ...
    },
    "requestContext": {
        "accountId": "123456789012",
        "apiId": "r3pmxmplak",
        "domainName": "r3pmxmplak.execute-api.us-east-2.amazonaws.com",
        "domainPrefix": "r3pmxmplak",
        "http": {
            "method": "GET",
            "path": "/default/nodejs-apig-function-1G3XMPLZXVXYI",
            "protocol": "HTTP/1.1",
            "sourceIp": "205.255.255.176",
            "userAgent": "Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36
 (KHTML, like Gecko) Chrome/80.0.3987.132 Safari/537.36"
        },
        "requestId": "JKJaXmPLvHcESHA=",
        "routeKey": "ANY /nodejs-apig-function-1G3XMPLZXVXYI",
        "stage": "default",
        "time": "10/Mar/2020:05:16:23 +0000",
        "timeEpoch": 1583817383220
    },
    "isBase64Encoded": true
}
```

For more information, see AWS Lambda integrations in the API Gateway Developer Guide.

# Sample applications

The GitHub repository for this guide provides the following sample application for API Gateway.

- API Gateway with Node.js – A function with an AWS SAM template that creates a REST API that has AWS X-Ray tracing enabled. It includes scripts for deploying, invoking the function, testing the API, and cleanup.

Lambda also provides blueprints (p. 20) and templates (p. 21) that you can use to create an API Gateway application in the Lambda console.

# Tutorial: Using Lambda with API Gateway

In this tutorial, you use Amazon API Gateway to create a REST API and a resource (`DynamoDBManager`). You define one method (`POST`) on the resource, and create a Lambda function (`LambdaFunctionOverHttps`) that backs the `POST` method. That way, when you call the API through an HTTPS endpoint, API Gateway invokes the Lambda function.

The `POST` method that you define on the `DynamoDBManager` resource supports the following Amazon DynamoDB operations:

- Create, update, and delete an item.
- Read an item.
- Scan an item.
- Other operations (echo, ping), not related to DynamoDB, that you can use for testing.

Using API Gateway with Lambda also provides advanced capabilities, such as:

- **Full request passthrough** – Using the Lambda proxy (`AWS_PROXY`) integration type, a Lambda function can receive an entire HTTP request (instead of just the request body) and set the HTTP response (instead of just the response body).

- **Catch-all methods** – Using the `ANY` catch-all method, you can map all methods of an API resource to a single Lambda function with a single mapping.
- **Catch-all resources** – Using a greedy path variable (`{proxy+}`), you can map all sub-paths of a resource to a Lambda function without any additional configuration.

For more information about these API Gateway features, see Set up a proxy integration with a proxy resource in the *API Gateway Developer Guide*.

**Sections**


- Prerequisites (p. 509)
- Create an execution role (p. 509)
- Create the function (p. 510)
- Test the function (p. 513)
- Create a REST API using API Gateway (p. 514)
- Create a DynamoDB table (p. 515)
- Test the setup (p. 515)
- Clean up your resources (p. 281)


## Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

## Create an execution role

Create an execution role (p. 52). This AWS Identity and Access Management (IAM) role uses a custom policy to give your Lambda function permission to access the required AWS resources. Note that you must first create the policy and then create the execution role.

### To create a custom policy

1. Open the Policies page of the IAM console.
2. Choose **Create Policy**.
3. Choose the **JSON** tab, and then paste the following custom policy into the JSON editor.

```
{
  "Version": "2012-10-17",
```

```
  "Statement": [
    {
      "Sid": "Stmt1428341300017",
      "Action": [
        "dynamodb:DeleteItem",
        "dynamodb:GetItem",
        "dynamodb:PutItem",
        "dynamodb:Query",
        "dynamodb:Scan",
        "dynamodb:UpdateItem"
      ],
      "Effect": "Allow",
      "Resource": "*"
    },
    {
      "Sid": "",
      "Resource": "*",
      "Action": [
        "logs:CreateLogGroup",
        "logs:CreateLogStream",
        "logs:PutLogEvents"
      ],
      "Effect": "Allow"
    }
  ]
}
```

This policy includes permissions for your function to access DynamoDB and Amazon CloudWatch Logs.

4. Choose **Next: Tags**.
5. Choose **Next: Review**.
6. Under **Review policy**, for the policy **Name**, enter **`lambda-apigateway-policy`**.
7. Choose **Create policy**.

### To create an execution role

1. Open the Roles page of the IAM console.
2. Choose **Create role**.
3. For the type of trusted entity, choose **AWS service**.
4. For the use case, choose **Lambda**.
5. Choose **Next: Permissions**.
6. In the policy search box, enter **`lambda-apigateway-policy`**.
7. In the search results, select the policy that you created (`lambda-apigateway-policy`), and then choose **Next: Tags**.
8. Choose **Next: Review**.
9. Under **Review**, for the **Role name**, enter **`lambda-apigateway-role`**.
10. Choose **Create role**.
11. On the **Roles** page, choose the name of your role (`lambda-apigateway-role`).
12. On the **Summary** page, copy the **Role ARN**. You need this later in the tutorial.

## Create the function

The following code example receives an API Gateway event input and processes the messages that this input contains. For illustration, the code writes some of the incoming event data to CloudWatch Logs.

Node.js

**Example index.js**

```
console.log('Loading function');

var AWS = require('aws-sdk');
var dynamo = new AWS.DynamoDB.DocumentClient();

/**
 * Provide an event that contains the following keys:
 *
 *   - operation: one of the operations in the switch statement below
 *   - tableName: required for operations that interact with DynamoDB
 *   - payload: a parameter to pass to the operation being performed
 */
exports.handler = function(event, context, callback) {
    //console.log('Received event:', JSON.stringify(event, null, 2));

    var operation = event.operation;

    if (event.tableName) {
        event.payload.TableName = event.tableName;
    }

    switch (operation) {
        case 'create':
            dynamo.put(event.payload, callback);
            break;
        case 'read':
            dynamo.get(event.payload, callback);
            break;
        case 'update':
            dynamo.update(event.payload, callback);
            break;
        case 'delete':
            dynamo.delete(event.payload, callback);
            break;
        case 'list':
            dynamo.scan(event.payload, callback);
            break;
        case 'echo':
            callback(null, "Success");
            break;
        case 'ping':
            callback(null, "pong");
            break;
        default:
            callback(`Unknown operation: ${operation}`);
    }
};
```

**To create the function**

1. Save the code example as a file named `index.js`.
2. Create a deployment package.

   ```
   zip function.zip index.js
   ```

3. Create a Lambda function using the `create-function` AWS Command Line Interface (AWS CLI) command. For the `role` parameter, enter the execution role's Amazon Resource Name (ARN), which you copied earlier.

```
aws lambda create-function --function-name LambdaFunctionOverHttps \
--zip-file fileb://function.zip --handler index.handler --runtime nodejs12.x \
--role arn:aws:iam::123456789012:role/service-role/lambda-apigateway-role
```

Python 3

**Example LambdaFunctionOverHttps.py**

```
from __future__ import print_function

import boto3
import json

print('Loading function')


def handler(event, context):
    '''Provide an event that contains the following keys:

      - operation: one of the operations in the operations dict below
      - tableName: required for operations that interact with DynamoDB
      - payload: a parameter to pass to the operation being performed
    '''
    #print("Received event: " + json.dumps(event, indent=2))

    operation = event['operation']

    if 'tableName' in event:
        dynamo = boto3.resource('dynamodb').Table(event['tableName'])

    operations = {
        'create': lambda x: dynamo.put_item(**x),
        'read': lambda x: dynamo.get_item(**x),
        'update': lambda x: dynamo.update_item(**x),
        'delete': lambda x: dynamo.delete_item(**x),
        'list': lambda x: dynamo.scan(**x),
        'echo': lambda x: x,
        'ping': lambda x: 'pong'
    }

    if operation in operations:
        return operations[operation](event.get('payload'))
    else:
        raise ValueError('Unrecognized operation "{}"'.format(operation))
```

**To create the function**

1. Save the code example as a file named `LambdaFunctionOverHttps.py`.
2. Create a deployment package.

```
zip function.zip LambdaFunctionOverHttps.py
```

3. Create a Lambda function using the `create-function` AWS Command Line Interface (AWS CLI) command. For the `role` parameter, enter the execution role's Amazon Resource Name (ARN), which you copied earlier.

```
aws lambda create-function --function-name LambdaFunctionOverHttps \
--zip-file fileb://function.zip --handler LambdaFunctionOverHttps.handler --runtime
 python3.8 \
```

```
--role arn:aws:iam::123456789012:role/service-role/lambda-apigateway-role
```

Go

**Example LambdaFunctionOverHttps.go**

```
package main

import (
    "context"
    "fmt"
    "github.com/aws/aws-lambda-go/events"
    runtime "github.com/aws/aws-lambda-go/lambda"
)

func main() {
    runtime.Start(handleRequest)
}

func handleRequest(ctx context.Context, request events.APIGatewayProxyRequest)
 (events.APIGatewayProxyResponse, error) {
    fmt.Printf("Processing request data for request %s.\n",
 request.RequestContext.RequestID)
    fmt.Printf("Body size = %d.\n", len(request.Body))

    fmt.Println("Headers:")
    for key, value := range request.Headers {
        fmt.Printf("    %s: %s\n", key, value)
    }

    return events.APIGatewayProxyResponse{Body: request.Body, StatusCode: 200}, nil
}
```

**To create the function**

1. Save the code example as a file named `LambdaFunctionOverHttps.go`.
2. Compile your executable.

   ```
   GOOS=linux go build LambdaFunctionOverHttps.go
   ```

3. Create a deployment package.

   ```
   zip function.zip LambdaFunctionOverHttps
   ```

4. Create a Lambda function using the `create-function` AWS Command Line Interface (AWS CLI) command. For the `role` parameter, enter the execution role's Amazon Resource Name (ARN), which you copied earlier.

   ```
   aws lambda create-function --function-name LambdaFunctionOverHttps \
   --zip-file fileb://function.zip --handler LambdaFunctionOverHttps --runtime go1.x \
   --role arn:aws:iam::123456789012:role/service-role/lambda-apigateway-role
   ```

## Test the function

Test the Lambda function manually using the following sample event data. You can invoke the function using the `invoke` AWS CLI command or by using the Lambda console (p. 165).

**To test the Lambda function (AWS CLI)**

1. Save the following JSON as a file named `input.txt`.

```
{
    "operation": "echo",
    "payload": {
        "somekey1": "somevalue1",
        "somekey2": "somevalue2"
    }
}
```

2. Run the following `invoke` AWS CLI command.

```
aws lambda invoke --function-name LambdaFunctionOverHttps \
--payload file://input.txt outputfile.txt --cli-binary-format raw-in-base64-out
```

   The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

3. Verify the output in the file `outputfile.txt`.

# Create a REST API using API Gateway

In this section, you create an API Gateway REST API (`DynamoDBOperations`) with one resource (`DynamoDBManager`) and one method (`POST`). You associate the `POST` method with your Lambda function. Then, you test the setup.

When your API method receives an HTTP request, API Gateway invokes your Lambda function.

## Create the API

In the following steps, you create the `DynamoDBOperations` REST API using the API Gateway console.

**To create the API**

1. Open the API Gateway console.
2. Choose **Create API**.
3. In the **REST API** box, choose **Build**.
4. Under **Create new API**, choose **New API**.
5. Under **Settings**, do the following:
   1. For **API name**, enter **`DynamoDBOperations`**.
   2. For **Endpoint Type**, choose **Regional**.
6. Choose **Create API**.

## Create a resource in the API

In the following steps, you create a resource named `DynamoDBManager` in your REST API.

**To create the resource**

1. In the API Gateway console, in the **Resources** tree of your API, make sure that the root (`/`) level is highlighted. Then, choose **Actions**, **Create Resource**.

2. Under **New child resource**, do the following:
    1. For **Resource Name**, enter **`DynamoDBManager`**.
    2. Keep **Resource Path** set to `/dynamodbmanager`.
3. Choose **Create Resource**.

### Create a POST method on the resource

In the following steps, you create a `POST` method on the `DynamoDBManager` resource that you created in the previous section.

**To create the method**

1. In the API Gateway console, in the **Resources** tree of your API, make sure that `/dynamodbmanager` is highlighted. Then, choose **Actions**, **Create Method**.
2. In the small dropdown menu that appears under `/dynamodbmanager`, choose `POST`, and then choose the check mark icon.
3. In the method's **Setup** pane, do the following:
    1. For **Integration type**, choose **Lambda Function**.
    2. For **Lambda Region**, choose the same AWS Region as your Lambda function.
    3. For **Lambda Function**, enter the name of your function (**`LambdaFunctionOverHttps`**).
    4. Select **Use Default Timeout**.
    5. Choose **Save**.
4. In the **Add Permission to Lambda Function** dialog box, choose **OK**.

## Create a DynamoDB table

Create the DynamoDB table that your Lambda function uses.

**To create the DynamoDB table**

1. Open the Tables page of the DynamoDB console.
2. Choose **Create table**.
3. Under **Table details**, do the following:
    1. For **Table name**, enter **`lambda-apigateway`**.
    2. For **Partition key**, enter **`id`**, and keep the data type set as **String**.
4. Under **Settings**, keep the **Default settings**.
5. Choose **Create table**.

## Test the setup

You're now ready to test the setup. You can send requests to your `POST` method directly from the API Gateway console. In this step, you use a `create` operation followed by an `update` operation.

**To create an item in your DynamoDB table**

Your Lambda function can use the `create` operation to create an item in your DynamoDB table.

1. In the API Gateway console, choose the name of your REST API (`DynamoDBOperations`).
2. In the **Resources** tree, under `/dynamodbmanager`, choose your `POST` method.

3. In the **Method Execution** pane, in the **Client** box, choose **Test**.
4. In the **Method Test** pane, keep **Query Strings** and **Headers** empty. For **Request Body**, paste the following JSON:

```
{
  "operation": "create",
  "tableName": "lambda-apigateway",
  "payload": {
    "Item": {
      "id": "1234ABCD",
      "number": 5
    }
  }
}
```

5. Choose **Test**.

The test results should show status `200`, indicating that the `create` operation was successful. To confirm, you can check that your DynamoDB table now contains an item with `"id": "1234ABCD"` and `"number": "5"`.

### To update the item in your DynamoDB table

You can also update items in the table using the `update` operation.

1. In the API Gateway console, return to your POST method's **Method Test** pane.
2. In the **Method Test** pane, keep **Query Strings** and **Headers** empty. In **Request Body**, paste the following JSON:

```
{
    "operation": "update",
    "tableName": "lambda-apigateway",
    "payload": {
        "Key": {
            "id": "1234ABCD"
        },
        "AttributeUpdates": {
            "number": {
                "Value": 10
            }
        }
    }
}
```

3. Choose **Test**.

The test results should show status `200`, indicating that the `update` operation was successful. To confirm, you can check that your DynamoDB table now contains an updated item with `"id": "1234ABCD"` and `"number": "10"`.

## Clean up your resources

You can now delete the resources that you created for this tutorial, unless you want to retain them. By deleting AWS resources that you're no longer using, you prevent unnecessary charges to your AWS account.

### To delete the Lambda function

1. Open the Functions page of the Lambda console.

2. Select the function that you created.
3. Choose **Actions**, then choose **Delete**.
4. Choose **Delete**.

### To delete the execution role

1. Open the Roles page of the IAM console.
2. Select the execution role that you created.
3. Choose **Delete role**.
4. Choose **Yes, delete**.

### To delete the API

1. Open the APIs page of the API Gateway console.
2. Select the API you created.
3. Choose **Actions**, **Delete**.
4. Choose **Delete**.

### To delete the DynamoDB table

1. Open the Tables page of the DynamoDB console.
2. Select the table you created.
3. Choose **Delete**.
4. Enter **`delete`** in the text box.
5. Choose **Delete**.

# Sample function code

Sample code is available for the following languages.

**Topics**


- Node.js (p. 517)
- Python 3 (p. 518)
- Go (p. 519)


# Node.js

The following example processes messages from API Gateway, and manages DynamoDB documents based on the request method.

### Example index.js

```
console.log('Loading function');

var AWS = require('aws-sdk');
var dynamo = new AWS.DynamoDB.DocumentClient();

/**
```

```
 * Provide an event that contains the following keys:
 *
 *   - operation: one of the operations in the switch statement below
 *   - tableName: required for operations that interact with DynamoDB
 *   - payload: a parameter to pass to the operation being performed
 */
exports.handler = function(event, context, callback) {
    //console.log('Received event:', JSON.stringify(event, null, 2));

    var operation = event.operation;

    if (event.tableName) {
        event.payload.TableName = event.tableName;
    }

    switch (operation) {
        case 'create':
            dynamo.put(event.payload, callback);
            break;
        case 'read':
            dynamo.get(event.payload, callback);
            break;
        case 'update':
            dynamo.update(event.payload, callback);
            break;
        case 'delete':
            dynamo.delete(event.payload, callback);
            break;
        case 'list':
            dynamo.scan(event.payload, callback);
            break;
        case 'echo':
            callback(null, "Success");
            break;
        case 'ping':
            callback(null, "pong");
            break;
        default:
            callback(`Unknown operation: ${operation}`);
    }
};
```

Zip up the sample code to create a deployment package. For instructions, see Deploy Node.js Lambda functions with .zip file archives (p. 288).

## Python 3

The following example processes messages from API Gateway, and manages DynamoDB documents based on the request method.

**Example LambdaFunctionOverHttps.py**

```
from __future__ import print_function

import boto3
import json

print('Loading function')


def handler(event, context):
    '''Provide an event that contains the following keys:
```

```
      - operation: one of the operations in the operations dict below
      - tableName: required for operations that interact with DynamoDB
      - payload: a parameter to pass to the operation being performed
    '''
    #print("Received event: " + json.dumps(event, indent=2))

    operation = event['operation']

    if 'tableName' in event:
        dynamo = boto3.resource('dynamodb').Table(event['tableName'])

    operations = {
        'create': lambda x: dynamo.put_item(**x),
        'read': lambda x: dynamo.get_item(**x),
        'update': lambda x: dynamo.update_item(**x),
        'delete': lambda x: dynamo.delete_item(**x),
        'list': lambda x: dynamo.scan(**x),
        'echo': lambda x: x,
        'ping': lambda x: 'pong'
    }

    if operation in operations:
        return operations[operation](event.get('payload'))
    else:
        raise ValueError('Unrecognized operation "{}"'.format(operation))
```

Zip up the sample code to create a deployment package. For instructions, see Deploy Python Lambda functions with .zip file archives (p. 330).

## Go

The following example processes messages from API Gateway, and logs information about the request.

**Example LambdaFunctionOverHttps.go**

```
import (
    "context"
    "fmt"
    "github.com/aws/aws-lambda-go/events"
    runtime "github.com/aws/aws-lambda-go/lambda"
)

func main() {
    runtime.Start(handleRequest)
}

func handleRequest(ctx context.Context, request events.APIGatewayProxyRequest)
 (events.APIGatewayProxyResponse, error) {
    fmt.Printf("Processing request data for request %s.\n",
 request.RequestContext.RequestID)
    fmt.Printf("Body size = %d.\n", len(request.Body))

    fmt.Println("Headers:")
    for key, value := range request.Headers {
        fmt.Printf("    %s: %s\n", key, value)
    }

    return events.APIGatewayProxyResponse{Body: request.Body, StatusCode: 200}, nil
}
```

Build the executable with `go build` and create a deployment package. For instructions, see Deploy Go Lambda functions with .zip file archives (p. 427).

# Create a simple microservice using Lambda and API Gateway

In this tutorial you will use the Lambda console to create a Lambda function, and an Amazon API Gateway endpoint to trigger that function. You will be able to call the endpoint with any method (`GET`, `POST`, `PATCH`, etc.) to trigger your Lambda function. When the endpoint is called, the entire request will be passed through to your Lambda function. Your function action will depend on the method you call your endpoint with:

- DELETE: delete an item from a DynamoDB table
- GET: scan table and return all items
- POST: Create an item
- PUT: Update an item

## Create an API using Amazon API Gateway

Follow the steps in this section to create a new Lambda function and an API Gateway endpoint to trigger it:

**To create an API**

1. Sign in to the AWS Management Console and open the AWS Lambda console.
2. Choose **Create Lambda function**.
3. Choose **Use a blueprint**.
4. Enter **`microservice`** in the search bar. Choose the **microservice-http-endpoint** blueprint.
5. Configure your function with the following settings.

   - **Name** – **`lambda-microservice`**.
   - **Role** – **Create a new role from AWS policy templates**.
   - **Role name** – **`lambda-apigateway-role`**.
   - **Policy templates** – **Simple microservice permissions**.
   - **API** – **Create an API**.
   - **API Type** – **HTTP API**.
   - **Security** – **Open**.

   Choose **Create function**.

When you complete the wizard and create your function, Lambda creates a proxy resource named `lambda-microservice` under the API name you selected. For more information about proxy resources, see Configure proxy integration for a proxy resource.

A proxy resource has an `AWS_PROXY` integration type and a catch-all method `ANY`. The `AWS_PROXY` integration type applies a default mapping template to pass through the entire request to the Lambda function and transforms the output from the Lambda function to HTTP responses. The `ANY` method defines the same integration setup for all the supported methods, including `GET`, `POST`, `PATCH`, `DELETE` and others.

## Test sending an HTTP request

In this step, you will use the console to test the Lambda function. In addition, you can run a `curl` command to test the end-to-end experience. That is, send an HTTP request to your API method and have

Amazon API Gateway invoke your Lambda function. In order to complete the steps, make sure you have created a DynamoDB table and named it "MyTable". For more information, see Create a DynamoDB table with a stream enabled (p. 574).

**To test the API**

1. With your `lambda-microservice` function still open in the Lambda console, choose the **Test** tab.
2. Choose **New event**.
3. Choose the **Hello World** template.
4. In **Name**, enter a name for the test event.
5. In the text entry panel, replace the existing text with the following:

```
{
 "httpMethod": "GET",
 "queryStringParameters": {
 "TableName": "MyTable"
    }
}
```

   This `GET` command scans your DynamoDB table and returns all items found.
6. After entering the text above choose **Test**.

Verify that the test succeeded. In the function response, you should see the following:

```
{
  "statusCode": "200",
  "body": "{\"Items\":[],\"Count\":0,\"ScannedCount\":0}",
  "headers": {
    "Content-Type": "application/json"
  }
}
```

# AWS SAM template for an API Gateway application

Below is a sample AWS SAM template for the Lambda application from the tutorial (p. 508). Copy the text below to a file and save it next to the ZIP package you created previously. Note that the `Handler` and `Runtime` parameter values should match the ones you used when you created the function in the previous section.

**Example template.yaml**

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Resources:
  LambdaFunctionOverHttps:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs12.x
      Policies: AmazonDynamoDBFullAccess
      Events:
        HttpPost:
          Type: Api
          Properties:
            Path: '/DynamoDBOperations/DynamoDBManager'
            Method: post
```

For information on how to package and deploy your serverless application using the package and deploy commands, see Deploying serverless applications in the *AWS Serverless Application Model Developer Guide*.

# Using AWS Lambda with AWS CloudTrail

AWS CloudTrail is a service that provides a record of actions taken by a user, role, or an AWS service. CloudTrail captures API calls as events. For an ongoing record of events in your AWS account, you create a trail. A trail enables CloudTrail to deliver log files of events to an Amazon S3 bucket.

You can take advantage of Amazon S3's bucket notification feature and direct Amazon S3 to publish object-created events to AWS Lambda. Whenever CloudTrail writes logs to your S3 bucket, Amazon S3 can then invoke your Lambda function by passing the Amazon S3 object-created event as a parameter. The S3 event provides information, including the bucket name and key name of the log object that CloudTrail created. Your Lambda function code can read the log object and process the access records logged by CloudTrail. For example, you might write Lambda function code to notify you if specific API call was made in your account.

In this scenario, CloudTrail writes access logs to your S3 bucket. As for AWS Lambda, Amazon S3 is the event source so Amazon S3 publishes events to AWS Lambda and invokes your Lambda function.

**Example CloudTrail log**

```
{
   "Records":[
      {
         "eventVersion":"1.02",
         "userIdentity":{
            "type":"Root",
            "principalId":"123456789012",
            "arn":"arn:aws:iam::123456789012:root",
            "accountId":"123456789012",
            "accessKeyId":"access-key-id",
            "sessionContext":{
               "attributes":{
                  "mfaAuthenticated":"false",
                  "creationDate":"2015-01-24T22:41:54Z"
               }
            }
         },
         "eventTime":"2015-01-24T23:26:50Z",
         "eventSource":"sns.amazonaws.com",
         "eventName":"CreateTopic",
         "awsRegion":"us-east-2",
         "sourceIPAddress":"205.251.233.176",
         "userAgent":"console.amazonaws.com",
         "requestParameters":{
            "name":"dropmeplease"
         },
         "responseElements":{
            "topicArn":"arn:aws:sns:us-east-2:123456789012:exampletopic"
         },
         "requestID":"3fdb7834-9079-557e-8ef2-350abc03536b",
         "eventID":"17b46459-dada-4278-b8e2-5a4ca9ff1a9c",
         "eventType":"AwsApiCall",
         "recipientAccountId":"123456789012"
      },
      {
         "eventVersion":"1.02",
         "userIdentity":{
            "type":"Root",
            "principalId":"123456789012",
            "arn":"arn:aws:iam::123456789012:root",
            "accountId":"123456789012",
            "accessKeyId": "AKIAIOSFODNN7EXAMPLE",
            "sessionContext":{
```

```
                "attributes":{
                   "mfaAuthenticated":"false",
                   "creationDate":"2015-01-24T22:41:54Z"
                }
             }
          },
          "eventTime":"2015-01-24T23:27:02Z",
          "eventSource":"sns.amazonaws.com",
          "eventName":"GetTopicAttributes",
          "awsRegion":"us-east-2",
          "sourceIPAddress":"205.251.233.176",
          "userAgent":"console.amazonaws.com",
          "requestParameters":{
             "topicArn":"arn:aws:sns:us-east-2:123456789012:exampletopic"
          },
          "responseElements":null,
          "requestID":"4a0388f7-a0af-5df9-9587-c5c98c29cbec",
          "eventID":"ec5bb073-8fa1-4d45-b03c-f07b9fc9ea18",
          "eventType":"AwsApiCall",
          "recipientAccountId":"123456789012"
       }
    ]
}
```


For detailed information about how to configure Amazon S3 as the event source, see Using AWS Lambda with Amazon S3 (p. 663).

**Topics**


- Logging Lambda API calls with CloudTrail (p. 525)
- Tutorial: Triggering a Lambda function with AWS CloudTrail events (p. 528)
- Sample function code (p. 533)

# Logging Lambda API calls with CloudTrail

Lambda is integrated with AWS CloudTrail, a service that provides a record of actions taken by a user, role, or an AWS service in Lambda. CloudTrail captures API calls for Lambda as events. The calls captured include calls from the Lambda console and code calls to the Lambda API operations. If you create a trail, you can enable continuous delivery of CloudTrail events to an Amazon Simple Storage Service (Amazon S3) bucket, including events for Lambda. If you don't configure a trail, you can still view the most recent events in the CloudTrail console in **Event history**. Using the information collected by CloudTrail, you can determine the request that was made to Lambda, the IP address from which the request was made, who made the request, when it was made, and additional details.

For more information about CloudTrail, including how to configure and enable it, see the AWS CloudTrail User Guide.

## Lambda information in CloudTrail

CloudTrail is enabled on your AWS account when you create the account. When supported event activity occurs in Lambda, that activity is recorded in a CloudTrail event along with other AWS service events in **Event history**. You can view, search, and download recent events in your AWS account. For more information, see Viewing events with CloudTrail event history in the *AWS CloudTrail User Guide*.

For an ongoing record of events in your AWS account, including events for Lambda, you create a *trail*. A trail enables CloudTrail to deliver log files to an Amazon S3 bucket. By default, when you create a trail in the console, the trail applies to all AWS Regions. The trail logs events from all Regions in the AWS partition and delivers the log files to the S3 bucket that you specify. Additionally, you can configure other AWS services to further analyze and act upon the event data collected in CloudTrail logs.

For more information, see the following topics in the *AWS CloudTrail User Guide*:

- Overview for creating a trail
- CloudTrail supported services and integrations
- Configuring Amazon SNS notifications for CloudTrail
- Receiving CloudTrail log files from multiple regions and Receiving CloudTrail log files from multiple accounts

Every log entry contains information about who generated the request. The user identity information in the log helps you determine whether the request was made with root or AWS Identity and Access Management (IAM) user credentials, with temporary security credentials for a role or federated user, or by another AWS service. For more information, see the **userIdentity** field in the CloudTrail event reference.

You can store your log files in your bucket for as long as you want, but you can also define Amazon S3 lifecycle rules to archive or delete log files automatically. By default, your log files are encrypted by using Amazon S3 server-side encryption (SSE).

You can choose to have CloudTrail publish Amazon Simple Notification Service (Amazon SNS) notifications when new log files are delivered if you want to take quick action upon log file delivery. For more information, see Configuring Amazon SNS notifications for CloudTrail.

You can also aggregate Lambda log files from multiple Regions and multiple AWS accounts into a single S3 bucket. For more information, see Working with CloudTrail log files.

### List of supported Lambda API actions

Lambda supports logging the following actions as events in CloudTrail log files.

**Note**
In the CloudTrail log file, the `eventName` might include date and version information, but it is still referring to the same public API. For example the, `GetFunction` action might appear as `"GetFunction20150331"`. To see the `eventName` for a particular action, view a log file entry in your event history. For more information, see Viewing events with CloudTrail event history in the *AWS CloudTrail User Guide*.

- AddLayerVersionPermission (p. 877)
- AddPermission (p. 881)
- CreateEventSourceMapping (p. 893)
- CreateFunction (p. 904)

  (The `Environment` and `ZipFile` parameters are omitted from the CloudTrail logs for `CreateFunction`.)
- CreateFunctionUrlConfig
- DeleteEventSourceMapping (p. 925)
- DeleteFunction (p. 931)
- DeleteFunctionUrlConfig
- GetEventSourceMapping (p. 952)
- GetFunction (p. 958)
- GetFunctionUrlConfig
- GetFunctionConfiguration (p. 967)
- GetLayerVersionPolicy (p. 986)
- GetPolicy (p. 988)
- ListEventSourceMappings (p. 1006)
- ListFunctions (p. 1013)
- ListFunctionUrlConfigs
- PublishLayerVersion (p. 1037)

  (The `ZipFile` parameter is omitted from the CloudTrail logs for `PublishLayerVersion`.)
- RemovePermission (p. 1065)
- UpdateEventSourceMapping (p. 1078)
- UpdateFunctionCode (p. 1088)

  (The `ZipFile` parameter is omitted from the CloudTrail logs for `UpdateFunctionCode`.)
- UpdateFunctionConfiguration (p. 1098)

  (The `Environment` parameter is omitted from the CloudTrail logs for `UpdateFunctionConfiguration`.)
- UpdateFunctionUrlConfig

## Understanding Lambda log file entries

CloudTrail log files contain one or more log entries where each entry is made up of multiple JSON-formatted events. A log entry represents a single request from any source and includes information about the requested action, any parameters, the date and time of the action, and so on. The log entries are not guaranteed to be in any particular order. That is, they are not an ordered stack trace of the public API calls.

The following example shows CloudTrail log entries for the `GetFunction` and `DeleteFunction` actions.

**Note**
The `eventName` might include date and version information, such as `"GetFunction20150331"`, but it is still referring to the same public API.


```
{
  "Records": [
    {
      "eventVersion": "1.03",
      "userIdentity": {
        "type": "IAMUser",
        "principalId": "A1B2C3D4E5F6G7EXAMPLE",
        "arn": "arn:aws:iam::999999999999:user/myUserName",
        "accountId": "999999999999",
        "accessKeyId": "AKIAIOSFODNN7EXAMPLE",
        "userName": "myUserName"
      },
      "eventTime": "2015-03-18T19:03:36Z",
      "eventSource": "lambda.amazonaws.com",
      "eventName": "GetFunction",
      "awsRegion": "us-east-1",
      "sourceIPAddress": "127.0.0.1",
      "userAgent": "Python-httplib2/0.8 (gzip)",
      "errorCode": "AccessDenied",
      "errorMessage": "User: arn:aws:iam::999999999999:user/myUserName is not
 authorized to perform: lambda:GetFunction on resource: arn:aws:lambda:us-
west-2:999999999999:function:other-acct-function",
      "requestParameters": null,
      "responseElements": null,
      "requestID": "7aebcd0f-cda1-11e4-aaa2-e356da31e4ff",
      "eventID": "e92a3e85-8ecd-4d23-8074-843aabfe89bf",
      "eventType": "AwsApiCall",
      "recipientAccountId": "999999999999"
    },
    {
      "eventVersion": "1.03",
      "userIdentity": {
        "type": "IAMUser",
        "principalId": "A1B2C3D4E5F6G7EXAMPLE",
        "arn": "arn:aws:iam::999999999999:user/myUserName",
        "accountId": "999999999999",
        "accessKeyId": "AKIAIOSFODNN7EXAMPLE",
        "userName": "myUserName"
      },
      "eventTime": "2015-03-18T19:04:42Z",
      "eventSource": "lambda.amazonaws.com",
      "eventName": "DeleteFunction",
      "awsRegion": "us-east-1",
      "sourceIPAddress": "127.0.0.1",
      "userAgent": "Python-httplib2/0.8 (gzip)",
      "requestParameters": {
        "functionName": "basic-node-task"
      },
      "responseElements": null,
      "requestID": "a2198ecc-cda1-11e4-aaa2-e356da31e4ff",
      "eventID": "20b84ce5-730f-482e-b2b2-e8fcc87ceb22",
      "eventType": "AwsApiCall",
      "recipientAccountId": "999999999999"
    }
  ]
}
```

## Using CloudTrail to track function invocations

CloudTrail also logs data events. You can turn on data event logging so that you log an event every time Lambda functions are invoked. This helps you understand what identities are invoking the functions and the frequency of their invocations. For more information on this option, see Logging data events for trails.

> **Note**
> CloudTrail logs only authenticated and authorized requests. CloudTrail does not log requests that fail authentication (credentials are missing or the provided credentials are not valid) or requests with credentials that are not authorized to invoke the function.

### Using CloudTrail to troubleshoot disabled event sources

One data event that can be encountered is a `LambdaESMDisabled` event. There are five general categories of error that are associated with this event:

**`RESOURCE_NOT_FOUND`**

The resource specified in the request does not exist.

**`FUNCTION_NOT_FOUND`**

The function attached to the event source does not exist.

**`REGION_NAME_NOT_VALID`**

A Region name provided to the event source or function is invalid.

**`AUTHORIZATION_ERROR`**

Permissions have not been set, or are misconfigured.

**`FUNCTION_IN_FAILED_STATE`**

The function code does not compile, has encountered an unrecoverable exception, or a bad deployment has occurred.

These errors are included in the CloudTrail event message within the `serviceEventDetails` entity.

**Example `serviceEventDetails` entity**

```
 "serviceEventDetails":{
    "ESMDisableReason":"Lambda Function not found"
}
```

# Tutorial: Triggering a Lambda function with AWS CloudTrail events

You can configure Amazon S3 to publish events to AWS Lambda when AWS CloudTrail stores API call logs. Your Lambda function can read the log object and process the access records logged by CloudTrail.

Use the following instructions to create a Lambda function that notifies you when a specific API call is made in your account. The function processes notification events from Amazon S3, reads logs from a bucket, and publishes alerts through an Amazon SNS topic. For this tutorial, you create:

- A CloudTrail trail and an S3 bucket to save logs to.
- An Amazon SNS topic to publish alert notifications.

- An IAM user role with permissions to read items from an S3 bucket and write logs to Amazon CloudWatch.
- A Lambda function that processes CloudTrail logs and sends a notification whenever an Amazon SNS topic is created.

## Requirements

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

Before you begin, make sure that you have the following tools:

- Node.js 12.x with `npm`.
- The Bash shell. For Linux and macOS, this is included by default. In Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.
- The AWS CLI.

## Step 1: Creating a trail in CloudTrail

When you create a trail, CloudTrail records the API calls in log files and stores them in Amazon S3. A CloudTrail log is an unordered array of events in JSON format. For each call to a supported API action, CloudTrail records information about the request and the entity that made it. Log events include the action name, parameters, response values, and details about the requester.

**To create a trail**

1. Open the **Trails** page of the CloudTrail console.
2. Choose **Create trail**.
3. For **Trail name**, enter a name.
4. For **S3 bucket**, enter a name.
5. Choose **Create**.
6. Save the bucket Amazon Resource Name (ARN) to add it to the IAM execution role, which you create later.

## Step 2: Creating an Amazon SNS topic

Create an Amazon SNS topic to send out a notification when new object events have occurred.

**To create a topic**

1. Open the **Topics** page of the Amazon SNS console.
2. Choose **Create topic**.
3. For **Topic name**, enter a name.
4. Choose **Create topic**.
5. Record the topic ARN. You will need it when you create the IAM execution role and Lambda function.

## Step 3: Creating an IAM execution role

An execution role (p. 52) gives your function permission to access AWS resources. Create an execution role that grants the function permission to access CloudWatch Logs, Amazon S3, and Amazon SNS.

### To create an execution role

1. Open the **Roles** page of the IAM console.
2. Choose **Create role**.
3. Create a role with the following properties:
   - For **Trusted entity**, choose **Lambda**.
   - For **Role name**, enter **`lambda-cloudtrail-role`**.
   - For **Permissions**, create a custom policy with the following statements. Replace the highlighted values with the names of your bucket and topic.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "logs:*"
      ],
      "Resource": "arn:aws:logs:*:*:*"
    },
    {
      "Effect": "Allow",
      "Action": [
        "s3:GetObject"
      ],
      "Resource": "arn:aws:s3:::my-bucket/*"
    },
    {
      "Effect": "Allow",
      "Action": [
        "sns:Publish"
      ],
      "Resource": "arn:aws:sns:us-west-2:123456789012:my-topic"
    }
  ]
}
```

4. Record the role ARN. You will need it when you create the Lambda function.

## Step 4: Creating the Lambda function

The following Lambda function processes CloudTrail logs, and sends a notification through Amazon SNS when a new Amazon SNS topic is created.

### To create the function

1. Create a folder and give it a name that indicates that it's your Lambda function (for example, *`lambda-cloudtrail`*).
2. In the folder, create a file named `index.js`.
3. Paste the following code into `index.js`. Replace the Amazon SNS topic ARN with the ARN that Amazon S3 created when you created the Amazon SNS topic.

```
var aws  = require('aws-sdk');
var zlib = require('zlib');
var async = require('async');

var EVENT_SOURCE_TO_TRACK = /sns.amazonaws.com/;
var EVENT_NAME_TO_TRACK   = /CreateTopic/;
```

```
var DEFAULT_SNS_REGION  = 'us-east-2';
var SNS_TOPIC_ARN       = 'arn:aws:sns:us-west-2:123456789012:my-topic';

var s3 = new aws.S3();
var sns = new aws.SNS({
    apiVersion: '2010-03-31',
    region: DEFAULT_SNS_REGION
});

exports.handler = function(event, context, callback) {
    var srcBucket = event.Records[0].s3.bucket.name;
    var srcKey = event.Records[0].s3.object.key;

    async.waterfall([
        function fetchLogFromS3(next){
            console.log('Fetching compressed log from S3...');
            s3.getObject({
               Bucket: srcBucket,
               Key: srcKey
            },
            next);
        },
        function uncompressLog(response, next){
            console.log("Uncompressing log...");
            zlib.gunzip(response.Body, next);
        },
        function publishNotifications(jsonBuffer, next) {
            console.log('Filtering log...');
            var json = jsonBuffer.toString();
            console.log('CloudTrail JSON from S3:', json);
            var records;
            try {
                records = JSON.parse(json);
            } catch (err) {
                next('Unable to parse CloudTrail JSON: ' + err);
                return;
            }
            var matchingRecords = records
                .Records
                .filter(function(record) {
                    return record.eventSource.match(EVENT_SOURCE_TO_TRACK)
                        && record.eventName.match(EVENT_NAME_TO_TRACK);
                });

            console.log('Publishing ' + matchingRecords.length + ' notification(s) in
 parallel...');
            async.each(
                matchingRecords,
                function(record, publishComplete) {
                    console.log('Publishing notification: ', record);
                    sns.publish({
                        Message:
                            'Alert... SNS topic created: \n TopicARN=' +
 record.responseElements.topicArn + '\n\n' +
                            JSON.stringify(record),
                        TopicArn: SNS_TOPIC_ARN
                    }, publishComplete);
                },
                next
            );
        }
    ], function (err) {
        if (err) {
            console.error('Failed to publish notifications: ', err);
        } else {
            console.log('Successfully published all notifications.');
```

```
        }
        callback(null,"message");
    });
};
```

4. In the *lambda-cloudtrail* folder, run the following script. It creates a `package-lock.json` file and a `node_modules` folder, which handle all dependencies.

```
npm install async
```

5. Run the following script to create a deployment package.

```
zip -r function.zip .
```

6. Create a Lambda function named CloudTrailEventProcessing with the `create-function` command by running the following script. Make the indicated replacements.

```
aws lambda create-function --function-name CloudTrailEventProcessing \
--zip-file fileb://function.zip --handler index.handler --runtime nodejs12.x --timeout
 10 --memory-size 1024 \
--role arn:aws:iam::123456789012:role/lambda-cloudtrail-role
```

## Step 5: Adding permissions to the Lambda function policy

The Lambda function's resource policy needs permissions to allow Amazon S3 to invoke the function.

**To give Amazon S3 permissions to invoke the function**

1. Run the following `add-permission` command. Replace the ARN and account ID with your own.

```
aws lambda add-permission --function-name CloudTrailEventProcessing \
--statement-id Id-1 --action "lambda:InvokeFunction" --principal s3.amazonaws.com \
--source-arn arn:aws:s3:::my-bucket \
--source-account 123456789012
```

   This command grants the Amazon S3 service principal (`s3.amazonaws.com`) permissions to perform the `lambda:InvokeFunction` action. Invoke permissions are granted to Amazon S3 only if the following conditions are met:

   - CloudTrail stores a log object in the specified bucket.
   - The bucket is owned by the specified AWS account. If the bucket owner deletes a bucket, another AWS account can create a bucket with the same name. This condition ensures that only the specified AWS account can invoke your Lambda function.

2. To view the Lambda function's access policy, run the following `get-policy` command, and replace the function name.

```
aws lambda get-policy --function-name function-name
```

## Step 6: Configuring notifications on an Amazon S3 bucket

To request that Amazon S3 publishes object-created events to Lambda, add a notification configuration to the S3 bucket. In the configuration, you specify the following:

- Event type – Any event types that create objects.

- Lambda function – The Lambda function that you want Amazon S3 to invoke.

**To configure notifications**

1. Open the Amazon S3 console.
2. Choose the source bucket.
3. Choose **Properties**.
4. Under **Events**, configure a notification with the following settings:
   - **Name** – `lambda-trigger`
   - **Events** – `All object create events`
   - **Send to** – `Lambda function`
   - **Lambda** – `CloudTrailEventProcessing`

When CloudTrail stores logs in the bucket, Amazon S3 sends an event to the function. The event provides information, including the bucket name and key name of the log object that CloudTrail created.

# Sample function code

Sample code is available for the following languages.

**Topics**

- Node.js (p. 533)

# Node.js

The following example processes CloudTrail logs, and sends a notification when an Amazon SNS topic was created.

**Example index.js**

```
var aws  = require('aws-sdk');
var zlib = require('zlib');
var async = require('async');

var EVENT_SOURCE_TO_TRACK = /sns.amazonaws.com/;
var EVENT_NAME_TO_TRACK   = /CreateTopic/;
var DEFAULT_SNS_REGION  = 'us-west-2';
var SNS_TOPIC_ARN       = 'The ARN of your SNS topic';

var s3 = new aws.S3();
var sns = new aws.SNS({
    apiVersion: '2010-03-31',
    region: DEFAULT_SNS_REGION
});

exports.handler = function(event, context, callback) {
    var srcBucket = event.Records[0].s3.bucket.name;
    var srcKey = event.Records[0].s3.object.key;

    async.waterfall([
        function fetchLogFromS3(next){
            console.log('Fetching compressed log from S3...');
            s3.getObject({
               Bucket: srcBucket,
               Key: srcKey
```

```
            },
            next);
        },
        function uncompressLog(response, next){
            console.log("Uncompressing log...");
            zlib.gunzip(response.Body, next);
        },
        function publishNotifications(jsonBuffer, next) {
            console.log('Filtering log...');
            var json = jsonBuffer.toString();
            console.log('CloudTrail JSON from S3:', json);
            var records;
            try {
                records = JSON.parse(json);
            } catch (err) {
                next('Unable to parse CloudTrail JSON: ' + err);
                return;
            }
            var matchingRecords = records
                .Records
                .filter(function(record) {
                    return record.eventSource.match(EVENT_SOURCE_TO_TRACK)
                        && record.eventName.match(EVENT_NAME_TO_TRACK);
                });

            console.log('Publishing ' + matchingRecords.length + ' notification(s) in
 parallel...');
            async.each(
                matchingRecords,
                function(record, publishComplete) {
                    console.log('Publishing notification: ', record);
                    sns.publish({
                        Message:
                            'Alert... SNS topic created: \n TopicARN=' +
 record.responseElements.topicArn + '\n\n' +
                            JSON.stringify(record),
                        TopicArn: SNS_TOPIC_ARN
                    }, publishComplete);
                },
                next
            );
        }
    ], function (err) {
        if (err) {
            console.error('Failed to publish notifications: ', err);
        } else {
            console.log('Successfully published all notifications.');
        }
        callback(null,"message");
    });
};
```

Zip up the sample code to create a deployment package. For instructions, see Deploy Node.js Lambda functions with .zip file archives (p. 288).

# Using AWS Lambda with Amazon EventBridge (CloudWatch Events)

> **Note**
> Amazon EventBridge is the preferred way to manage your events. CloudWatch Events and EventBridge are the same underlying service and API, but EventBridge provides more features. Changes you make in either CloudWatch Events or EventBridge will appear in each console. For more information, see the Amazon EventBridge documentation.

EventBridge (CloudWatch Events) helps you to respond to state changes in your AWS resources. For more information about EventBridge, see What is Amazon EventBridge? in the *Amazon EventBridge User Guide*.

When your resources change state, they automatically send events into an event stream. With EventBridge (CloudWatch Events), you can create rules that match selected events in the stream and route them to your AWS Lambda function to take action. For example, you can automatically invoke an AWS Lambda function to log the state of an EC2 instance or AutoScaling group.

EventBridge (CloudWatch Events) invokes your function asynchronously with an event document that wraps the event from its source. The following example shows an event that originated from a database snapshot in Amazon Relational Database Service.

**Example EventBridge (CloudWatch Events) event**

```
{
    "version": "0",
    "id": "fe8d3c65-xmpl-c5c3-2c87-81584709a377",
    "detail-type": "RDS DB Instance Event",
    "source": "aws.rds",
    "account": "123456789012",
    "time": "2020-04-28T07:20:20Z",
    "region": "us-east-2",
    "resources": [
        "arn:aws:rds:us-east-2:123456789012:db:rdz6xmpliljlb1"
    ],
    "detail": {
        "EventCategories": [
            "backup"
        ],
        "SourceType": "DB_INSTANCE",
        "SourceArn": "arn:aws:rds:us-east-2:123456789012:db:rdz6xmpliljlb1",
        "Date": "2020-04-28T07:20:20.112Z",
        "Message": "Finished DB Instance backup",
        "SourceIdentifier": "rdz6xmpliljlb1"
    }
}
```

You can also create a Lambda function and direct AWS Lambda to invoke it on a regular schedule. You can specify a fixed rate (for example, invoke a Lambda function every hour or 15 minutes), or you can specify a Cron expression.

**Example EventBridge (CloudWatch Events) message event**

```
{
  "version": "0",
  "account": "123456789012",
  "region": "us-east-2",
  "detail": {},
  "detail-type": "Scheduled Event",
```

```
  "source": "aws.events",
  "time": "2019-03-01T01:23:45Z",
  "id": "cdc73f9d-aea9-11e3-9d5a-835b769c0d9c",
  "resources": [
    "arn:aws:events:us-east-2:123456789012:rule/my-schedule"
  ]
}
```

**To configure EventBridge (CloudWatch Events) to invoke your function**

1. Open the Functions page of the Lambda console.
2. Choose a function
3. Under **Function overview**, choose **Add trigger**.
4. Set the trigger type to **EventBridge (CloudWatch Events)**.
5. For **Rule**, choose **Create a new rule**.
6. Configure the remaining options and choose **Add**.

For more information on expressions schedules, see Schedule expressions using rate or cron (p. 539).

Each AWS account can have up to 100 unique event sources of the **EventBridge (CloudWatch Events)-Schedule** source type. Each of these can be the event source for up to five Lambda functions. That is, you can have up to 500 Lambda functions that can be executing on a schedule in your AWS account.

**Topics**


- Tutorial: Using AWS Lambda with scheduled events (p. 536)
- Schedule expressions using rate or cron (p. 539)


# Tutorial: Using AWS Lambda with scheduled events

In this tutorial, you do the following:

- Create a Lambda function using the **lambda-canary** blueprint. You configure the Lambda function to run every minute. Note that if the function returns an error, Lambda logs error metrics to Amazon CloudWatch.
- Configure a CloudWatch alarm on the `Errors` metric of your Lambda function to post a message to your Amazon SNS topic when AWS Lambda emits error metrics to CloudWatch. You subscribe to the Amazon SNS topics to get email notification. In this tutorial, you do the following to set this up:
  - Create an Amazon SNS topic.
  - Subscribe to the topic so you can get email notifications when a new message is posted to the topic.
  - In Amazon CloudWatch, set an alarm on the `Errors` metric of your Lambda function to publish a message to your SNS topic when errors occur.

## Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

## Create a Lambda function

1. Sign in to the AWS Management Console and open the AWS Lambda console at https://console.aws.amazon.com/lambda/.

2. Choose **Create function**.
3. Choose **Use a blueprint**.
4. Enter `canary` in the search bar. Choose the **lambda-canary** blueprint, and then choose **Configure**.
5. Configure the following settings.

   - **Name** – `lambda-canary`.
   - **Role** – **Create a new role from AWS policy templates**.
   - **Role name** – `lambda-apigateway-role`.
   - **Policy templates** – **Simple microservice permissions**.
   - **Rule** – **Create a new rule**.
   - **Rule name** – `CheckWebsiteScheduledEvent`.
   - **Rule description** – `CheckWebsiteScheduledEvent trigger`.
   - **Rule type** – `Schedule expression`.
   - **Schedule expression** – `rate(1 minute)`.
   - **Environment variables**
     - **site** – `https://docs.aws.amazon.com/lambda/latest/dg/welcome.html`.
     - **expected** – `What is AWS Lambda?`.
6. Choose **Create function**.

EventBridge (CloudWatch Events) emits an event every minute, based on the schedule expression. The event triggers the Lambda function, which verifies that the expected string appears in the specified page. For more information on expressions schedules, see Schedule expressions using rate or cron (p. 539).

## Test the Lambda function

Test the function with a sample event provided by the Lambda console.

1. Open the Functions page of the Lambda console.
2. Choose the **lambda-canary** function.
3. Choose **Test**.
4. Create a new event using the **CloudWatch** event template.
5. Choose **Create event**.
6. Choose **Invoke**.

The output from the function execution is shown at the top of the page.

## Create an Amazon SNS topic and subscribe to it

Create an Amazon Simple Notification Service (Amazon SNS) topic to receive notifications when the canary function returns an error.

### To create a topic

1. Open the Amazon SNS console.
2. Choose **Create topic**.
3. Create a topic with the following settings.

   - **Name** – `lambda-canary-notifications`.
   - **Display name** – `Canary`.
4. Choose **Create subscription**.

5. Create a subscription with the following settings.

   - **Protocol** – **`Email`**.
   - **Endpoint** – Your email address.

Amazon SNS sends an email from `Canary <no-reply@sns.amazonaws.com>`, reflecting the friendly name of the topic. Use the link in the email to confirm your address.

## Configure an alarm

Configure an alarm in Amazon CloudWatch that monitors the Lambda function and sends a notification when it fails.

**To create an alarm**

1. Open the CloudWatch console.
2. Choose **Alarms**.
3. Choose **Create alarm**.
4. Choose **Alarms**.
5. Create an alarm with the following settings.

   - **Metrics** – **lambda-canary Errors**.

     Search for **`lambda canary errors`** to find the metric.
   - Statistic – **`Sum`**.

     Choose the statistic from the drop-down menu above the preview graph.
   - **Name** – **`lambda-canary-alarm`**.
   - **Description** – **`Lambda canary alarm`**.
   - Threshold – **Whenever Errors is `>=1`**.
   - **Send notification to** – **`lambda-canary-notifications`**.

## Test the alarm

Update the function configuration to cause the function to return an error, which triggers the alarm.

**To trigger an alarm**

1. Open the Functions page of the Lambda console.
2. Choose the **lambda-canary** function.
3. Scroll down. Under **Environment variables**, choose **Edit**.
4. Set **expected** to **`404`**.
5. Choose **Save**.

Wait a minute, and then check your email for a message from Amazon SNS.

## Clean up your resources

You can now delete the resources that you created for this tutorial, unless you want to retain them. By deleting AWS resources that you're no longer using, you prevent unnecessary charges to your AWS account.

### To delete the Lambda function

1. Open the Functions page of the Lambda console.
2. Select the function that you created.
3. Choose **Actions**, then choose **Delete**.
4. Choose **Delete**.

### To delete the CloudWatch alarm

1. Open the Alarms page of the CloudWatch console.
2. Select the alarm you created.
3. Choose **Actions**, **Delete**.
4. Choose **Delete**.

### To delete the Amazon SNS subscription

1. Open the Subscriptions page of the Amazon SNS console.
2. Select the subscription you created.
3. Choose **Delete**, **Delete**.

### To delete the Amazon SNS topic

1. Open the Topics page of the Amazon SNS console.
2. Select the topic you created.
3. Choose **Delete**.
4. Enter **`delete me`** in the text box.
5. Choose **Delete**.

# Schedule expressions using rate or cron

AWS Lambda supports standard rate and cron expressions for frequencies of up to once per minute. EventBridge (CloudWatch Events) rate expressions have the following format.

```
rate(Value Unit)
```

Where *`Value`* is a positive integer and *`Unit`* can be minute(s), hour(s), or day(s). For a singular value the unit must be singular (for example, `rate(1 day)`), otherwise plural (for example, `rate(5 days)`).

### Rate expression examples

| Frequency | Expression |
|---|---|
| Every 5 minutes | `rate(5 minutes)` |
| Every hour | `rate(1 hour)` |
| Every seven days | `rate(7 days)` |

Cron expressions have the following format.

```
cron(Minutes Hours Day-of-month Month Day-of-week Year)
```

### Cron expression examples

| Frequency | Expression |
| --- | --- |
| 10:15 AM (UTC) every day | `cron(15 10 * * ? *)` |
| 6:00 PM Monday through Friday | `cron(0 18 ? * MON-FRI *)` |
| 8:00 AM on the first day of the month | `cron(0 8 1 * ? *)` |
| Every 10 min on weekdays | `cron(0/10 * ? * MON-FRI *)` |
| Every 5 minutes between 8:00 AM and 5:55 PM weekdays | `cron(0/5 8-17 ? * MON-FRI *)` |
| 9:00 AM on the first Monday of each month | `cron(0 9 ? * 2#1 *)` |

Note the following:

- If you are using the Lambda console, do not include the `cron` prefix in your expression.
- One of the day-of-month or day-of-week values must be a question mark (`?`).

For more information, see Schedule expressions for rules in the *EventBridge User Guide*.

# Using Lambda with CloudWatch Logs

You can use a Lambda function to monitor and analyze logs from an Amazon CloudWatch Logs log stream. Create subscriptions for one or more log streams to invoke a function when logs are created or match an optional pattern. Use the function to send a notification or persist the log to a database or storage.

CloudWatch Logs invokes your function asynchronously with an event that contains log data. The value of the data field is a Base64-encoded .gzip file archive.

**Example CloudWatch Logs message event**

```
{
  "awslogs": {
    "data":
 "ewogICAgIm1lc3NhZ2VUeXBlIjogIkRBVEFfTUVTU0FHRSIsCiAgICAib3duZXIiOiAiMTIzNDU2Nzg5MDEyIiwKICAgICJsb2dHc
  }
}
```

When decoded and decompressed, the log data is a JSON document with the following structure:

**Example CloudWatch Logs message data (decoded)**

```
{
    "messageType": "DATA_MESSAGE",
    "owner": "123456789012",
    "logGroup": "/aws/lambda/echo-nodejs",
    "logStream": "2019/03/13/[$LATEST]94fa867e5374431291a7fc14e2f56ae7",
    "subscriptionFilters": [
        "LambdaStream_cloudwatchlogs-node"
    ],
    "logEvents": [
        {
            "id": "34622316099697884706540976068822859012661220141643892546",
            "timestamp": 1552518348220,
            "message": "REPORT RequestId: 6234bffe-149a-b642-81ff-2e8e376d8aff\tDuration:
 46.84 ms\tBilled Duration: 47 ms \tMemory Size: 192 MB\tMax Memory Used: 72 MB\t\n"
        }
    ]
}
```

For a sample application that uses CloudWatch Logs as a trigger, see Error processor sample application for AWS Lambda (p. 807).

# Using AWS Lambda with AWS CloudFormation

In an AWS CloudFormation template, you can specify a Lambda function as the target of a custom resource. Use custom resources to process parameters, retrieve configuration values, or call other AWS services during stack lifecycle events.

The following example invokes a function that's defined elsewhere in the template.

**Example – Custom resource definition**

```
Resources:
  primerinvoke:
    Type: AWS::CloudFormation::CustomResource
    Version: "1.0"
    Properties:
      ServiceToken: !GetAtt primer.Arn
      FunctionName: !Ref randomerror
```

The service token is the Amazon Resource Name (ARN) of the function that AWS CloudFormation invokes when you create, update, or delete the stack. You can also include additional properties like `FunctionName`, which AWS CloudFormation passes to your function as is.

AWS CloudFormation invokes your Lambda function asynchronously (p. 228) with an event that includes a callback URL.

**Example – AWS CloudFormation message event**

```
{
    "RequestType": "Create",
    "ServiceToken": "arn:aws:lambda:us-east-2:123456789012:function:lambda-error-processor-
primer-14ROR2T3JKU66",
    "ResponseURL": "https://cloudformation-custom-resource-response-useast2.s3-us-
east-2.amazonaws.com/arn%3Aaws%3Acloudformation%3Aus-east-2%3A123456789012%3Astack/lambda-
error-processor/1134083a-2608-1e91-9897-022501a2c456%7Cprimerinvoke%7C5d478078-13e9-
baf0-464a-7ef285ecc786?
AWSAccessKeyId=AKIAIOSFODNN7EXAMPLE&Expires=1555451971&Signature=28UijZePE5I4dvukKQqM
%2F9Rf1o4%3D",
    "StackId": "arn:aws:cloudformation:us-east-2:123456789012:stack/lambda-error-
processor/1134083a-2608-1e91-9897-022501a2c456",
    "RequestId": "5d478078-13e9-baf0-464a-7ef285ecc786",
    "LogicalResourceId": "primerinvoke",
    "ResourceType": "AWS::CloudFormation::CustomResource",
    "ResourceProperties": {
        "ServiceToken": "arn:aws:lambda:us-east-2:123456789012:function:lambda-error-
processor-primer-14ROR2T3JKU66",
        "FunctionName": "lambda-error-processor-randomerror-ZWUC391MQAJK"
    }
}
```

The function is responsible for returning a response to the callback URL that indicates success or failure. For the full response syntax, see Custom resource response objects.

**Example – AWS CloudFormation custom resource response**

```
{
    "Status": "SUCCESS",
    "PhysicalResourceId": "2019/04/18/[$LATEST]b3d1bfc65f19ec610654e4d9b9de47a0",
    "StackId": "arn:aws:cloudformation:us-east-2:123456789012:stack/lambda-error-
processor/1134083a-2608-1e91-9897-022501a2c456",
```

```
    "RequestId": "5d478078-13e9-baf0-464a-7ef285ecc786",
    "LogicalResourceId": "primerinvoke"
}
```

AWS CloudFormation provides a library called `cfn-response` that handles sending the response. If you define your function within a template, you can require the library by name. AWS CloudFormation then adds the library to the deployment package that it creates for the function.

The following example function invokes a second function. If the call succeeds, the function sends a success response to AWS CloudFormation, and the stack update continues. The template uses the AWS::Serverless::Function resource type provided by AWS Serverless Application Model.

**Example error-processor/template.yml – Custom resource function**

```
Transform: 'AWS::Serverless-2016-10-31'
Resources:
  primer:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs12.x
      InlineCode: |
        var aws = require('aws-sdk');
        var response = require('cfn-response');
        exports.handler = function(event, context) {
            // For Delete requests, immediately send a SUCCESS response.
            if (event.RequestType == "Delete") {
                response.send(event, context, "SUCCESS");
                return;
            }
            var responseStatus = "FAILED";
            var responseData = {};
            var functionName = event.ResourceProperties.FunctionName
            var lambda = new aws.Lambda();
            lambda.invoke({ FunctionName: functionName }, function(err, invokeResult) {
                if (err) {
                    responseData = {Error: "Invoke call failed"};
                    console.log(responseData.Error + ":\n", err);
                }
                else responseStatus = "SUCCESS";
                response.send(event, context, responseStatus, responseData);
            });
        };
      Description: Invoke a function to create a log stream.
      MemorySize: 128
      Timeout: 8
      Role: !GetAtt role.Arn
      Tracing: Active
```

If the function that the custom resource invokes isn't defined in a template, you can get the source code for `cfn-response` from cfn-response module in the AWS CloudFormation User Guide.

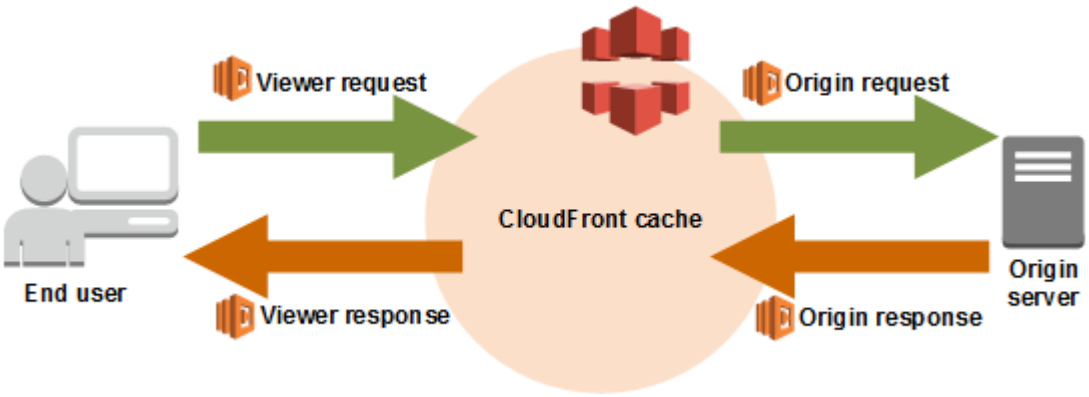
For a sample application that uses a custom resource to ensure that a function's log group is created before another resource that depends on it, see Error processor sample application for AWS Lambda (p. 807).

For more information about custom resources, see Custom resources in the *AWS CloudFormation User Guide*.

# Using AWS Lambda with CloudFront Lambda@Edge

Lambda@Edge lets you run Node.js and Python Lambda functions to customize content that CloudFront delivers, executing the functions in AWS locations closer to the viewer. The functions run in response to CloudFront events, without provisioning or managing servers. You can use Lambda functions to change CloudFront requests and responses at the following points:

- After CloudFront receives a request from a viewer (viewer request)
- Before CloudFront forwards the request to the origin (origin request)
- After CloudFront receives the response from the origin (origin response)
- Before CloudFront forwards the response to the viewer (viewer response)




**Note**
Lambda@Edge supports a limited set of runtimes and features. For details, see Requirements and restrictions on Lambda functions in the Amazon CloudFront developer guide.

You can also generate responses to viewers without ever sending the request to the origin.

### Example CloudFront message event

```
{
  "Records": [
    {
      "cf": {
        "config": {
          "distributionId": "EDFDVBD6EXAMPLE"
        },
        "request": {
          "clientIp": "2001:0db8:85a3:0:0:8a2e:0370:7334",
          "method": "GET",
          "uri": "/picture.jpg",
          "headers": {
            "host": [
              {
                "key": "Host",
                "value": "d111111abcdef8.cloudfront.net"
              }
            ],
            "user-agent": [
              {
                "key": "User-Agent",
```

```
                "value": "curl/7.51.0"
              }
            ]
          }
        }
      }
    }
  ]
}
```

With Lambda@Edge, you can build a variety of solutions, for example:

- Inspect cookies to rewrite URLs to different versions of a site for A/B testing.
- Send different objects to your users based on the `User-Agent` header, which contains information about the device that submitted the request. For example, you can send images in different resolutions to users based on their devices.
- Inspect headers or authorized tokens, inserting a corresponding header and allowing access control before forwarding a request to the origin.
- Add, delete, and modify headers, and rewrite the URL path to direct users to different objects in the cache.
- Generate new HTTP responses to do things like redirect unauthenticated users to login pages, or create and deliver static webpages right from the edge. For more information, see Using Lambda functions to generate HTTP responses to viewer and origin requests in the *Amazon CloudFront Developer Guide*.

For more information about using Lambda@Edge, see Using CloudFront with Lambda@Edge.

# Using AWS Lambda with AWS CodeCommit

You can create a trigger for an AWS CodeCommit repository so that events in the repository will invoke a Lambda function. For example, you can invoke a Lambda function when a branch or tag is created or when a push is made to an existing branch.

**Example AWS CodeCommit message event**

```
{
    "Records": [
        {
            "awsRegion": "us-east-2",
            "codecommit": {
                "references": [
                    {
                        "commit": "5e493c6f3067653f3d04eca608b4901eb227078",
                        "ref": "refs/heads/master"
                    }
                ]
            },
            "eventId": "31ade2c7-f889-47c5-a937-1cf99e2790e9",
            "eventName": "ReferenceChanges",
            "eventPartNumber": 1,
            "eventSource": "aws:codecommit",
            "eventSourceARN": "arn:aws:codecommit:us-east-2:123456789012:lambda-pipeline-
repo",
            "eventTime": "2019-03-12T20:58:25.400+0000",
            "eventTotalParts": 1,
            "eventTriggerConfigId": "0d17d6a4-efeb-46f3-b3ab-a63741badeb8",
            "eventTriggerName": "index.handler",
            "eventVersion": "1.0",
            "userIdentityARN": "arn:aws:iam::123456789012:user/intern"
        }
    ]
}
```

For more information, see Manage triggers for an AWS CodeCommit repository.

# Using AWS Lambda with AWS CodePipeline

AWS CodePipeline is a service that enables you to create continuous delivery pipelines for applications that run on AWS. You can create a pipeline to deploy your Lambda application. You can also configure a pipeline to invoke a Lambda function to perform a task when the pipeline runs. When you create a Lambda application (p. 760) in the Lambda console, Lambda creates a pipeline that includes source, build, and deploy stages.

CodePipeline invokes your function asynchronously with an event that contains details about the job. The following example shows an event from a pipeline that invoked a function named `my-function`.

**Example CodePipeline event**

```
{
    "CodePipeline.job": {
        "id": "c0d76431-b0e7-xmpl-97e3-e8ee786eb6f6",
        "accountId": "123456789012",
        "data": {
            "actionConfiguration": {
                "configuration": {
                    "FunctionName": "my-function",
                    "UserParameters": "{\"KEY\": \"VALUE\"}"
                }
            },
            "inputArtifacts": [
                {
                    "name": "my-pipeline-SourceArtifact",
                    "revision": "e0c7xmpl2308ca3071aa7bab414de234ab52eea",
                    "location": {
                        "type": "S3",
                        "s3Location": {
                            "bucketName": "us-west-2-123456789012-my-pipeline",
                            "objectKey": "my-pipeline/test-api-2/TdOSFRV"
                        }
                    }
                }
            ],
            "outputArtifacts": [
                {
                    "name": "invokeOutput",
                    "revision": null,
                    "location": {
                        "type": "S3",
                        "s3Location": {
                            "bucketName": "us-west-2-123456789012-my-pipeline",
                            "objectKey": "my-pipeline/invokeOutp/D0YHsJn"
                        }
                    }
                }
            ],
            "artifactCredentials": {
                "accessKeyId": "AKIAIOSFODNN7EXAMPLE",
                "secretAccessKey": "6CGtmAa3lzWtV7a...",
                "sessionToken": "IQoJb3JpZ2luX2VjEA...",
                "expirationTime": 1575493418000
            }
        }
    }
}
```

To complete the job, the function must call the CodePipeline API to signal success or failure. The following example Node.js function uses the `PutJobSuccessResult` operation to signal success. It gets the job ID for the API call from the event object.

**Example index.js**

```
var AWS = require('aws-sdk')
var codepipeline = new AWS.CodePipeline()

exports.handler = async (event) => {
    console.log(JSON.stringify(event, null, 2))
    var jobId = event["CodePipeline.job"].id
    var params = {
        jobId: jobId
    }
    return codepipeline.putJobSuccessResult(params).promise()
}
```

For asynchronous invocation, Lambda queues the message and retries (p. 250) if your function returns an error. Configure your function with a destination (p. 230) to retain events that your function could not process.

For a tutorial on how to configure a pipeline to invoke a Lambda function, see Invoke an AWS Lambda function in a pipeline in the *AWS CodePipeline User Guide*.

You can use AWS CodePipeline to create a continuous delivery pipeline for your Lambda application. CodePipeline combines source control, build, and deployment resources to create a pipeline that runs whenever you make a change to your application's source code.

For an alternate method of creating a pipeline with AWS Serverless Application Model and AWS CloudFormation, watch Automate your serverless application deployments on the Amazon Web Services YouTube channel.

# Permissions

To invoke a function, a CodePipeline pipeline needs permission to use the following API operations:

- ListFunctions (p. 1013)
- InvokeFunction (p. 993)

The default pipeline service role includes these permissions.

To complete a job, the function needs the following permissions in its execution role (p. 52).

- `codepipeline:PutJobSuccessResult`
- `codepipeline:PutJobFailureResult`

These permissions are included in the AWSCodePipelineCustomActionAccess managed policy.

# Working with Amazon CodeWhisperer in the Lambda console

Amazon CodeWhisperer is a general purpose, machine learning-powered code generator that provides you with code recommendations in realtime. When activated in the Lambda console, CodeWhisperer automatically generates suggestions based on your existing code and comments. Your personalized recommendations can vary in size and scope, ranging from a single one-liner to fully-formed functions.

**Topics**


- Setting up Amazon CodeWhisperer with Lambda (p. 550)
- Overview of Amazon CodeWhisperer for AWS Lambda (p. 550)

# Setting up Amazon CodeWhisperer with Lambda

This document describes how to request access to and activate Amazon CodeWhisperer for the Lambda console. Once activated, CodeWhisperer can make code recommendations on-demand in the Lambda code editor as you develop your function.

> **Note**
> In the Lambda console, CodeWhisperer only supports functions using the Python and Node.js runtimes.

**Topics**


- Requesting CodeWhisperer access (experimental feature) (p. 550)
- Activating Amazon CodeWhisperer (experimental feature) (p. 550)


## Requesting CodeWhisperer access (experimental feature)

To use Amazon CodeWhisperer in the Lambda console, you must first get allow listed. Request allow listing by completing these steps.

1. Open the Functions page of the Lambda console, and choose the function that you want to edit.
2. In the code editor under **Code source**, choose **Tools** in the top menu bar.
3. Choose **Request CodeWhisperer access**. This opens up a link to a request form in a new tab.
4. Fill out the form. For Lambda users, you must fill out the **AWS Account ID** field.

You will receive an email when the CodeWhisperer team approves your request.

## Activating Amazon CodeWhisperer (experimental feature)

> **Note**
> You must be allow listed to use CodeWhisperer in the Lambda console. If you aren't allow listed, see the section called “Requesting CodeWhisperer access (experimental feature)” (p. 550).

To activate CodeWhisperer in the Lambda console code editor, complete these steps.

1. Open the Functions page of the Lambda console, and choose the function that you want to edit.
2. In the code editor under **Code source**, choose **Tools** in the top menu bar.
3. Choose **CodeWhisperer code suggestions**. This immediately activates the CodeWhisperer service, and a check mark appears next to this option. To deactivate, choose this option again.

The first time you activate CodeWhisperer, you'll see a pop-up containing terms and conditions for using CodeWhisperer. Read the terms and conditions and choose **Accept** to continue.

# Overview of Amazon CodeWhisperer for AWS Lambda

This overview contains a list of Amazon CodeWhisperer user actions and common ways for you to utilize CodeWhisperer in the AWS Lambda code editor.

> **Note**
> In the Lambda console, CodeWhisperer only supports functions using the Python and Node.js runtimes.

**Topics**

- User actions (p. 551)
- Use cases and examples (p. 551)

## User actions

When you're using the Lambda code editor, you can use the following keyboard shortcuts to perform various CodeWhisperer user actions.

**CodeWhisperer user actions and keyboard shortcuts**

| Action | Keyboard shortcut |
| --- | --- |
| Manually fetch a code suggestion | MacOS: `Option + C`<br>Windows: `Alt + C` |
| Accept a suggestion | `Tab` |
| Reject a suggestion | `ESC`, `Backspace`, scroll in any direction, or keep typing and the recommendation automatically disappears. |

## Use cases and examples

Here are some common ways for you to utilize Amazon CodeWhisperer while authoring Lambda functions.

### Single-line code completion

When you start typing out single lines of code, CodeWhisperer makes suggestions based on your current and previous inputs. In the image below, a user has begun to define a variable for an Amazon S3 client. Based on this, CodeWhisperer then suggests a way to complete this line of code.

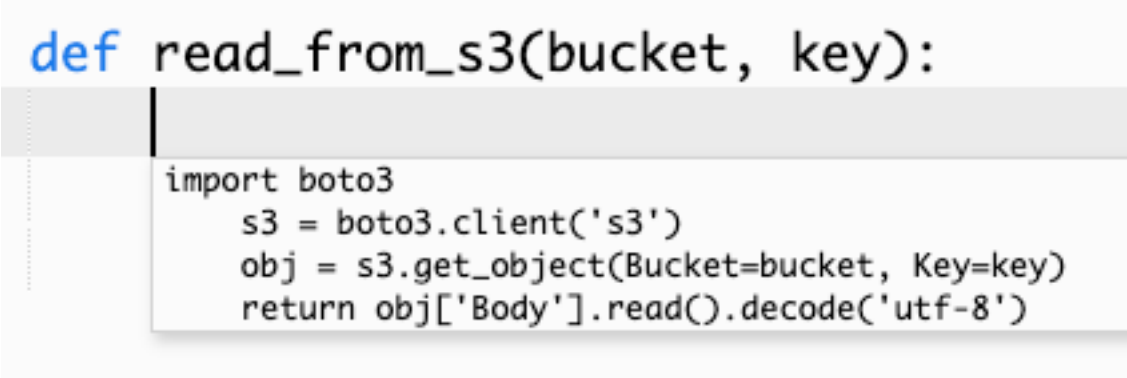



As another example, in the image below, a user has already written some code, and now wants to send a message to an Amazon SQS queue. CodeWhisperer suggests a way to complete this final line of code.



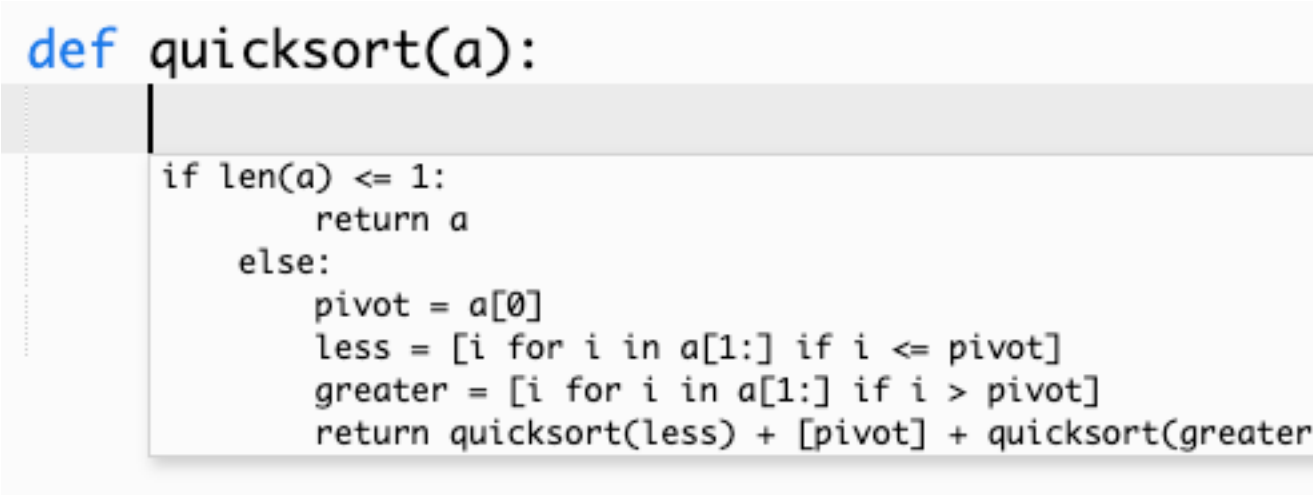

### Full function generation

CodeWhisperer can generate an entire function based on your function signature or code comments. In the following image, a user has written a function signature for reading a file from Amazon S3. Amazon CodeWhisperer then suggests a full implementation of the `read_from_s3` method.




**Note**
Sometimes, as in the previous example, CodeWhisperer includes `import` statements as part of its suggestions. As a best practice, manually move these `import` statements to the top of your file.

As another example, in the following image, a user has written a function signature. CodeWhisperer then suggests a full implementation of the `quicksort` method.



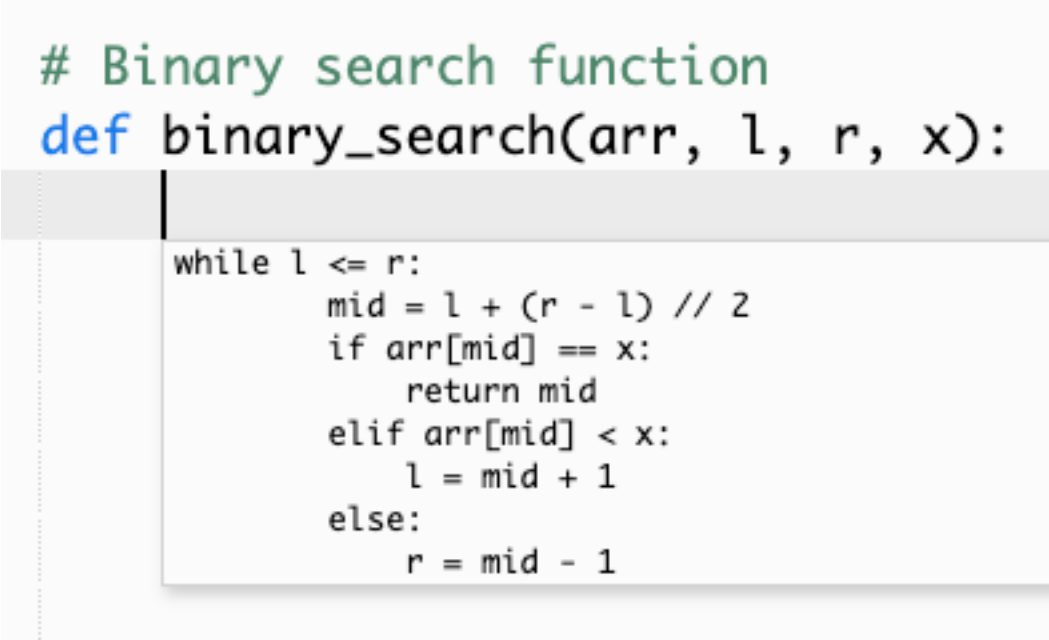

CodeWhisperer considers past code snippets when making suggestions. In the following image, the user in the previous example has accepted the suggested implementation for `quicksort` above. The user then writes another function signature for a generic `sort` method. CodeWhisperer then suggests an implementation based on what has already been written.

```
def quicksort(a):
    if len(a) <= 1:
        return a
    else:
        pivot = a[0]
        less = [i for i in a[1:] if i <= pivot]
        greater = [i for i in a[1:] if i > pivot]
        return quicksort(less) + [pivot] + quicksort(gre

def sort(a):

    return quicksort(a)
```

In the following image, a user has written a comment. Based on this comment, CodeWhisperer then suggests a function signature.

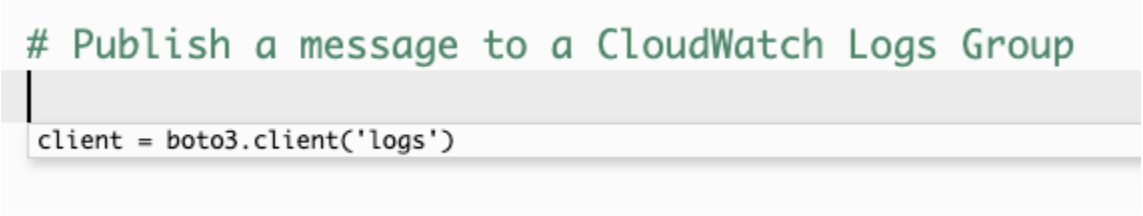
```
# Binary search function

def binary_search(arr, l, r, x):
```

In the following image, the user in the previous example has accepted the suggested function signature. CodeWhisperer can then suggest a complete implementation of the `binary_search` function.

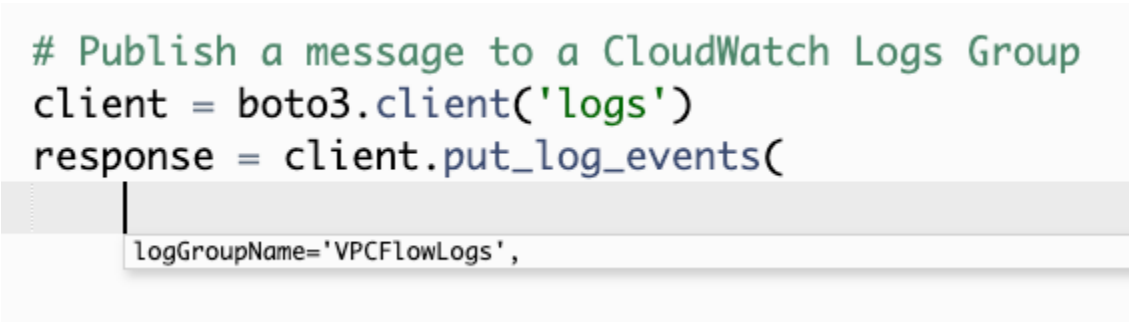



## Line-by-line recommendations

Depending on your use case, CodeWhisperer may not be able to generate an entire function block in one recommendation. However, CodeWhisperer can still provide line-by-line recommendations. In the following image, the customer has written an initial comment indicating that they want to publish a message to an Amazon CloudWatch Logs group. Given this context, CodeWhisperer is only able to suggest the client initialization code in its first recommendation, as shown in the following image.




However, if the user continues to request line-by-line recommendations, CodeWhisperer also continues to suggest lines of code based on what's already been written.




**Note**
In the example above, `VPCFlowLogs` may not be the correct constant value. As CodeWhisperer makes suggestions, remember to rename any constants as required.

CodeWhisperer can eventually complete the entire code block as shown in the following image.

```
# Publish a message to a CloudWatch Logs Group
client = boto3.client('logs')
response = client.put_log_events(
    logGroupName='VPCFlowLogs',
    logStreamName='VPCFlowLogs',
    logEvents=[
        {
            'timestamp': int(round(time.time() * 1000)),
            'message': json.dumps(event)
        }
    ]
)
```

No recommendations

# Using AWS Lambda with Amazon Cognito

The Amazon Cognito Events feature enables you to run Lambda functions in response to events in Amazon Cognito. For example, you can invoke a Lambda function for the Sync Trigger events, that is published each time a dataset is synchronized. To learn more and walk through an example, see Introducing Amazon Cognito Events: Sync Triggers in the Mobile Development blog.

**Example Amazon Cognito message event**

```
{
  "datasetName": "datasetName",
  "eventType": "SyncTrigger",
  "region": "us-east-1",
  "identityId": "identityId",
  "datasetRecords": {
    "SampleKey2": {
      "newValue": "newValue2",
      "oldValue": "oldValue2",
      "op": "replace"
    },
    "SampleKey1": {
      "newValue": "newValue1",
      "oldValue": "oldValue1",
      "op": "replace"
    }
  },
  "identityPoolId": "identityPoolId",
  "version": 2
}
```

You configure event source mapping using Amazon Cognito event subscription configuration. For information about event source mapping and a sample event, see Amazon Cognito events in the *Amazon Cognito Developer Guide*.

# Using AWS Lambda with AWS Config

You can use AWS Lambda functions to evaluate whether your AWS resource configurations comply with your custom Config rules. As resources are created, deleted, or changed, AWS Config records these changes and sends the information to your Lambda functions. Your Lambda functions then evaluate the changes and report results to AWS Config. You can then use AWS Config to assess overall resource compliance: you can learn which resources are noncompliant and which configuration attributes are the cause of noncompliance.

**Example AWS Config message event**

```
{
    "invokingEvent": "{\"configurationItem\":{\"configurationItemCaptureTime\":
\"2016-02-17T01:36:34.043Z\",\"awsAccountId\":\"000000000000\",\"configurationItemStatus\":
\"OK\",\"resourceId\":\"i-00000000\",\"ARN\":\"arn:aws:ec2:us-east-1:000000000000:instance/
i-00000000\",\"awsRegion\":\"us-east-1\",\"availabilityZone\":\"us-east-1a\",
\"resourceType\":\"AWS::EC2::Instance\",\"tags\":{\"Foo\":\"Bar\"},\"relationships\":
[{\"resourceId\":\"eipalloc-00000000\",\"resourceType\":\"AWS::EC2::EIP\",\"name\":
\"Is attached to ElasticIp\"}],\"configuration\":{\"foo\":\"bar\"}},\"messageType\":
\"ConfigurationItemChangeNotification\"}",
    "ruleParameters": "{\"myParameterKey\":\"myParameterValue\"}",
    "resultToken": "myResultToken",
    "eventLeftScope": false,
    "executionRoleArn": "arn:aws:iam::111122223333:role/config-role",
    "configRuleArn": "arn:aws:config:us-east-1:111122223333:config-rule/config-
rule-0123456",
    "configRuleName": "change-triggered-config-rule",
    "configRuleId": "config-rule-0123456",
    "accountId": "111122223333",
    "version": "1.0"
}
```

For more information, see Evaluating resources with AWS Config rules.

# Using Lambda with Amazon Connect

You can use a Lambda function to process requests from Amazon Connect.

Amazon Connect invokes your Lambda function synchronously with an event that contains the request body and metadata.

**Example Amazon Connect request event**

```
{
  "Details": {
      "ContactData": {
          "Attributes": {},
          "Channel": "VOICE",
          "ContactId": "4a573372-1f28-4e26-b97b-XXXXXXXXXXX",
          "CustomerEndpoint": {
              "Address": "+1234567890",
              "Type": "TELEPHONE_NUMBER"
          },
          "InitialContactId": "4a573372-1f28-4e26-b97b-XXXXXXXXXXX",
          "InitiationMethod": "INBOUND | OUTBOUND | TRANSFER | CALLBACK",
          "InstanceARN": "arn:aws:connect:aws-region:1234567890:instance/
c8c0e68d-2200-4265-82c0-XXXXXXXXXX",
          "PreviousContactId": "4a573372-1f28-4e26-b97b-XXXXXXXXXXX",
          "Queue": {
             "ARN": "arn:aws:connect:eu-west-2:111111111111:instance/cccccccc-bbbb-dddd-
eeee-ffffffffffff/queue/aaaaaaaa-bbbb-cccc-dddd-eeeeeeeeeeee",
              "Name": "PasswordReset"
           },
          "SystemEndpoint": {
              "Address": "+1234567890",
              "Type": "TELEPHONE_NUMBER"
          }
      },
      "Parameters": {
          "sentAttributeKey": "sentAttributeValue"
      }
  },
  "Name": "ContactFlowEvent"
}
```

For information about how to use Amazon Connect with Lambda, see Invoke Lambda functions in the *Amazon Connect administrator guide*.

# Using AWS Lambda with Amazon DynamoDB

You can use an AWS Lambda function to process records in an Amazon DynamoDB stream. With DynamoDB Streams, you can trigger a Lambda function to perform additional work each time a DynamoDB table is updated.

Lambda reads records from the stream and invokes your function synchronously (p. 225) with an event that contains stream records. Lambda reads records in batches and invokes your function to process records from the batch.

**Example DynamoDB Streams record event**

```
{
  "Records": [
    {
      "eventID": "1",
      "eventVersion": "1.0",
      "dynamodb": {
        "Keys": {
          "Id": {
            "N": "101"
          }
        },
        "NewImage": {
          "Message": {
            "S": "New item!"
          },
          "Id": {
            "N": "101"
          }
        },
        "StreamViewType": "NEW_AND_OLD_IMAGES",
        "SequenceNumber": "111",
        "SizeBytes": 26
      },
      "awsRegion": "us-west-2",
      "eventName": "INSERT",
      "eventSourceARN": "arn:aws:dynamodb:us-west-2:111122223333:table/TestTable/
stream/2015-05-11T21:21:33.291",
      "eventSource": "aws:dynamodb"
    },
    {
      "eventID": "2",
      "eventVersion": "1.0",
      "dynamodb": {
        "OldImage": {
          "Message": {
            "S": "New item!"
          },
          "Id": {
            "N": "101"
          }
        },
        "SequenceNumber": "222",
        "Keys": {
          "Id": {
            "N": "101"
          }
        },
        "SizeBytes": 59,
        "NewImage": {
          "Message": {
            "S": "This item has changed"
```

```
          },
          "Id": {
            "N": "101"
          }
        },
        "StreamViewType": "NEW_AND_OLD_IMAGES"
      },
      "awsRegion": "us-west-2",
      "eventName": "MODIFY",
      "eventSourceARN": "arn:aws:dynamodb:us-west-2:111122223333:table/TestTable/
stream/2015-05-11T21:21:33.291",
      "eventSource": "aws:dynamodb"
    }
  ]}
```

Lambda polls shards in your DynamoDB stream for records at a base rate of 4 times per second. When records are available, Lambda invokes your function and waits for the result. If processing succeeds, Lambda resumes polling until it receives more records.

By default, Lambda invokes your function as soon as records are available. If the batch that Lambda reads from the event source has only one record in it, Lambda sends only one record to the function. To avoid invoking the function with a small number of records, you can tell the event source to buffer records for up to 5 minutes by configuring a *batching window*. Before invoking the function, Lambda continues to read records from the event source until it has gathered a full batch, the batching window expires, or the batch reaches the payload limit of 6 MB. For more information, see Batching behavior (p. 237).

If your function returns an error, Lambda retries the batch until processing succeeds or the data expires. To avoid stalled shards, you can configure the event source mapping to retry with a smaller batch size, limit the number of retries, or discard records that are too old. To retain discarded events, you can configure the event source mapping to send details about failed batches to an SQS queue or SNS topic.

You can also increase concurrency by processing multiple batches from each shard in parallel. Lambda can process up to 10 batches in each shard simultaneously. If you increase the number of concurrent batches per shard, Lambda still ensures in-order processing at the shard level.

Configure the `ParallelizationFactor` setting to process one shard of a Kinesis or DynamoDB data stream with more than one Lambda invocation simultaneously. You can specify the number of concurrent batches that Lambda polls from a shard via a parallelization factor from 1 (default) to 10. For example, when you set `ParallelizationFactor` to 2, you can have 200 concurrent Lambda invocations at maximum to process 100 Kinesis data shards. This helps scale up the processing throughput when the data volume is volatile and the `IteratorAge` is high. Note that parallelization factor will not work if you are using Kinesis aggregation. For more information, see New AWS Lambda scaling controls for Kinesis and DynamoDB event sources. Also, see the Serverless Data Processing on AWS workshop for complete tutorials.

**Sections**


- Execution role permissions (p. 561)
- Configuring a stream as an event source (p. 561)
- Event source mapping APIs (p. 562)
- Error handling (p. 564)
- Amazon CloudWatch metrics (p. 565)
- Time windows (p. 565)
- Reporting batch item failures (p. 568)
- Amazon DynamoDB Streams configuration parameters (p. 570)
- Tutorial: Using AWS Lambda with Amazon DynamoDB streams (p. 571)
- Sample function code (p. 576)

- AWS SAM template for a DynamoDB application (p. 579)

# Execution role permissions

Lambda needs the following permissions to manage resources related to your DynamoDB stream. Add them to your function's execution role.

- dynamodb:DescribeStream
- dynamodb:GetRecords
- dynamodb:GetShardIterator
- dynamodb:ListStreams

The `AWSLambdaDynamoDBExecutionRole` managed policy includes these permissions. For more information, see Lambda execution role (p. 52).

To send records of failed batches to an SQS queue or SNS topic, your function needs additional permissions. Each destination service requires a different permission, as follows:

- **Amazon SQS** – sqs:SendMessage
- **Amazon SNS** – sns:Publish

# Configuring a stream as an event source

Create an event source mapping to tell Lambda to send records from your stream to a Lambda function. You can create multiple event source mappings to process the same data with multiple Lambda functions, or to process items from multiple streams with a single function.

To configure your function to read from DynamoDB Streams in the Lambda console, create a **DynamoDB** trigger.

### To create a trigger

1. Open the Functions page of the Lambda console.
2. Choose the name of a function.
3. Under **Function overview**, choose **Add trigger**.
4. Choose a trigger type.
5. Configure the required options, and then choose **Add**.

Lambda supports the following options for DynamoDB event sources.

### Event source options

- **DynamoDB table** – The DynamoDB table to read records from.
- **Batch size** – The number of records to send to the function in each batch, up to 10,000. Lambda passes all of the records in the batch to the function in a single call, as long as the total size of the events doesn't exceed the payload limit (p. 796) for synchronous invocation (6 MB).
- **Batch window** – Specify the maximum amount of time to gather records before invoking the function, in seconds.
- **Starting position** – Process only new records, or all existing records.
  - **Latest** – Process new records that are added to the stream.
  - **Trim horizon** – Process all records in the stream.

After processing any existing records, the function is caught up and continues to process new records.

- **On-failure destination** – An SQS queue or SNS topic for records that can't be processed. When Lambda discards a batch of records that's too old or has exhausted all retries, Lambda sends details about the batch to the queue or topic.
- **Retry attempts** – The maximum number of times that Lambda retries when the function returns an error. This doesn't apply to service errors or throttles where the batch didn't reach the function.
- **Maximum age of record** – The maximum age of a record that Lambda sends to your function.
- **Split batch on error** – When the function returns an error, split the batch into two before retrying. Your original batch size setting remains unchanged.
- **Concurrent batches per shard** – Concurrently process multiple batches from the same shard.
- **Enabled** – Set to true to enable the event source mapping. Set to false to stop processing records. Lambda keeps track of the last record processed and resumes processing from that point when the mapping is reenabled.

**Note**
You are not charged for GetRecords API calls invoked by Lambda as part of DynamoDB triggers.

To manage the event source configuration later, choose the trigger in the designer.

# Event source mapping APIs

To manage an event source with the AWS Command Line Interface (AWS CLI) or an AWS SDK, you can use the following API operations:

- CreateEventSourceMapping (p. 893)
- ListEventSourceMappings (p. 1006)
- GetEventSourceMapping (p. 952)
- UpdateEventSourceMapping (p. 1078)
- DeleteEventSourceMapping (p. 925)

The following example uses the AWS CLI to map a function named `my-function` to a DynamoDB stream that its Amazon Resource Name (ARN) specifies, with a batch size of 500.

```
aws lambda create-event-source-mapping --function-name my-function --batch-size 500 --
maximum-batching-window-in-seconds 5 --starting-position LATEST \
--event-source-arn arn:aws:dynamodb:us-east-2:123456789012:table/my-table/
stream/2019-06-10T19:26:16.525
```

You should see the following output:

```
{
    "UUID": "14e0db71-5d35-4eb5-b481-8945cf9d10c2",
    "BatchSize": 500,
    "MaximumBatchingWindowInSeconds": 5,
    "ParallelizationFactor": 1,
    "EventSourceArn": "arn:aws:dynamodb:us-east-2:123456789012:table/my-table/
stream/2019-06-10T19:26:16.525",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "LastModified": 1560209851.963,
    "LastProcessingResult": "No records processed",
    "State": "Creating",
    "StateTransitionReason": "User action",
    "DestinationConfig": {},
    "MaximumRecordAgeInSeconds": 604800,
```

```
    "BisectBatchOnFunctionError": false,
    "MaximumRetryAttempts": 10000
}
```

Configure additional options to customize how batches are processed and to specify when to discard records that can't be processed. The following example updates an event source mapping to send a failure record to an SQS queue after two retry attempts, or if the records are more than an hour old.

```
aws lambda update-event-source-mapping --uuid f89f8514-cdd9-4602-9e1f-01a5b77d449b \
--maximum-retry-attempts 2  --maximum-record-age-in-seconds 3600
--destination-config '{"OnFailure": {"Destination": "arn:aws:sqs:us-
east-2:123456789012:dlq"}}'
```

You should see this output:

```
{
    "UUID": "f89f8514-cdd9-4602-9e1f-01a5b77d449b",
    "BatchSize": 100,
    "MaximumBatchingWindowInSeconds": 0,
    "ParallelizationFactor": 1,
    "EventSourceArn": "arn:aws:dynamodb:us-east-2:123456789012:table/my-table/
stream/2019-06-10T19:26:16.525",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "LastModified": 1573243620.0,
    "LastProcessingResult": "PROBLEM: Function call failed",
    "State": "Updating",
    "StateTransitionReason": "User action",
    "DestinationConfig": {},
    "MaximumRecordAgeInSeconds": 604800,
    "BisectBatchOnFunctionError": false,
    "MaximumRetryAttempts": 10000
}
```

Updated settings are applied asynchronously and aren't reflected in the output until the process completes. Use the `get-event-source-mapping` command to view the current status.

```
aws lambda get-event-source-mapping --uuid f89f8514-cdd9-4602-9e1f-01a5b77d449b
```

You should see this output:

```
{
    "UUID": "f89f8514-cdd9-4602-9e1f-01a5b77d449b",
    "BatchSize": 100,
    "MaximumBatchingWindowInSeconds": 0,
    "ParallelizationFactor": 1,
    "EventSourceArn": "arn:aws:dynamodb:us-east-2:123456789012:table/my-table/
stream/2019-06-10T19:26:16.525",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "LastModified": 1573244760.0,
    "LastProcessingResult": "PROBLEM: Function call failed",
    "State": "Enabled",
    "StateTransitionReason": "User action",
    "DestinationConfig": {
        "OnFailure": {
            "Destination": "arn:aws:sqs:us-east-2:123456789012:dlq"
        }
    },
    "MaximumRecordAgeInSeconds": 3600,
    "BisectBatchOnFunctionError": false,
    "MaximumRetryAttempts": 2
```

```
}
```

To process multiple batches concurrently, use the `--parallelization-factor` option.

```
aws lambda update-event-source-mapping --uuid 2b733gdc-8ac3-cdf5-af3a-1827b3b11284 \
--parallelization-factor 5
```

# Error handling

The event source mapping that reads records from your DynamoDB stream, invokes your function synchronously, and retries on errors. If Lambda throttles the function or returns an error without invoking the function, Lambda retries until the records expire or exceed the maximum age that you configure on the event source mapping.

If the function receives the records but returns an error, Lambda retries until the records in the batch expire, exceed the maximum age, or reach the configured retry quota. For function errors, you can also configure the event source mapping to split a failed batch into two batches. Retrying with smaller batches isolates bad records and works around timeout issues. Splitting a batch does not count towards the retry quota.

If the error handling measures fail, Lambda discards the records and continues processing batches from the stream. With the default settings, this means that a bad record can block processing on the affected shard for up to one day. To avoid this, configure your function's event source mapping with a reasonable number of retries and a maximum record age that fits your use case.

To retain a record of discarded batches, configure a failed-event destination. Lambda sends a document to the destination queue or topic with details about the batch.

### To configure a destination for failed-event records

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Under **Function overview**, choose **Add destination**.
4. For **Source**, choose **Stream invocation**.
5. For **Stream**, choose a stream that is mapped to the function.
6. For **Destination type**, choose the type of resource that receives the invocation record.
7. For **Destination**, choose a resource.
8. Choose **Save**.

The following example shows an invocation record for a DynamoDB stream.

### Example Invocation Record

```
{
    "requestContext": {
        "requestId": "316aa6d0-8154-xmpl-9af7-85d5f4a6bc81",
        "functionArn": "arn:aws:lambda:us-east-2:123456789012:function:myfunction",
        "condition": "RetryAttemptsExhausted",
        "approximateInvokeCount": 1
    },
    "responseContext": {
        "statusCode": 200,
        "executedVersion": "$LATEST",
        "functionError": "Unhandled"
    },
    "version": "1.0",
    "timestamp": "2019-11-14T00:13:49.717Z",
```

```
    "DDBStreamBatchInfo": {
        "shardId": "shardId-00000001573689847184-864758bb",
        "startSequenceNumber": "80000000003126276362",
        "endSequenceNumber": "80000000003126276362",
        "approximateArrivalOfFirstRecord": "2019-11-14T00:13:19Z",
        "approximateArrivalOfLastRecord": "2019-11-14T00:13:19Z",
        "batchSize": 1,
        "streamArn": "arn:aws:dynamodb:us-east-2:123456789012:table/mytable/
stream/2019-11-14T00:04:06.388"
    }
}
```

You can use this information to retrieve the affected records from the stream for troubleshooting. The actual records aren't included, so you must process this record and retrieve them from the stream before they expire and are lost.

# Amazon CloudWatch metrics

Lambda emits the `IteratorAge` metric when your function finishes processing a batch of records. The metric indicates how old the last record in the batch was when processing finished. If your function is processing new events, you can use the iterator age to estimate the latency between when a record is added and when the function processes it.

An increasing trend in iterator age can indicate issues with your function. For more information, see Working with Lambda function metrics (p. 727).

# Time windows

Lambda functions can run continuous stream processing applications. A stream represents unbounded data that flows continuously through your application. To analyze information from this continuously updating input, you can bound the included records using a window defined in terms of time.

Tumbling windows are distinct time windows that open and close at regular intervals. By default, Lambda invocations are stateless—you cannot use them for processing data across multiple continuous invocations without an external database. However, with tumbling windows, you can maintain your state across invocations. This state contains the aggregate result of the messages previously processed for the current window. Your state can be a maximum of 1 MB per shard. If it exceeds that size, Lambda terminates the window early.

Each record in a stream belongs to a specific window. Lambda will process each record at least once, but doesn't guarantee that each record will be processed only once. In rare cases, such as error handling, some records might be processed more than once. Records are always processed in order the first time. If records are processed more than once, they might be processed out of order.

## Aggregation and processing

Your user managed function is invoked both for aggregation and for processing the final results of that aggregation. Lambda aggregates all records received in the window. You can receive these records in multiple batches, each as a separate invocation. Each invocation receives a state. Thus, when using tumbling windows, your Lambda function response must contain a `state` property. If the response does not contain a `state` property, Lambda considers this a failed invocation. To satisfy this condition, your function can return a `TimeWindowEventResponse` object, which has the following JSON shape:

**Example `TimeWindowEventResponse` values**

```
{
    "state": {
        "1": 282,
        "2": 715
```

```
    },
    "batchItemFailures": []
}
```

**Note**
For Java functions, we recommend using a `Map<String, String>` to represent the state.

At the end of the window, the flag `isFinalInvokeForWindow` is set to `true` to indicate that this is the final state and that it's ready for processing. After processing, the window completes and your final invocation completes, and then the state is dropped.

At the end of your window, Lambda uses final processing for actions on the aggregation results. Your final processing is synchronously invoked. After successful invocation, your function checkpoints the sequence number and stream processing continues. If invocation is unsuccessful, your Lambda function suspends further processing until a successful invocation.

**Example DynamodbTimeWindowEvent**

```
{
   "Records":[
      {
         "eventID":"1",
         "eventName":"INSERT",
         "eventVersion":"1.0",
         "eventSource":"aws:dynamodb",
         "awsRegion":"us-east-1",
         "dynamodb":{
            "Keys":{
               "Id":{
                  "N":"101"
               }
            },
            "NewImage":{
               "Message":{
                  "S":"New item!"
               },
               "Id":{
                  "N":"101"
               }
            },
            "SequenceNumber":"111",
            "SizeBytes":26,
            "StreamViewType":"NEW_AND_OLD_IMAGES"
         },
         "eventSourceARN":"stream-ARN"
      },
      {
         "eventID":"2",
         "eventName":"MODIFY",
         "eventVersion":"1.0",
         "eventSource":"aws:dynamodb",
         "awsRegion":"us-east-1",
         "dynamodb":{
            "Keys":{
               "Id":{
                  "N":"101"
               }
            },
            "NewImage":{
               "Message":{
                  "S":"This item has changed"
               },
               "Id":{
```

```
                    "N":"101"
                }
            },
            "OldImage":{
                "Message":{
                    "S":"New item!"
                },
                "Id":{
                    "N":"101"
                }
            },
            "SequenceNumber":"222",
            "SizeBytes":59,
            "StreamViewType":"NEW_AND_OLD_IMAGES"
        },
        "eventSourceARN":"stream-ARN"
    },
    {
        "eventID":"3",
        "eventName":"REMOVE",
        "eventVersion":"1.0",
        "eventSource":"aws:dynamodb",
        "awsRegion":"us-east-1",
        "dynamodb":{
            "Keys":{
                "Id":{
                    "N":"101"
                }
            },
            "OldImage":{
                "Message":{
                    "S":"This item has changed"
                },
                "Id":{
                    "N":"101"
                }
            },
            "SequenceNumber":"333",
            "SizeBytes":38,
            "StreamViewType":"NEW_AND_OLD_IMAGES"
        },
        "eventSourceARN":"stream-ARN"
    }
  ],
   "window": {
       "start": "2020-07-30T17:00:00Z",
       "end": "2020-07-30T17:05:00Z"
   },
   "state": {
       "1": "state1"
   },
   "shardId": "shard123456789",
   "eventSourceARN": "stream-ARN",
   "isFinalInvokeForWindow": false,
   "isWindowTerminatedEarly": false
}
```

## Configuration

You can configure tumbling windows when you create or update an event source mapping (p. 236). To configure a tumbling window, specify the window in seconds. The following example AWS Command Line Interface (AWS CLI) command creates a streaming event source mapping that has a tumbling window of 120 seconds. The Lambda function defined for aggregation and processing is named `tumbling-window-example-function`.

```
aws lambda create-event-source-mapping --event-source-arn arn:aws:dynamodb:us-
east-1:123456789012:stream/lambda-stream --function-name "arn:aws:lambda:us-
east-1:123456789018:function:tumbling-window-example-function" --region us-east-1 --
starting-position TRIM_HORIZON --tumbling-window-in-seconds 120
```

Lambda determines tumbling window boundaries based on the time when records were inserted into the stream. All records have an approximate timestamp available that Lambda uses in boundary determinations.

Tumbling window aggregations do not support resharding. When the shard ends, Lambda considers the window closed, and the child shards start their own window in a fresh state.

Tumbling windows fully support the existing retry policies `maxRetryAttempts` and `maxRecordAge`.

**Example Handler.py – Aggregation and processing**

The following Python function demonstrates how to aggregate and then process your final state:

```
def lambda_handler(event, context):
    print('Incoming event: ', event)
    print('Incoming state: ', event['state'])

#Check if this is the end of the window to either aggregate or process.
    if event['isFinalInvokeForWindow']:
        # logic to handle final state of the window
        print('Destination invoke')
    else:
        print('Aggregate invoke')

#Check for early terminations
    if event['isWindowTerminatedEarly']:
        print('Window terminated early')

    #Aggregation logic
    state = event['state']
    for record in event['Records']:
        state[record['dynamodb']['NewImage']['Id']] = state.get(record['dynamodb']
['NewImage']['Id'], 0) + 1

    print('Returning state: ', state)
    return {'state': state}
```

# Reporting batch item failures

When consuming and processing streaming data from an event source, by default Lambda checkpoints to the highest sequence number of a batch only when the batch is a complete success. Lambda treats all other results as a complete failure and retries processing the batch up to the retry limit. To allow for partial successes while processing batches from a stream, turn on `ReportBatchItemFailures`. Allowing partial successes can help to reduce the number of retries on a record, though it doesn't entirely prevent the possibility of retries in a successful record.

To turn on `ReportBatchItemFailures`, include the enum value **`ReportBatchItemFailures`** in the `FunctionResponseTypes` list. This list indicates which response types are enabled for your function. You can configure this list when you create or update an event source mapping (p. 236).

## Report syntax

When configuring reporting on batch item failures, the `StreamsEventResponse` class is returned with a list of batch item failures. You can use a `StreamsEventResponse` object to return the sequence

number of the first failed record in the batch. You can also create your own custom class using the correct response syntax. The following JSON structure shows the required response syntax:

```
{
  "batchItemFailures": [
        {
            "itemIdentifier": "<id>"
        }
    ]
}
```

**Note**
If the `batchItemFailures` array contains multiple items, Lambda uses the record with the lowest sequence number as the checkpoint. Lambda then retries all records starting from that checkpoint.

## Success and failure conditions

Lambda treats a batch as a complete success if you return any of the following:

- An empty `batchItemFailure` list
- A null `batchItemFailure` list
- An empty `EventResponse`
- A null `EventResponse`

Lambda treats a batch as a complete failure if you return any of the following:

- An empty string `itemIdentifier`
- A null `itemIdentifier`
- An `itemIdentifier` with a bad key name

Lambda retries failures based on your retry strategy.

## Bisecting a batch

If your invocation fails and `BisectBatchOnFunctionError` is turned on, the batch is bisected regardless of your `ReportBatchItemFailures` setting.

When a partial batch success response is received and both `BisectBatchOnFunctionError` and `ReportBatchItemFailures` are turned on, the batch is bisected at the returned sequence number and Lambda retries only the remaining records.

Java

**Example Handler.java – return new StreamsEventResponse()**

```
import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.services.lambda.runtime.RequestHandler;
import com.amazonaws.services.lambda.runtime.events.DynamodbEvent;
import com.amazonaws.services.lambda.runtime.events.StreamsEventResponse;
import com.amazonaws.services.lambda.runtime.events.models.dynamodb.StreamRecord;

import java.io.Serializable;
import java.util.ArrayList;
```

```
import java.util.List;

public class ProcessDynamodbRecords implements RequestHandler<DynamodbEvent,
 Serializable> {

    @Override
    public StreamsEventResponse handleRequest(DynamodbEvent input, Context context) {

        List<StreamsEventResponse.BatchItemFailure> batchItemFailures = new
 ArrayList<>();
        String curRecordSequenceNumber = "";

        for (DynamodbEvent.DynamodbStreamRecord dynamodbStreamRecord :
 input.getRecords()) {
          try {
                //Process your record
                StreamRecord dynamodbRecord = dynamodbStreamRecord.getDynamodb();
                curRecordSequenceNumber = dynamodbRecord.getSequenceNumber();

            } catch (Exception e) {
                /* Since we are working with streams, we can return the failed item
 immediately.
                   Lambda will immediately begin to retry processing from this failed
 item onwards. */
                batchItemFailures.add(new
 StreamsEventResponse.BatchItemFailure(curRecordSequenceNumber));
                return new StreamsEventResponse(batchItemFailures);
            }
        }

       return new StreamsEventResponse();
    }
}
```

Python

**Example Handler.py – return batchItemFailures[]**

```
def handler(event, context):
    records = event.get("Records")
    curRecordSequenceNumber = "";

    for record in records:
        try:
            # Process your record
            curRecordSequenceNumber = record["dynamodb"]["SequenceNumber"]
        except Exception as e:
            # Return failed record's sequence number
            return {"batchItemFailures":[{"itemIdentifier": curRecordSequenceNumber}]}

    return {"batchItemFailures":[]}
```

# Amazon DynamoDB Streams configuration parameters

All Lambda event source types share the same CreateEventSourceMapping (p. 893) and UpdateEventSourceMapping (p. 1078) API operations. However, only some of the parameters apply to DynamoDB Streams.

**Event source parameters that apply to DynamoDB Streams**

| Parameter | Required | Default | Notes |
|---|---|---|---|
| BatchSize | N | 100 | Maximum: 10,000 |
| BisectBatchOnFunctionError | N | false | |
| DestinationConfig | N | | Amazon SQS queue or Amazon SNS topic destination for discarded records |
| Enabled | N | true | |
| EventSourceArn | Y | | ARN of the data stream or a stream consumer |
| FunctionName | Y | | |
| MaximumBatchingWindowInSeconds | N | 0 | |
| MaximumRecordAgeInSeconds | N | -1 | -1 means infinite: failed records are retried until the record expires<br>Minimum: -1<br>Maximum: 604800 |
| MaximumRetryAttempts | N | -1 | -1 means infinite: failed records are retried until the record expires<br>Minimum: -1<br>Maximum: 604800 |
| ParallelizationFactor | N | 1 | Maximum: 10 |
| StartingPosition | Y | | TRIM_HORIZON or LATEST |
| TumblingWindowInSeconds | N | | Minimum: 0<br>Maximum: 900 |

# Tutorial: Using AWS Lambda with Amazon DynamoDB streams

In this tutorial, you create a Lambda function to consume events from an Amazon DynamoDB stream.

## Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

## Create the execution role

Create the execution role (p. 52) that gives your function permission to access AWS resources.

### To create an execution role

1. Open the roles page in the IAM console.
2. Choose **Create role**.
3. Create a role with the following properties.
   - **Trusted entity** – Lambda.
   - **Permissions** – **AWSLambdaDynamoDBExecutionRole**.
   - **Role name** – **`lambda-dynamodb-role`**.

The **AWSLambdaDynamoDBExecutionRole** has the permissions that the function needs to read items from DynamoDB and write logs to CloudWatch Logs.

## Create the function

The following example code receives a DynamoDB event input and processes the messages that it contains. For illustration, the code writes some of the incoming event data to CloudWatch Logs.

> **Note**
> For sample code in other languages, see Sample function code (p. 576).

### Example index.js

```
console.log('Loading function');

exports.handler = function(event, context, callback) {
    console.log(JSON.stringify(event, null, 2));
    event.Records.forEach(function(record) {
        console.log(record.eventID);
        console.log(record.eventName);
        console.log('DynamoDB Record: %j', record.dynamodb);
    });
    callback(null, "message");
};
```

### To create the function

1. Copy the sample code into a file named `index.js`.

2. Create a deployment package.

```
zip function.zip index.js
```

3. Create a Lambda function with the `create-function` command.

```
aws lambda create-function --function-name ProcessDynamoDBRecords \
--zip-file fileb://function.zip --handler index.handler --runtime nodejs12.x \
--role arn:aws:iam::123456789012:role/lambda-dynamodb-role
```

## Test the Lambda function

In this step, you invoke your Lambda function manually using the `invoke` AWS Lambda CLI command and the following sample DynamoDB event.

**Example input.txt**

```
{
   "Records":[
      {
         "eventID":"1",
         "eventName":"INSERT",
         "eventVersion":"1.0",
         "eventSource":"aws:dynamodb",
         "awsRegion":"us-east-1",
         "dynamodb":{
            "Keys":{
               "Id":{
                  "N":"101"
               }
            },
            "NewImage":{
               "Message":{
                  "S":"New item!"
               },
               "Id":{
                  "N":"101"
               }
            },
            "SequenceNumber":"111",
            "SizeBytes":26,
            "StreamViewType":"NEW_AND_OLD_IMAGES"
         },
         "eventSourceARN":"stream-ARN"
      },
      {
         "eventID":"2",
         "eventName":"MODIFY",
         "eventVersion":"1.0",
         "eventSource":"aws:dynamodb",
         "awsRegion":"us-east-1",
         "dynamodb":{
            "Keys":{
               "Id":{
                  "N":"101"
               }
            },
            "NewImage":{
               "Message":{
                  "S":"This item has changed"
               },
```

```
                "Id":{
                   "N":"101"
                }
             },
             "OldImage":{
                "Message":{
                   "S":"New item!"
                },
                "Id":{
                   "N":"101"
                }
             },
             "SequenceNumber":"222",
             "SizeBytes":59,
             "StreamViewType":"NEW_AND_OLD_IMAGES"
          },
          "eventSourceARN":"stream-ARN"
       },
       {
          "eventID":"3",
          "eventName":"REMOVE",
          "eventVersion":"1.0",
          "eventSource":"aws:dynamodb",
          "awsRegion":"us-east-1",
          "dynamodb":{
             "Keys":{
                "Id":{
                   "N":"101"
                }
             },
             "OldImage":{
                "Message":{
                   "S":"This item has changed"
                },
                "Id":{
                   "N":"101"
                }
             },
             "SequenceNumber":"333",
             "SizeBytes":38,
             "StreamViewType":"NEW_AND_OLD_IMAGES"
          },
          "eventSourceARN":"stream-ARN"
       }
    ]
}
```

Run the following `invoke` command.

```
aws lambda invoke --function-name ProcessDynamoDBRecords --payload file://input.txt
 outputfile.txt
```

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

The function returns the string `message` in the response body.

Verify the output in the `outputfile.txt` file.

## Create a DynamoDB table with a stream enabled

Create an Amazon DynamoDB table with a stream enabled.

### To create a DynamoDB table

1. Open the DynamoDB console.
2. Choose **Create table**.
3. Create a table with the following settings.
   - **Table name** – **`lambda-dynamodb-stream`**
   - **Primary key** – **`id`** (string)
4. Choose **Create**.

### To enable streams

1. Open the DynamoDB console.
2. Choose **Tables**.
3. Choose the **lambda-dynamodb-stream** table.
4. Under **Exports and streams**, choose **DynamoDB stream details**.
5. Choose **Enable**.
6. Choose **Enable stream**.

Write down the stream ARN. You need this in the next step when you associate the stream with your Lambda function. For more information on enabling streams, see Capturing table activity with DynamoDB Streams.

## Add an event source in AWS Lambda

Create an event source mapping in AWS Lambda. This event source mapping associates the DynamoDB stream with your Lambda function. After you create this event source mapping, AWS Lambda starts polling the stream.

Run the following AWS CLI `create-event-source-mapping` command. After the command runs, note down the UUID. You'll need this UUID to refer to the event source mapping in any commands, for example, when deleting the event source mapping.

```
aws lambda create-event-source-mapping --function-name ProcessDynamoDBRecords \
 --batch-size 100 --starting-position LATEST --event-source DynamoDB-stream-arn
```

This creates a mapping between the specified DynamoDB stream and the Lambda function. You can associate a DynamoDB stream with multiple Lambda functions, and associate the same Lambda function with multiple streams. However, the Lambda functions will share the read throughput for the stream they share.

You can get the list of event source mappings by running the following command.

```
aws lambda list-event-source-mappings
```

The list returns all of the event source mappings you created, and for each mapping it shows the `LastProcessingResult`, among other things. This field is used to provide an informative message if there are any problems. Values such as `No records processed` (indicates that AWS Lambda has not started polling or that there are no records in the stream) and `OK` (indicates AWS Lambda successfully read records from the stream and invoked your Lambda function) indicate that there are no issues. If there are issues, you receive an error message.

If you have a lot of event source mappings, use the function name parameter to narrow down the results.

```
aws lambda list-event-source-mappings --function-name ProcessDynamoDBRecords
```

## Test the setup

Test the end-to-end experience. As you perform table updates, DynamoDB writes event records to the stream. As AWS Lambda polls the stream, it detects new records in the stream and invokes your Lambda function on your behalf by passing events to the function.

1. In the DynamoDB console, add, update, and delete items to the table. DynamoDB writes records of these actions to the stream.
2. AWS Lambda polls the stream and when it detects updates to the stream, it invokes your Lambda function by passing in the event data it finds in the stream.
3. Your function runs and creates logs in Amazon CloudWatch. You can verify the logs reported in the Amazon CloudWatch console.

## Clean up your resources

You can now delete the resources that you created for this tutorial, unless you want to retain them. By deleting AWS resources that you're no longer using, you prevent unnecessary charges to your AWS account.

### To delete the Lambda function

1. Open the Functions page of the Lambda console.
2. Select the function that you created.
3. Choose **Actions**, then choose **Delete**.
4. Choose **Delete**.

### To delete the execution role

1. Open the Roles page of the IAM console.
2. Select the execution role that you created.
3. Choose **Delete role**.
4. Choose **Yes, delete**.

### To delete the DynamoDB table

1. Open the Tables page of the DynamoDB console.
2. Select the table you created.
3. Choose **Delete**.
4. Enter **`delete`** in the text box.
5. Choose **Delete**.

# Sample function code

Sample code is available for the following languages.

**Topics**

- Node.js (p. 577)

- Java 11 (p. 577)
- C# (p. 578)
- Python 3 (p. 579)
- Go (p. 579)

## Node.js

The following example processes messages from DynamoDB, and logs their contents.

**Example ProcessDynamoDBStream.js**

```
console.log('Loading function');

exports.lambda_handler = function(event, context, callback) {
    console.log(JSON.stringify(event, null, 2));
    event.Records.forEach(function(record) {
        console.log(record.eventID);
        console.log(record.eventName);
        console.log('DynamoDB Record: %j', record.dynamodb);
    });
    callback(null, "message");
};
```

Zip up the sample code to create a deployment package. For instructions, see Deploy Node.js Lambda functions with .zip file archives (p. 288).

## Java 11

The following example processes messages from DynamoDB, and logs their contents. `handleRequest` is the handler that AWS Lambda invokes and provides event data. The handler uses the predefined `DynamodbEvent` class, which is defined in the `aws-lambda-java-events` library.

**Example DDBEventProcessor.java**

```
package example;

import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.services.lambda.runtime.LambdaLogger;
import com.amazonaws.services.lambda.runtime.RequestHandler;
import com.amazonaws.services.lambda.runtime.events.DynamodbEvent;
import com.amazonaws.services.lambda.runtime.events.DynamodbEvent.DynamodbStreamRecord;

public class DDBEventProcessor implements
        RequestHandler<DynamodbEvent, String> {

    public String handleRequest(DynamodbEvent ddbEvent, Context context) {
        for (DynamodbStreamRecord record : ddbEvent.getRecords()){
           System.out.println(record.getEventID());
           System.out.println(record.getEventName());
           System.out.println(record.getDynamodb().toString());

        }
        return "Successfully processed " + ddbEvent.getRecords().size() + " records.";
    }
}
```

If the handler returns normally without exceptions, Lambda considers the input batch of records as processed successfully and begins reading new records in the stream. If the handler throws an exception,

Lambda considers the input batch of records as not processed and invokes the function with the same batch of records again.

### Dependencies

- `aws-lambda-java-core`
- `aws-lambda-java-events`

Build the code with the Lambda library dependencies to create a deployment package. For instructions, see Deploy Java Lambda functions with .zip or JAR file archives (p. 386).

## C#

The following example processes messages from DynamoDB, and logs their contents. `ProcessDynamoEvent` is the handler that AWS Lambda invokes and provides event data. The handler uses the predefined `DynamoDbEvent` class, which is defined in the `Amazon.Lambda.DynamoDBEvents` library.

### Example ProcessingDynamoDBStreams.cs

```
using System;
using System.IO;
using System.Text;
using Amazon.Lambda.Core;
using Amazon.Lambda.DynamoDBEvents;

using Amazon.Lambda.Serialization.Json;

namespace DynamoDBStreams
{
    public class DdbSample
    {
        private static readonly JsonSerializer _jsonSerializer = new JsonSerializer();

        public void ProcessDynamoEvent(DynamoDBEvent dynamoEvent)
        {
            Console.WriteLine($"Beginning to process {dynamoEvent.Records.Count}
 records...");

            foreach (var record in dynamoEvent.Records)
            {
                Console.WriteLine($"Event ID: {record.EventID}");
                Console.WriteLine($"Event Name: {record.EventName}");

                string streamRecordJson = SerializeObject(record.Dynamodb);
                Console.WriteLine($"DynamoDB Record:");
                Console.WriteLine(streamRecordJson);
            }

            Console.WriteLine("Stream processing complete.");
        }

        private string SerializeObject(object streamRecord)
        {
            using (var ms = new MemoryStream())
            {
                _jsonSerializer.Serialize(streamRecord, ms);
                return Encoding.UTF8.GetString(ms.ToArray());
            }
        }
    }
```

```
}
```

Replace the `Program.cs` in a .NET Core project with the above sample. For instructions, see Deploy C# Lambda functions with .zip file archives (p. 458).

## Python 3

The following example processes messages from DynamoDB, and logs their contents.

**Example ProcessDynamoDBStream.py**

```
from __future__ import print_function

def lambda_handler(event, context):
    for record in event['Records']:
        print(record['eventID'])
        print(record['eventName'])
    print('Successfully processed %s records.' % str(len(event['Records'])))
```

Zip up the sample code to create a deployment package. For instructions, see Deploy Python Lambda functions with .zip file archives (p. 330).

## Go

The following example processes messages from DynamoDB, and logs their contents.

**Example**

```
import (
    "strings"

    "github.com/aws/aws-lambda-go/events"
)

func handleRequest(ctx context.Context, e events.DynamoDBEvent) {

    for _, record := range e.Records {
        fmt.Printf("Processing request data for event ID %s, type %s.\n", record.EventID,
 record.EventName)

        // Print new values for attributes of type String
        for name, value := range record.Change.NewImage {
            if value.DataType() == events.DataTypeString {
                fmt.Printf("Attribute name: %s, value: %s\n", name, value.String())
            }
        }
    }
}
```

Build the executable with `go build` and create a deployment package. For instructions, see Deploy Go Lambda functions with .zip file archives (p. 427).

# AWS SAM template for a DynamoDB application

You can build this application using AWS SAM. To learn more about creating AWS SAM templates, see AWS SAM template basics in the *AWS Serverless Application Model Developer Guide*.

Below is a sample AWS SAM template for the tutorial application (p. 571). Copy the text below to a .yaml file and save it next to the ZIP package you created previously. Note that the `Handler` and

`Runtime` parameter values should match the ones you used when you created the function in the previous section.

**Example template.yaml**

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Resources:
  ProcessDynamoDBStream:
    Type: AWS::Serverless::Function
    Properties:
      Handler: handler
      Runtime: runtime
      Policies: AWSLambdaDynamoDBExecutionRole
      Events:
        Stream:
          Type: DynamoDB
          Properties:
            Stream: !GetAtt DynamoDBTable.StreamArn
            BatchSize: 100
            StartingPosition: TRIM_HORIZON

  DynamoDBTable:
    Type: AWS::DynamoDB::Table
    Properties:
      AttributeDefinitions:
        - AttributeName: id
          AttributeType: S
      KeySchema:
        - AttributeName: id
          KeyType: HASH
      ProvisionedThroughput:
        ReadCapacityUnits: 5
        WriteCapacityUnits: 5
      StreamSpecification:
        StreamViewType: NEW_IMAGE
```

For information on how to package and deploy your serverless application using the package and deploy commands, see Deploying serverless applications in the *AWS Serverless Application Model Developer Guide*.

# Using AWS Lambda with Amazon EC2

You can use AWS Lambda to process lifecycle events from Amazon Elastic Compute Cloud and manage Amazon EC2 resources. Amazon EC2 sends events to Amazon EventBridge (CloudWatch Events) for lifecycle events such as when an instance changes state, when an Amazon Elastic Block Store volume snapshot completes, or when a spot instance is scheduled to be terminated. You configure EventBridge (CloudWatch Events) to forward those events to a Lambda function for processing.

EventBridge (CloudWatch Events) invokes your Lambda function asynchronously with the event document from Amazon EC2.

**Example instance lifecycle event**

```
{
    "version": "0",
    "id": "b6ba298a-7732-2226-xmpl-976312c1a050",
    "detail-type": "EC2 Instance State-change Notification",
    "source": "aws.ec2",
    "account": "111122223333",
    "time": "2019-10-02T17:59:30Z",
    "region": "us-east-2",
    "resources": [
        "arn:aws:ec2:us-east-2:111122223333:instance/i-0c314xmplcd5b8173"
    ],
    "detail": {
        "instance-id": "i-0c314xmplcd5b8173",
        "state": "running"
    }
}
```

For details on configuring events in EventBridge (CloudWatch Events), see Using AWS Lambda with Amazon EventBridge (CloudWatch Events) (p. 535). For an example function that processes Amazon EBS snapshot notifications, see Amazon EventBridge (CloudWatch Events) for Amazon EBS in the Amazon EC2 User Guide for Linux Instances.

You can also use the AWS SDK to manage instances and other resources with the Amazon EC2 API. For a tutorial with a sample application in C#, see Tutorial: Using AWS SDK for .NET to manage Amazon EC2 Spot Instances (p. 582).

## Permissions

To process lifecycle events from Amazon EC2, EventBridge (CloudWatch Events) needs permission to invoke your function. This permission comes from the function's resource-based policy (p. 68). If you use the EventBridge (CloudWatch Events) console to configure an event trigger, the console updates the resource-based policy on your behalf. Otherwise, add a statement like the following:

**Example resource-based policy statement for Amazon EC2 lifecycle notifications**

```
{
  "Sid": "ec2-events",
  "Effect": "Allow",
  "Principal": {
    "Service": "events.amazonaws.com"
  },
  "Action": "lambda:InvokeFunction",
  "Resource": "arn:aws:lambda:us-east-2:12456789012:function:my-function",
  "Condition": {
    "ArnLike": {
      "AWS:SourceArn": "arn:aws:events:us-east-2:12456789012:rule/*"
```

```
    }
  }
}
```

To add a statement, use the `add-permission` AWS CLI command.

```
aws lambda add-permission --action lambda:InvokeFunction --statement-id ec2-events \
--principal events.amazonaws.com --function-name my-function --source-arn
 'arn:aws:events:us-east-2:12456789012:rule/*'
```

If your function uses the AWS SDK to manage Amazon EC2 resources, add Amazon EC2 permissions to the function's execution role (p. 52).

# Tutorial: Using AWS SDK for .NET to manage Amazon EC2 Spot Instances

You can use the AWS SDK for .NET to manage Amazon EC2 spot instances with C# code. The SDK enables you to use the Amazon EC2 API to create spot instance requests, determine when the request is fulfilled, delete requests, and identify the instances created.

This tutorial provides code that performs these tasks and a sample application that you can run locally or on AWS. It includes a sample project that you can deploy to AWS Lambda's .NET Core 2.1 runtime.

For more information about spot instances usage and best practices, see Spot Instances in the Amazon EC2 user guide.

## Prerequisites

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

This tutorial uses code from the developer guide's GitHub repository. The repository also contains helper scripts and configuration files that are needed to follow its procedures. Clone the repository at github.com/awsdocs/aws-lambda-developer-guide.

To use the sample code you need the following tools:

- **AWS CLI** – To deploy the sample application to AWS, install the AWS CLI. The AWS CLI also provides credentials to the sample code when you run it locally.
- **.NET Core CLI** – To run and test the code locally, install the .NET Core SDK 2.1.
- **Lambda .NET Core Global Tool** – To build the deployment package for Lambda, install the .NET Core global tool with the .NET Core CLI.

```
dotnet tool install -g Amazon.Lambda.Tools
```

The code in this tutorial manages spot requests that launch Amazon EC2 instances. To run the code locally, you need SDK credentials with permission to use the following APIs.

- `ec2:RequestSpotInstance`
- `ec2:GetSpotRequestState`
- `ec2:CancelSpotRequest`
- `ec2:TerminateInstances`

To run the sample application in AWS, you need permission to use Lambda (p. 51) and the following services.

- AWS CloudFormation (pricing)
- Amazon Elastic Compute Cloud (pricing)

Standard charges apply for each service.

## Review the code

Locate the sample project in the guide repository under sample-apps/ec2-spot. This directory contains Lambda function code, tests, project files, scripts, and a AWS CloudFormation template.

The `Function` class includes a `FunctionHandler` method that calls other methods to create spot requests, check their status, and clean up. It creates an Amazon EC2 client with the AWS SDK for .NET in a static constructor to allow it to be used throughout the class.

**Example Function.cs – FunctionHandler**

```
using Amazon.EC2;
...
    public class Function
    {
        private static AmazonEC2Client ec2Client;

        static Function() {
          AWSSDKHandler.RegisterXRayForAllServices();
          ec2Client = new AmazonEC2Client();
        }

        public async Task<string> FunctionHandler(Dictionary<string, string> input,
 ILambdaContext context)
        {
          // More AMI IDs: amazon-linux-2/release-notes/
          // us-east-2  HVM  EBS-Backed  64-bit  Amazon Linux 2
          string ami = "ami-09d9edae5eb90d556";
          string sg = "default";
          InstanceType type = InstanceType.T3aNano;
          string price = "0.003";
          int count = 1;
          var requestSpotInstances = await RequestSpotInstance(ami, sg, type, price,
 count);
          var spotRequestId =
 requestSpotInstances.SpotInstanceRequests[0].SpotInstanceRequestId;
```

The `RequestSpotInstance` method creates a spot instance request.

**Example Function.cs – RequestSpotInstance**

```
using Amazon;
using Amazon.Util;
using Amazon.EC2;
using Amazon.EC2.Model;
...
    public async Task<RequestSpotInstancesResponse> RequestSpotInstance(
      string amiId,
      string securityGroupName,
      InstanceType instanceType,
      string spotPrice,
      int instanceCount)
    {
      var request = new RequestSpotInstancesRequest();

      var launchSpecification = new LaunchSpecification();
      launchSpecification.ImageId = amiId;
      launchSpecification.InstanceType = instanceType;
      launchSpecification.SecurityGroups.Add(securityGroupName);

      request.SpotPrice = spotPrice;
      request.InstanceCount = instanceCount;
      request.LaunchSpecification = launchSpecification;

      RequestSpotInstancesResponse response =  await
 ec2Client.RequestSpotInstancesAsync(request);

      return response;
    }
...
```

Next, you need to wait until the spot request reaches the `Active` state before proceeding to the last step. To determine the state of your spot request, use the DescribeSpotInstanceRequests method to obtain the state of the spot request ID to monitor.

```
public async Task<SpotInstanceRequest> GetSpotRequest(string spotRequestId)
{
  var request = new DescribeSpotInstanceRequestsRequest();
  request.SpotInstanceRequestIds.Add(spotRequestId);

  var describeResponse = await ec2Client.DescribeSpotInstanceRequestsAsync(request);

  return describeResponse.SpotInstanceRequests[0];
}
```

The final step is to clean up your requests and instances. It is important to both cancel any outstanding requests and terminate any instances. Just canceling your requests will not terminate your instances, which means that you will continue to be charged for them. If you terminate your instances, your Spot requests may be canceled, but there are some scenarios, such as if you use persistent requests, where terminating your instances is not sufficient to stop your request from being re-fulfilled. Therefore, it is a best practice to both cancel any active requests and terminate any running instances.

You use the CancelSpotInstanceRequests method to cancel a Spot request. The following example demonstrates how to cancel a Spot request.

```
public async Task CancelSpotRequest(string spotRequestId)
{
  Console.WriteLine("Canceling request " + spotRequestId);
  var cancelRequest = new CancelSpotInstanceRequestsRequest();
  cancelRequest.SpotInstanceRequestIds.Add(spotRequestId);

  await ec2Client.CancelSpotInstanceRequestsAsync(cancelRequest);
}
```

You use the TerminateInstances method to terminate an instance.

```
public async Task TerminateSpotInstance(string instanceId)
{
  Console.WriteLine("Terminating instance " + instanceId);
  var terminateRequest = new TerminateInstancesRequest();
  terminateRequest.InstanceIds = new List<string>() { instanceId };
  try
  {
    var terminateResponse = await ec2Client.TerminateInstancesAsync(terminateRequest);
  }
  catch (AmazonEC2Exception ex)
  {
    // Check the ErrorCode to see if the instance does not exist.
    if ("InvalidInstanceID.NotFound" == ex.ErrorCode)
    {
      Console.WriteLine("Instance {0} does not exist.", instanceId);
    }
    else
    {
      // The exception was thrown for another reason, so re-throw the exception.
      throw;
    }
  }
}
```

## Run the code locally

Run the code on your local machine to create a spot instance request. After the request is fulfilled, the code deletes the request and terminates the instance.

### To run the application code

1. Navigate to the `ec2Spot.Tests` directory.

   ```
   cd test/ec2Spot.Tests
   ```

2. Use the .NET CLI to run the project's unit tests.

   ```
   dotnet test
   ```

   You should see the following output:

   ```
   Starting test execution, please wait...
   sir-x5tgs5ij
   open
   open
   open
   open
   open
   active
   Canceling request sir-x5tgs5ij
   Terminating instance i-0b3fdff0e12e0897e
   Complete

   Test Run Successful.
   Total tests: 1
        Passed: 1
    Total time: 7.6060 Seconds
   ```

The unit test invokes the FunctionHandler method to create a spot instance request, monitor it, and clean up. It is implemented in the xUnit.net testing framework.

## Deploy the application

Run the code in Lambda as a starting point for creating a serverless application.

### To deploy and test the application

1. Set your region to `us-east-2`.

```
export AWS_DEFAULT_REGION=us-east-2
```

2. Create a bucket for deployment artifacts.

```
./create-bucket.sh
```

   You should see the following output:

```
make_bucket: lambda-artifacts-63d5cbbf18fa5ecc
```

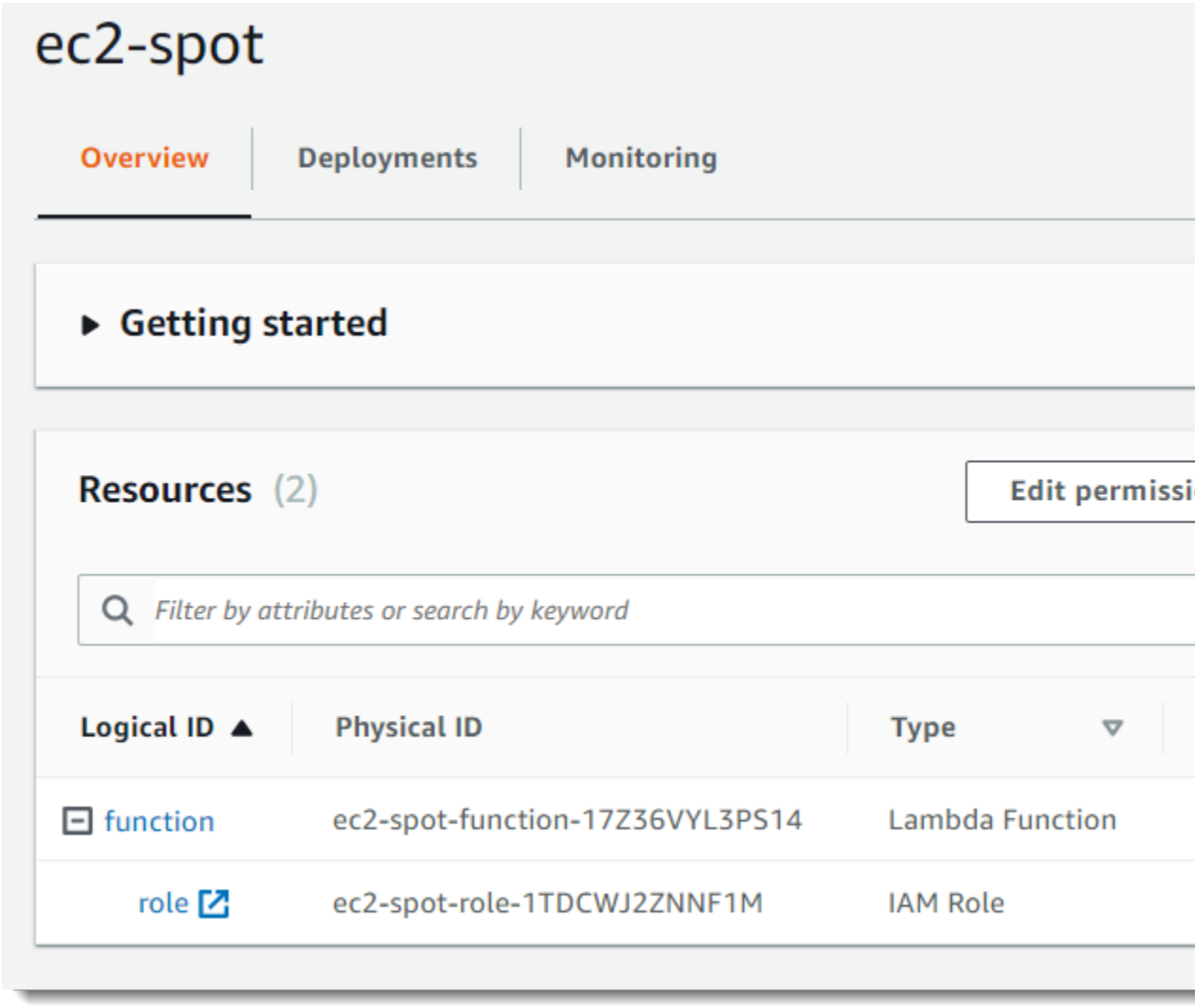
3. Create a deployment package and deploy the application.

```
./deploy.sh
```

   You should see the following output:

```
Amazon Lambda Tools for .NET Core applications (3.3.0)
Project Home: https://github.com/aws/aws-extensions-for-dotnet-cli, https://github.com/
aws/aws-lambda-dotnet

Executing publish command
...
Created publish archive (ec2spot.zip)
Lambda project successfully packaged: ec2spot.zip
Uploading to ebd38e401cedd7d676d05d22b76f0209  1305107 / 1305107.0  (100.00%)
Successfully packaged artifacts and wrote output template to file out.yaml.
Run the following command to deploy the packaged template
aws cloudformation deploy --template-file out.yaml --stack-name <YOUR STACK NAME>

Waiting for changeset to be created..
Waiting for stack create/update to complete
Successfully created/updated stack - ec2-spot
```

4. Open the Applications page of the Lambda console.




5. Under **Resources**, choose **function**.
6. Choose **Test** and create a test event from the default template.
7. Choose **Test** again to invoke the function.

View the logs and trace information to see the spot request ID and sequence of calls to Amazon EC2.

To view the service map, open the Service map page in the X-Ray console.

Choose a node in the service map and then choose **View traces** to see a list of traces. Choose a trace from the list to see the timeline of calls that the function made to Amazon EC2.

## Clean up

The code provided in this tutorial is designed to create and delete spot instance requests, and to terminate the instances that they launch. However, if an error occurs, the requests and instances might not be cleaned up automatically. View the spot requests and instances in the Amazon EC2 console.

**To confirm that Amazon EC2 resources are cleaned up**

1. Open the Spot Requests page in the Amazon EC2 console.

2. Verify that the state of the requests is **Cancelled**.
3. Choose the instance ID in the **Capacity** column to view the instance.
4. Verify that the state of the instances is **Terminated** or **Shutting down**.

To clean up the sample function and support resources, delete its AWS CloudFormation stack and the artifacts bucket that you created.

```
./cleanup.sh
```

You should see the following output:

```
Delete deployment artifacts and bucket (lambda-artifacts-63d5cbbf18fa5ecc)?y
delete: s3://lambda-artifacts-63d5cbbf18fa5ecc/ebd38e401cedd7d676d05d22b76f0209
remove_bucket: lambda-artifacts-63d5cbbf18fa5ecc
```

The function's log group is not deleted automatically. You can delete it in the CloudWatch Logs console. Traces in X-Ray expire after a few weeks and are deleted automatically.

# Tutorial: Configuring a Lambda function to access Amazon ElastiCache in an Amazon VPC

In this tutorial, you do the following:

- Create an Amazon ElastiCache cluster in your default Amazon Virtual Private Cloud. For more information about Amazon ElastiCache, see Amazon ElastiCache.
- Create a Lambda function to access the ElastiCache cluster. When you create the Lambda function, you provide subnet IDs in your Amazon VPC and a VPC security group to allow the Lambda function to access resources in your VPC. For illustration in this tutorial, the Lambda function generates a UUID, writes it to the cache, and retrieves it from the cache.
- Invoke the Lambda function and verify that it accessed the ElastiCache cluster in your VPC.

For details on using Lambda with Amazon VPC, see Configuring a Lambda function to access resources in a VPC (p. 191).

## Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

## Create the execution role

Create the execution role (p. 52) that gives your function permission to access AWS resources.

**To create an execution role**

1. Open the roles page in the IAM console.
2. Choose **Create role**.
3. Create a role with the following properties.
   - **Trusted entity** – Lambda.
   - **Permissions** – **AWSLambdaVPCAccessExecutionRole**.
   - **Role name** – **`lambda-vpc-role`**.

The **AWSLambdaVPCAccessExecutionRole** has the permissions that the function needs to manage network connections to a VPC.

# Create an ElastiCache cluster

Create an ElastiCache cluster in your default VPC.

1. Run the following AWS CLI command to create a Memcached cluster.

   ```
   aws elasticache create-cache-cluster --cache-cluster-id ClusterForLambdaTest --cache-node-type cache.t3.medium --engine memcached --num-cache-nodes 1 --security-group-ids sg-0123a1b123456c1de
   ```

   You can look up the default VPC security group in the VPC console under **Security Groups**. Your example Lambda function will add and retrieve an item from this cluster.
2. Write down the configuration endpoint for the cache cluster that you launched. You can get this from the Amazon ElastiCache console. You will specify this value in your Lambda function code in the next section.

# Create a deployment package

The following example Python code reads and writes an item to your ElastiCache cluster.

**Example app.py**

```
from __future__ import print_function
import time
import uuid
import sys
import socket
import elasticache_auto_discovery
from pymemcache.client.hash import HashClient

#elasticache settings
elasticache_config_endpoint = "your-elasticache-cluster-endpoint:port"
nodes = elasticache_auto_discovery.discover(elasticache_config_endpoint)
nodes = map(lambda x: (x[1], int(x[2])), nodes)
memcache_client = HashClient(nodes)

def handler(event, context):
    """
    This function puts into memcache and get from it.
    Memcache is hosted using elasticache
    """

    #Create a random UUID... this will be the sample element we add to the cache.
    uuid_inserted = uuid.uuid4().hex
    #Put the UUID to the cache.
    memcache_client.set('uuid', uuid_inserted)
    #Get item (UUID) from the cache.
    uuid_obtained = memcache_client.get('uuid')
    if uuid_obtained.decode("utf-8") == uuid_inserted:
        # this print should go to the CloudWatch Logs and Lambda console.
        print ("Success: Fetched value %s from memcache" %(uuid_inserted))
    else:
        raise Exception("Value is not the same as we put :(. Expected %s got %s"
 %(uuid_inserted, uuid_obtained))

    return "Fetched value from memcache: " + uuid_obtained.decode("utf-8")
```

**Dependencies**

- pymemcache – The Lambda function code uses this library to create a `HashClient` object to set and get items from memcache.
- elasticache-auto-discovery – The Lambda function uses this library to get the nodes in your Amazon ElastiCache cluster.

Install dependencies with Pip and create a deployment package. For instructions, see Deploy Python Lambda functions with .zip file archives (p. 330).

# Create the Lambda function

Create the Lambda function with the `create-function` command.

```
aws lambda create-function --function-name AccessMemCache --timeout 30 --memory-size 1024 \
--zip-file fileb://function.zip --handler app.handler --runtime python3.8 \
--role arn:aws:iam::123456789012:role/lambda-vpc-role \
--vpc-config SubnetIds=subnet-0532bb6758ce7c71f,subnet-
d6b7fda068036e11f,SecurityGroupIds=sg-0897d5f549934c2fb
```

You can find the subnet IDs and the default security group ID of your VPC from the VPC console.

# Test the Lambda function

In this step, you invoke the Lambda function manually using the `invoke` command. When the Lambda function runs, it generates a UUID and writes it to the ElastiCache cluster that you specified in your Lambda code. The Lambda function then retrieves the item from the cache.

1. Invoke the Lambda function with the `invoke` command.

   ```
   aws lambda invoke --function-name AccessMemCache output.txt
   ```

2. Verify that the Lambda function executed successfully as follows:

   - Review the output.txt file.
   - Review the results in the AWS Lambda console.
   - Verify the results in CloudWatch Logs.

Now that you have created a Lambda function that accesses an ElastiCache cluster in your VPC, you can have the function invoked in response to events. For information about configuring event sources and examples, see Using AWS Lambda with other services (p. 496).

# Clean up your resources

You can now delete the resources that you created for this tutorial, unless you want to retain them. By deleting AWS resources that you're no longer using, you prevent unnecessary charges to your AWS account.

**To delete the Lambda function**

1. Open the Functions page of the Lambda console.
2. Select the function that you created.
3. Choose **Actions**, then choose **Delete**.

4. Choose **Delete**.

### To delete the execution role

1. Open the Roles page of the IAM console.
2. Select the execution role that you created.
3. Choose **Delete role**.
4. Choose **Yes, delete**.

### To delete the ElastiCache cluster

1. Open the Memcached page of the ElastiCache console.
2. Select the cluster you created.
3. Choose **Actions**, **Delete**.
4. Choose **Delete**.

# Using AWS Lambda with an Application Load Balancer

You can use a Lambda function to process requests from an Application Load Balancer. Elastic Load Balancing supports Lambda functions as a target for an Application Load Balancer. Use load balancer rules to route HTTP requests to a function, based on path or header values. Process the request and return an HTTP response from your Lambda function.

Elastic Load Balancing invokes your Lambda function synchronously with an event that contains the request body and metadata.

**Example Application Load Balancer request event**

```
{
    "requestContext": {
        "elb": {
            "targetGroupArn": "arn:aws:elasticloadbalancing:us-
east-2:123456789012:targetgroup/lambda-279XGJDqGZ5rsrHC2Fjr/49e9d65c45c6791a"
        }
    },
    "httpMethod": "GET",
    "path": "/lambda",
    "queryStringParameters": {
        "query": "1234ABCD"
    },
    "headers": {
        "accept": "text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,image/
apng,*/*;q=0.8",
        "accept-encoding": "gzip",
        "accept-language": "en-US,en;q=0.9",
        "connection": "keep-alive",
        "host": "lambda-alb-123578498.us-east-2.elb.amazonaws.com",
        "upgrade-insecure-requests": "1",
        "user-agent": "Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML,
 like Gecko) Chrome/71.0.3578.98 Safari/537.36",
        "x-amzn-trace-id": "Root=1-5c536348-3d683b8b04734faae651f476",
        "x-forwarded-for": "72.12.164.125",
        "x-forwarded-port": "80",
        "x-forwarded-proto": "http",
        "x-imforwards": "20"
    },
    "body": "",
    "isBase64Encoded": false
}
```

Your function processes the event and returns a response document to the load balancer in JSON. Elastic Load Balancing converts the document to an HTTP success or error response and returns it to the user.

**Example response document format**

```
{
    "statusCode": 200,
    "statusDescription": "200 OK",
    "isBase64Encoded": False,
    "headers": {
        "Content-Type": "text/html"
    },
    "body": "<h1>Hello from Lambda!</h1>"
}
```

To configure an Application Load Balancer as a function trigger, grant Elastic Load Balancing permission to run the function, create a target group that routes requests to the function, and add a rule to the load balancer that sends requests to the target group.

Use the `add-permission` command to add a permission statement to your function's resource-based policy.

```
aws lambda add-permission --function-name alb-function \
--statement-id load-balancer --action "lambda:InvokeFunction" \
--principal elasticloadbalancing.amazonaws.com
```

You should see the following output:

```
{
    "Statement": "{\"Sid\":\"load-balancer\",\"Effect\":\"Allow\",\"Principal\":{\"Service
\":\"elasticloadbalancing.amazonaws.com\"},\"Action\":\"lambda:InvokeFunction\",\"Resource
\":\"arn:aws:lambda:us-west-2:123456789012:function:alb-function\"}"
}
```

For instructions on configuring the Application Load Balancer listener and target group, see Lambda functions as a target in the *User Guide for Application Load Balancers*.

# Using Amazon EFS with Lambda

Lambda integrates with Amazon Elastic File System (Amazon EFS) to support secure, shared file system access for Lambda applications. You can configure functions to mount a file system during initialization with the NFS protocol over the local network within a VPC. Lambda manages the connection and encrypts all traffic to and from the file system.

The file system and the Lambda function must be in the same region. A Lambda function in one account can mount a file system in a different account. For this scenario, you configure VPC peering between the function VPC and the file system VPC.

> **Note**
> To configure a function to connect to a file system, see Configuring file system access for Lambda functions (p. 206).

Amazon EFS supports file locking to prevent corruption if multiple functions try to write to the same file system at the same time. Locking in Amazon EFS follows the NFS v4.1 protocol for advisory locking, and enables your applications to use both whole file and byte range locks.

Amazon EFS provides options to customize your file system based on your application's need to maintain high performance at scale. There are three primary factors to consider: the number of connections, throughput (in MiB per second), and IOPS.

> **Quotas**
> For detail on file system quotas and limits, see Quotas for Amazon EFS file systems in the *Amazon Elastic File System User Guide*.

To avoid issues with scaling, throughput, and IOPS, monitor the metrics that Amazon EFS sends to Amazon CloudWatch. For an overview of monitoring in Amazon EFS, see Monitoring Amazon EFS in the *Amazon Elastic File System User Guide*.

**Sections**


- Connections (p. 595)
- Throughput (p. 596)
- IOPS (p. 596)


## Connections

Amazon EFS supports up to 25,000 connections per file system. During initialization, each instance of a function creates a single connection to its file system that persists across invocations. This means that you can reach 25,000 concurrency across one or more functions connected to a file system. To limit the number of connections a function creates, use reserved concurrency (p. 180).

However, when you make changes to your function's code or configuration at scale, there is a temporary increase in the number of function instances beyond the current concurrency. Lambda provisions new instances to handle new requests and there is some delay before old instances close their connections to the file system. To avoid hitting the maximum connections limit during a deployment, use rolling deployments (p. 773). With rolling deployments, you gradually shift traffic to the new version each time you make a change.

If you connect to the same file system from other services such as Amazon EC2, you should also be aware of the scaling behavior of connections in Amazon EFS. A file system supports the creation of up to 3,000 connections in a burst, after which it supports 500 new connections per minute. This matches burst scaling (p. 30) behavior in Lambda, which applies across all functions in a Region. But if you are creating connections outside of Lambda, your functions may not be able to scale at full speed.

To monitor and trigger an alarm on connections, use the `ClientConnections` metric.

# Throughput

At scale, it is also possible to exceed the maximum *throughput* for a file system. In *bursting mode* (the default), a file system has a low baseline throughput that scales linearly with its size. To allow for bursts of activity, the file system is granted burst credits that allow it to use 100 MiB/s or more of throughput. Credits accumulate continually and are expended with every read and write operation. If the file system runs out of credits, it throttles read and write operations beyond the baseline throughput, which can cause invocations to time out.

> **Note**
> If you use provisioned concurrency (p. 180), your function can consume burst credits even when idle. With provisioned concurrency, Lambda initializes instances of your function before it is invoked, and recycles instances every few hours. If you use files on an attached file system during initialization, this activity can use all of your burst credits.

To monitor and trigger an alarm on throughput, use the `BurstCreditBalance` metric. It should increase when your function's concurrency is low and decrease when it is high. If it always decreases or does not accumulate enough during low activity to cover peak traffic, you may need to limit your function's concurrency or enable provisioned throughput.

# IOPS

Input/output operations per second (IOPS) is a measurement of the number of read and write operations processed by the file system. In general purpose mode, IOPS is limited in favor of lower latency, which is beneficial for most applications.

To monitor and alarm on IOPS in general purpose mode, use the `PercentIOLimit` metric. If this metric reaches 100%, your function can time out waiting for read and write operations to complete.

# Using AWS Lambda with AWS IoT

AWS IoT provides secure communication between internet-connected devices (such as sensors) and the AWS Cloud. This makes it possible for you to collect, store, and analyze telemetry data from multiple devices.

You can create AWS IoT rules for your devices to interact with AWS services. The AWS IoT Rules Engine provides a SQL-based language to select data from message payloads and send the data to other services, such as Amazon S3, Amazon DynamoDB, and AWS Lambda. You define a rule to invoke a Lambda function when you want to invoke another AWS service or a third-party service.

When an incoming IoT message triggers the rule, AWS IoT invokes your Lambda function asynchronously (p. 228) and passes data from the IoT message to the function.

The following example shows a moisture reading from a greenhouse sensor. The **row** and **pos** values identify the location of the sensor. This example event is based on the greenhouse type in the AWS IoT Rules tutorials.

**Example AWS IoT message event**

```
{
    "row" : "10",
    "pos" : "23",
    "moisture" : "75"
}
```

For asynchronous invocation, Lambda queues the message and retries (p. 250) if your function returns an error. Configure your function with a destination (p. 230) to retain events that your function could not process.

You need to grant permission for the AWS IoT service to invoke your Lambda function. Use the `add-permission` command to add a permission statement to your function's resource-based policy.

```
aws lambda add-permission --function-name my-function \
--statement-id iot-events --action "lambda:InvokeFunction" --principal iot.amazonaws.com
```

You should see the following output:

```
{
    "Statement": "{\"Sid\":\"iot-events\",\"Effect\":\"Allow\",\"Principal\":
{\"Service\":\"iot.amazonaws.com\"},\"Action\":\"lambda:InvokeFunction\",\"Resource\":
\"arn:aws:lambda:us-west-2:123456789012:function:my-function\"}"
}
```

For more information about how to use Lambda with AWS IoT, see Creating an AWS Lambda rule.

# Using AWS Lambda with AWS IoT Events

AWS IoT Events monitors the inputs from multiple IoT sensors and applications to recognize event patterns. Then it takes appropriate actions when events occur. AWS IoT Events receives its inputs as JSON payloads from many sources. AWS IoT Events supports simple events (where each input triggers an event) and complex events (where multiple inputs must occur to trigger the event).

To use AWS IoT Events, you define a detector model, which is a state-machine model of your equipment or process. In addition to states, you define inputs and events for the model. You also define the actions to take when an event occurs. Use a Lambda function for an action when you want to invoke another AWS service (such as Amazon Connect), or take actions in an external application (such as your enterprise resource planning (ERP) application).

When the event occurs, AWS IoT Events invokes your Lambda function asynchronously. It provides information about the detector model and the event that triggered the action. The following example message event is based on the definitions in the AWS IoT Events simple step-by-step example.

**Example AWS IoT Events message event**

```
{
  "event: ":{
    "eventName": "myChargedEvent",
    "eventTime": 1567797571647,
    "payload":{
      "detector":{
         "detectorModelName": "AWS_IoTEvents_Hello_World1567793458261",
         "detectorModelVersion": "4",
         "keyValue": "100009"
      },
      "eventTriggerDetails":{
         "triggerType": "Message",
         "inputName": "AWS_IoTEvents_HelloWorld_VoltageInput",
         "messageId": "64c75a34-068b-4a1d-ae58-c16215dc4efd"
      },
      "actionExecutionId": "49f0f32f-1209-38a7-8a76-d6ca49dd0bc4",
      "state":{
         "variables": {},
         "stateName": "Charged",
         "timers": {}
      }
    }
  }
}
```

The event that is passed into the Lambda function includes the following fields:

- `eventName` – The name for this event in the detector model.
- `eventTime` – The time that the event occurred.
- `detector` – The name and version of the detector model.
- `eventTriggerDetails` – A description of the input that triggered the event.
- `actionExecutionId` – The unique execution identifier of the action.
- `state` – The state of the detector model when the event occurred.
  - `stateName` – The name of the state in the detector model.
  - `timers` – Any timers that are set in this state.
  - `variables` – Any variable values that are set in this state.

You need to grant permission for the AWS IoT Events service to invoke your Lambda function. Use the `add-permission` command to add a permission statement to your function's resource-based policy.

```
aws lambda add-permission --function-name my-function \
--statement-id iot-events --action "lambda:InvokeFunction" --principal
 iotevents.amazonaws.com
```

You should see the following output:

```
{
    "Statement": "{\"Sid\":\"iot-events\",\"Effect\":\"Allow\",\"Principal\":{\"Service
\":\"iotevents.amazonaws.com\"},\"Action\":\"lambda:InvokeFunction\",\"Resource\":
\"arn:aws:lambda:us-west-2:123456789012:function:my-function\"}"
}
```

For more information about using Lambda with AWS IoT Events, see Using AWS IoT Events with other services.

# Using Lambda with self-managed Apache Kafka

Lambda supports Apache Kafka as an event source (p. 236). Apache Kafka is a an open-source event streaming platform that supports workloads such as data pipelines and streaming analytics.

You can use the AWS managed Kafka service Amazon Managed Streaming for Apache Kafka (Amazon MSK), or a self-managed Kafka cluster. For details about using Lambda with Amazon MSK, see Using Lambda with Amazon MSK (p. 646).

This topic describes how to use Lambda with a self-managed Kafka cluster. In AWS terminology, a self-managed cluster includes non-AWS hosted Kafka clusters. For example, you can host your Kafka cluster with a cloud provider such as CloudKarafka. You can also use other AWS hosting options for your cluster. For more information, see Best Practices for Running Apache Kafka on AWS on the AWS Big Data Blog.

Apache Kafka as an event source operates similarly to using Amazon Simple Queue Service (Amazon SQS) or Amazon Kinesis. Lambda internally polls for new messages from the event source and then synchronously invokes the target Lambda function. Lambda reads the messages in batches and provides these to your function as an event payload. The maximum batch size is configurable. (The default is 100 messages.)

For Kafka-based event sources, Lambda supports processing control parameters, such as batching windows and batch size. For more information, see Batching behavior (p. 237).

For an example of how to use self-managed Kafka as an event source, see Using self-hosted Apache Kafka as an event source for AWS Lambda on the AWS Compute Blog.

Lambda sends the batch of messages in the event parameter when it invokes your Lambda function. The event payload contains an array of messages. Each array item contains details of the Kafka topic and Kafka partition identifier, together with a timestamp and a base64-encoded message.

```
{
   "eventSource":"aws:SelfManagedKafka",
   "bootstrapServers":"b-2.demo-cluster-1.a1bcde.c1.kafka.us-
east-1.amazonaws.com:9092,b-1.demo-cluster-1.a1bcde.c1.kafka.us-east-1.amazonaws.com:9092",
   "records":{
      "mytopic-0":[
         {
            "topic":"mytopic",
            "partition":0,
            "offset":15,
            "timestamp":1545084650987,
            "timestampType":"CREATE_TIME",
            "key":"abcDEFghiJKLmnoPQRstuVWXyz1234==",
            "value":"SGVsbG8sIHRoaXMgaXMgYSB0ZXN0Lg==",
            "headers":[
               {
                  "headerKey":[
                     104,
                     101,
                     97,
                     100,
                     101,
                     114,
                     86,
                     97,
                     108,
                     117,
                     101
                  ]
               }
            ]
```

```
            }
        ]
    }
}
```

**Topics**


- Kafka cluster authentication (p. 601)
- Managing API access and permissions (p. 603)
- Authentication and authorization errors (p. 605)
- Network configuration (p. 606)
- Adding a Kafka cluster as an event source (p. 606)
- Using a Kafka cluster as an event source (p. 609)
- Auto scaling of the Kafka event source (p. 609)
- Event source API operations (p. 609)
- Event source mapping errors (p. 610)
- Amazon CloudWatch metrics (p. 610)
- Self-managed Apache Kafka configuration parameters (p. 610)


# Kafka cluster authentication

Lambda supports several methods to authenticate with your self-managed Apache Kafka cluster. Make sure that you configure the Kafka cluster to use one of these supported authentication methods. For more information about Kafka security, see the Security section of the Kafka documentation.

## VPC access

If only Kafka users within your VPC access your Kafka brokers, you must configure the Kafka event source for Amazon Virtual Private Cloud (Amazon VPC) access.

## SASL/SCRAM authentication

Lambda supports Simple Authentication and Security Layer/Salted Challenge Response Authentication Mechanism (SASL/SCRAM) authentication with Transport Layer Security (TLS) encryption. Lambda sends the encrypted credentials to authenticate with the cluster. For more information about SASL/SCRAM authentication, see RFC 5802.

Lambda supports SASL/PLAIN authentication with TLS encryption. With SASL/PLAIN authentication, Lambda sends credentials as clear text (unencrypted) to the server.

For SASL authentication, you store the user name and password as a secret in AWS Secrets Manager. For more information about using Secrets Manager, see Tutorial: Create and retrieve a secret in the *AWS Secrets Manager User Guide*.

## Mutual TLS authentication

Mutual TLS (mTLS) provides two-way authentication between the client and server. The client sends a certificate to the server for the server to verify the client, and the server sends a certificate to the client for the client to verify the server.

In self-managed Apache Kafka, Lambda acts as the client. You configure a client certificate (as a secret in Secrets Manager) to authenticate Lambda with your Kafka brokers. The client certificate must be signed by a CA in the server's trust store.

The Kafka cluster sends a server certificate to Lambda to authenticate the Kafka brokers with Lambda. The server certificate can be a public CA certificate or a private CA/self-signed certificate. The public CA certificate must be signed by a certificate authority (CA) that's in the Lambda trust store. For a private CA/self-signed certificate, you configure the server root CA certificate (as a secret in Secrets Manager). Lambda uses the root certificate to verify the Kafka brokers.

For more information about mTLS, see Introducing mutual TLS authentication for Amazon MSK as an event source.

## Configuring the client certificate secret

The CLIENT_CERTIFICATE_TLS_AUTH secret requires a certificate field and a private key field. For an encrypted private key, the secret requires a private key password. Both the certificate and private key must be in PEM format.

**Note**
Lambda supports the PBES1 (but not PBES2) private key encryption algorithms.

The certificate field must contain a list of certificates, beginning with the client certificate, followed by any intermediate certificates, and ending with the root certificate. Each certificate must start on a new line with the following structure:

```
-----BEGIN CERTIFICATE-----
        <certificate contents>
-----END CERTIFICATE-----
```

Secrets Manager supports secrets up to 65,536 bytes, which is enough space for long certificate chains.

The private key must be in PKCS #8 format, with the following structure:

```
-----BEGIN PRIVATE KEY-----
         <private key contents>
-----END PRIVATE KEY-----
```

For an encrypted private key, use the following structure:

```
-----BEGIN ENCRYPTED PRIVATE KEY-----
          <private key contents>
-----END ENCRYPTED PRIVATE KEY-----
```

The following example shows the contents of a secret for mTLS authentication using an encrypted private key. For an encrypted private key, include the private key password in the secret.

```
{
 "privateKeyPassword": "testpassword",
 "certificate": "-----BEGIN CERTIFICATE-----
MIIE5DCCAsygAwIBAgIRAPJdwaFaNRrytHBto0j5BA0wDQYJKoZIhvcNAQELBQAw
...
j0Lh4/+1HfgyE2KlmII36dg4IMzNjAFEBZiCRoPimO40s1cRqtFHXoal0QQbIlxk
cmUuiAii9R0=
-----END CERTIFICATE-----
-----BEGIN CERTIFICATE-----
MIIFgjCCA2qgAwIBAgIQdjNZd6uFf9hbNC5RdfmHrzANBgkqhkiG9w0BAQsFADBb
...
rQoiowbbk5wXCheYSANQIfTZ6weQTgiCHCCbuuMKNVS95FkXm0vqVD/YpXKwA/no
c8PH3PSoAaRwMMgOSA2ALJvbRz8mpg==
-----END CERTIFICATE-----",
```

```
 "privateKey": "-----BEGIN ENCRYPTED PRIVATE KEY-----
MIIFKzBVBgkqhkiG9w0BBQ0wSDAnBgkqhkiG9w0BBQwwGgQUiAFcK5hT/X7Kjmgp
...
QrSekqF+kWzmB6nAfSzgO9IaoAaytLvNgGTckWeUkWn/V0Ck+LdGUXzAC4RxZnoQ
zp2mwJn2NYB7AZ7+imp0azDZb+8YG2aUCiyqb6PnnA==
-----END ENCRYPTED PRIVATE KEY-----"
}
```

## Configuring the server root CA certificate secret

You create this secret if your Kafka brokers use TLS encryption with certificates signed by a private CA. You can use TLS encryption for VPC, SASL/SCRAM, SASL/PLAIN, or mTLS authentication.

The server root CA certificate secret requires a field that contains the Kafka broker's root CA certificate in PEM format. The following example shows the structure of the secret.

```
{
    "certificate": "-----BEGIN CERTIFICATE-----
  MIID7zCCAtegAwIBAgIBADANBgkqhkiG9w0BAQsFADCBmDELMAkGA1UEBhMCVVMx
  EDAOBgNVBAgTB0FyaXpvbmExEzARBgNVBAcTClNjb3R0c2RhbGUxJTAjBgNVBAoT
  HFN0YXJmaWVsZCBUZWNobm9sb2dpZXMsIEluY4xOzA5BgNVBAMTMlN0YXJmaWVs
  ZCBTZXJ2aWNlcyBSb290IENlcnRpZmljYXRlIEF1dG...
  -----END CERTIFICATE-----"
```

# Managing API access and permissions

In addition to accessing your self-managed Kafka cluster, your Lambda function needs permissions to perform various API actions. You add these permissions to the function's execution role (p. 52). If your users need access to any API actions, add the required permissions to the identity policy for the AWS Identity and Access Management (IAM) user or role.

## Required Lambda function permissions

To create and store logs in a log group in Amazon CloudWatch Logs, your Lambda function must have the following permissions in its execution role:

- logs:CreateLogGroup
- logs:CreateLogStream
- logs:PutLogEvents

## Optional Lambda function permissions

Your Lambda function might also need permissions to:

- Describe your Secrets Manager secret.
- Access your AWS Key Management Service (AWS KMS) customer managed key.
- Access your Amazon VPC.

### Secrets Manager and AWS KMS permissions

Depending on the type of access control that you're configuring for your Kafka brokers, your Lambda function might need permission to access your Secrets Manager secret or to decrypt your AWS KMS

customer managed key. To access these resources, your function's execution role must have the following permissions:

- secretsmanager:GetSecretValue
- kms:Decrypt

### VPC permissions

If only users within a VPC can access your self-managed Apache Kafka cluster, your Lambda function must have permission to access your Amazon VPC resources. These resources include your VPC, subnets, security groups, and network interfaces. To access these resources, your function's execution role must have the following permissions:

- ec2:CreateNetworkInterface
- ec2:DescribeNetworkInterfaces
- ec2:DescribeVpcs
- ec2:DeleteNetworkInterface
- ec2:DescribeSubnets
- ec2:DescribeSecurityGroups

## Adding permissions to your execution role

To access other AWS services that your self-managed Apache Kafka cluster uses, Lambda uses the permissions policies that you define in your Lambda function's execution role (p. 52).

By default, Lambda is not permitted to perform the required or optional actions for a self-managed Apache Kafka cluster. You must create and define these actions in an IAM trust policy, and then attach the policy to your execution role. This example shows how you might create a policy that allows Lambda to access your Amazon VPC resources.

```
{
        "Version":"2012-10-17",
        "Statement":[
           {
              "Effect":"Allow",
              "Action":[
                 "ec2:CreateNetworkInterface",
                 "ec2:DescribeNetworkInterfaces",
                 "ec2:DescribeVpcs",
                 "ec2:DeleteNetworkInterface",
                 "ec2:DescribeSubnets",
                 "ec2:DescribeSecurityGroups"
              ],
              "Resource":"*"
           }
        ]
    }
```

For information about creating a JSON policy document in the IAM console, see Creating policies on the JSON tab in the *IAM User Guide*.

## Granting users access with an IAM policy

By default, IAM users and roles don't have permission to perform event source API operations (p. 609). To grant access to users in your organization or account, you create or update an identity-based policy. For more information, see Controlling access to AWS resources using policies in the *IAM User Guide*.

# Authentication and authorization errors

If any of the permissions required to consume data from the Kafka cluster are missing, Lambda displays one of the following error messages in the event source mapping under **LastProcessingResult**.

**Error messages**


- Cluster failed to authorize Lambda (p. 605)
- SASL authentication failed (p. 605)
- Server failed to authenticate Lambda (p. 605)
- Lambda failed to authenticate server (p. 605)
- Provided certificate or private key is invalid (p. 606)


## Cluster failed to authorize Lambda

For SASL/SCRAM or mTLS, this error indicates that the provided user doesn't have all of the following required Kafka access control list (ACL) permissions:

- DescribeConfigs Cluster
- Describe Group
- Read Group
- Describe Topic
- Read Topic

When you create Kafka ACLs with the required `kafka-cluster` permissions, specify the topic and group as resources. The topic name must match the topic in the event source mapping. The group name must match the event source mapping's UUID.

After you add the required permissions to the execution role, it might take several minutes for the changes to take effect.

## SASL authentication failed

For SASL/SCRAM or SASL/PLAIN, this error indicates that the provided user name and password aren't valid.

## Server failed to authenticate Lambda

This error indicates that the Kafka broker failed to authenticate Lambda. This can occur for any of the following reasons:

- You didn't provide a client certificate for mTLS authentication.
- You provided a client certificate, but the Kafka brokers aren't configured to use mTLS authentication.
- A client certificate isn't trusted by the Kafka brokers.

## Lambda failed to authenticate server

This error indicates that Lambda failed to authenticate the Kafka broker. This can occur for any of the following reasons:

- The Kafka brokers use self-signed certificates or a private CA, but didn't provide the server root CA certificate.

- The server root CA certificate doesn't match the root CA that signed the broker's certificate.
- Hostname validation failed because the broker's certificate doesn't contain the broker's DNS name or IP address as a subject alternative name.

### Provided certificate or private key is invalid

This error indicates that the Kafka consumer couldn't use the provided certificate or private key. Make sure that the certificate and key use PEM format, and that the private key encryption uses a PBES1 algorithm.

## Network configuration

If you configure Amazon VPC access to your Kafka brokers, Lambda must have access to the Amazon VPC resources associated with your Kafka cluster. We recommend that you deploy AWS PrivateLink VPC endpoints for Lambda and AWS Security Token Service (AWS STS). If the broker uses authentication, also deploy a VPC endpoint for Secrets Manager.

Alternatively, ensure that the VPC associated with your Kafka cluster includes one NAT gateway per public subnet. For more information, see Internet and service access for VPC-connected functions (p. 197).

Configure your Amazon VPC security groups with the following rules (at minimum):

- Inbound rules – Allow all traffic on the Kafka broker port for the security groups specified for your event source. Kafka uses port 9092 by default.
- Outbound rules – Allow all traffic on port 443 for all destinations. Allow all traffic on the Kafka broker port for the security groups specified for your event source. Kafka uses port 9092 by default.
- If you are using VPC endpoints instead of a NAT gateway, the security groups associated with the VPC endpoints must allow all inbound traffic on port 443 from the event source's security groups.

For more information about configuring the network, see Setting up AWS Lambda with an Apache Kafka cluster within a VPC on the AWS Compute Blog.

## Adding a Kafka cluster as an event source

To create an event source mapping (p. 236), add your Kafka cluster as a Lambda function trigger (p. 12) using the Lambda console, an AWS SDK, or the AWS Command Line Interface (AWS CLI).

This section describes how to create an event source mapping using the Lambda console and the AWS CLI.

### Prerequisites

- A self-managed Apache Kafka cluster. Lambda supports Apache Kafka version 0.10.0.0 and later.
- An execution role (p. 52) with permission to access the AWS resources that your self-managed Kafka cluster uses.

### Customizable consumer group ID

When setting up Kafka as an event source, you can specify a consumer group ID. This consumer group ID is an existing identifier for the Kafka consumer group that you want your Lambda function to join.

You can use this feature to seamlessly migrate any ongoing Kafka record processing setups from other consumers to Lambda.

If you specify a consumer group ID and there are other active pollers within that consumer group, Kafka distributes messages across all consumers. In other words, Lambda doesn't receive all message for the Kafka topic. If you want Lambda to handle all messages in the topic, turn off any other pollers in that consumer group.

Additionally, if you specify a consumer group ID, and Kafka finds a valid existing consumer group with the same ID, Lambda ignores the `StartingPosition` parameter for your event source mapping. Instead, Lambda begins processing records according to the committed offset of the consumer group. If you specify a consumer group ID, and Kafka cannot find an existing consumer group, then Lambda configures your event source with the specified `StartingPosition`.

The consumer group ID that you specify must be unique among all your Kafka event sources. After creating a Kafka event source mapping with the consumer group ID specified, you cannot update this value.

## Adding a self-managed Kafka cluster (console)

Follow these steps to add your self-managed Apache Kafka cluster and a Kafka topic as a trigger for your Lambda function.

**To add an Apache Kafka trigger to your Lambda function (console)**

1. Open the Functions page of the Lambda console.
2. Choose the name of your Lambda function.
3. Under **Function overview**, choose **Add trigger**.
4. Under **Trigger configuration**, do the following:

    a. Choose the **Apache Kafka** trigger type.
    b. For **Bootstrap servers**, enter the host and port pair address of a Kafka broker in your cluster, and then choose **Add**. Repeat for each Kafka broker in the cluster.
    c. For **Topic name**, enter the name of the Kafka topic used to store records in the cluster.
    d. (Optional) For **Batch size**, enter the maximum number of records to receive in a single batch.
    e. For **Batch window**, enter the maximum amount of seconds that Lambda spends gathering records before invoking the function.
    f. (Optional) For **Consumer group ID**, enter the ID of a Kafka consumer group to join.
    g. (Optional) For **Starting position**, choose **Latest** to start reading the stream from the latest record. Or, choose **Trim horizon** to start at the earliest available record.
    h. (Optional) For **VPC**, choose the Amazon VPC for your Kafka cluster. Then, choose the **VPC subnets** and **VPC security groups**.

        This setting is required if only users within your VPC access your brokers.

    i. (Optional) For **Authentication**, choose **Add**, and then do the following:

        i. Choose the access or authentication protocol of the Kafka brokers in your cluster.
            - If your Kafka broker uses SASL plaintext authentication, choose **BASIC_AUTH**.
            - If your broker uses SASL/SCRAM authentication, choose one of the **SASL_SCRAM** protocols.
            - If you're configuring mTLS authentication, choose the **CLIENT_CERTIFICATE_TLS_AUTH** protocol.
        ii. For SASL/SCRAM or mTLS authentication, choose the Secrets Manager secret key that contains the credentials for your Kafka cluster.

j. (Optional) For **Encryption**, choose the Secrets Manager secret containing the root CA certificate that your Kafka brokers use for TLS encryption, if your Kafka brokers use certificates signed by a private CA.

   This setting applies to TLS encryption for SASL/SCRAM or SASL/PLAIN, and to mTLS authentication.

k. To create the trigger in a disabled state for testing (recommended), clear **Enable trigger**. Or, to enable the trigger immediately, select **Enable trigger**.

5. To create the trigger, choose **Add**.

# Adding a self-managed Kafka cluster (AWS CLI)

Use the following example AWS CLI commands to create and view a self-managed Apache Kafka trigger for your Lambda function.

## Using SASL/SCRAM

If Kafka users access your Kafka brokers over the internet, specify the Secrets Manager secret that you created for SASL/SCRAM authentication. The following example uses the `create-event-source-mapping` AWS CLI command to map a Lambda function named `my-kafka-function` to a Kafka topic named `AWSKafkaTopic`.

```
aws lambda create-event-source-mapping --topics AWSKafkaTopic
          --source-access-configuration
 Type=SASL_SCRAM_512_AUTH,URI=arn:aws:secretsmanager:us-
east-1:01234567890:secret:MyBrokerSecretName
          --function-name arn:aws:lambda:us-east-1:01234567890:function:my-kafka-function
          --self-managed-event-source '{"Endpoints":{"KAFKA_BOOTSTRAP_SERVERS":
["abc3.xyz.com:9092", "abc2.xyz.com:9092"]}}'
```

For more information, see the CreateEventSourceMapping (p. 893) API reference documentation.

## Using a VPC

If only Kafka users within your VPC access your Kafka brokers, you must specify your VPC, subnets, and VPC security group. The following example uses the `create-event-source-mapping` AWS CLI command to map a Lambda function named `my-kafka-function` to a Kafka topic named `AWSKafkaTopic`.

```
aws lambda create-event-source-mapping
          --topics AWSKafkaTopic
          --source-access-configuration '[{"Type": "VPC_SUBNET", "URI":
 "subnet:subnet-0011001100"},
          {"Type": "VPC_SUBNET", "URI": "subnet:subnet-0022002200"},
          {"Type": "VPC_SECURITY_GROUP", "URI": "security_group:sg-0123456789"}]'
          --function-name arn:aws:lambda:us-east-1:01234567890:function:my-kafka-function
          --self-managed-event-source '{"Endpoints":{"KAFKA_BOOTSTRAP_SERVERS":
["abc3.xyz.com:9092",
          "abc2.xyz.com:9092"]}}'
```

For more information, see the CreateEventSourceMapping (p. 893) API reference documentation.

## Viewing the status using the AWS CLI

The following example uses the `get-event-source-mapping` AWS CLI command to describe the status of the event source mapping that you created.

```
aws lambda get-event-source-mapping
          --uuid dh38738e-992b-343a-1077-3478934hjkfd7
```

# Using a Kafka cluster as an event source

When you add your Apache Kafka cluster as a trigger for your Lambda function, the cluster is used as an event source (p. 236).

Lambda reads event data from the Kafka topics that you specify as `Topics` in a CreateEventSourceMapping (p. 893) request, based on the `StartingPosition` that you specify. After successful processing, your Kafka topic is committed to your Kafka cluster.

If you specify the `StartingPosition` as `LATEST`, Lambda starts reading from the latest message in each partition belonging to the topic. Because there can be some delay after trigger configuration before Lambda starts reading the messages, Lambda doesn't read any messages produced during this window.

Lambda processes records from one or more Kafka topic partitions that you specify and sends a JSON payload to your function. When more records are available, Lambda continues processing records in batches, based on the `BatchSize` value that you specify in a CreateEventSourceMapping (p. 893) request, until your function catches up with the topic.

If your function returns an error for any of the messages in a batch, Lambda retries the whole batch of messages until processing succeeds or the messages expire.

> **Note**
> While Lambda functions typically have a maximum timeout limit of 15 minutes, event source mappings for Amazon MSK, self-managed Apache Kafka, and Amazon MQ for ActiveMQ and RabbitMQ only support functions with maximum timeout limits of 14 minutes. This constraint ensures that the event source mapping can properly handle function errors and retries.

# Auto scaling of the Kafka event source

When you initially create an an Apache Kafka event source (p. 236), Lambda allocates one consumer to process all partitions in the Kafka topic. Each consumer has multiple processors running in parallel to handle increased workloads. Additionally, Lambda automatically scales up or down the number of consumers, based on workload. To preserve message ordering in each partition, the maximum number of consumers is one consumer per partition in the topic.

In one-minute intervals, Lambda evaluates the consumer offset lag of all the partitions in the topic. If the lag is too high, the partition is receiving messages faster than Lambda can process them. If necessary, Lambda adds or removes consumers from the topic. The scaling process of adding or removing consumers occurs within three minutes of evaluation.

If your target Lambda function is overloaded, Lambda reduces the number of consumers. This action reduces the workload on the function by reducing the number of messages that consumers can retrieve and send to the function.

To monitor the throughput of your Kafka topic, you can view the Apache Kafka consumer metrics, such as `consumer_lag` and `consumer_offset`. To check how many function invocations occur in parallel, you can also monitor the concurrency metrics (p. 729) for your function.

# Event source API operations

When you add your Kafka cluster as an event source (p. 236) for your Lambda function using the Lambda console, an AWS SDK, or the AWS CLI, Lambda uses APIs to process your request.

To manage an event source with the AWS Command Line Interface (AWS CLI) or an AWS SDK, you can use the following API operations:

- CreateEventSourceMapping (p. 893)
- ListEventSourceMappings (p. 1006)
- GetEventSourceMapping (p. 952)
- UpdateEventSourceMapping (p. 1078)
- DeleteEventSourceMapping (p. 925)

# Event source mapping errors

When you add your Apache Kafka cluster as an event source (p. 236) for your Lambda function, if your function encounters an error, your Kafka consumer stops processing records. Consumers of a topic partition are those that subscribe to, read, and process your records. Your other Kafka consumers can continue processing records, provided they don't encounter the same error.

To determine the cause of a stopped consumer, check the `StateTransitionReason` field in the response of `EventSourceMapping`. The following list describes the event source errors that you can receive:

**`ESM_CONFIG_NOT_VALID`**

The event source mapping configuration isn't valid.

**`EVENT_SOURCE_AUTHN_ERROR`**

Lambda couldn't authenticate the event source.

**`EVENT_SOURCE_AUTHZ_ERROR`**

Lambda doesn't have the required permissions to access the event source.

**`FUNCTION_CONFIG_NOT_VALID`**

The function configuration isn't valid.

**Note**
If your Lambda event records exceed the allowed size limit of 6 MB, they can go unprocessed.

# Amazon CloudWatch metrics

Lambda emits the `OffsetLag` metric while your function processes records. The value of this metric is the difference in offset between the last record written to the Kafka event source topic and the last record that your function's consumer group processed. You can use `OffsetLag` to estimate the latency between when a record is added and when your consumer group processes it.

An increasing trend in `OffsetLag` can indicate issues with pollers in your function's consumer group. For more information, see Working with Lambda function metrics (p. 727).

# Self-managed Apache Kafka configuration parameters

All Lambda event source types share the same CreateEventSourceMapping (p. 893) and UpdateEventSourceMapping (p. 1078) API operations. However, only some of the parameters apply to Apache Kafka.

**Event source parameters that apply to self-managed Apache Kafka**

| Parameter | Required | Default | Notes |
|---|---|---|---|
| BatchSize | N | 100 | Maximum: 10,000 |
| Enabled | N | Enabled | |
| FunctionName | Y | | |
| SelfManagedEventSource | Y | | List of Kafka Brokers. Can set only on Create |
| SelfManagedKafkaEventSourceConfig | N | Contains the ConsumerGroupId field which defaults to a unique value. | Can set only on Create |
| SourceAccessConfigurations | N | No credentials | VPC information or authentication credentials for the cluster<br><br>For SASL_PLAIN, set to BASIC_AUTH |
| StartingPosition | Y | | TRIM_HORIZON or LATEST<br><br>Can set only on Create |
| Topics | Y | | Topic name<br><br>Can set only on Create |

# Using AWS Lambda with Amazon Kinesis Data Firehose

Amazon Kinesis Data Firehose captures, transforms, and loads streaming data into downstream services such as Kinesis Data Analytics or Amazon S3. You can write Lambda functions to request additional, customized processing of the data before it is sent downstream.

**Example Amazon Kinesis Data Firehose message event**

```
{
  "invocationId": "invoked123",
  "deliveryStreamArn": "aws:lambda:events",
  "region": "us-west-2",
  "records": [
    {
      "data": "SGVsbG8gV29ybGQ=",
      "recordId": "record1",
      "approximateArrivalTimestamp": 1510772160000,
      "kinesisRecordMetadata": {
        "shardId": "shardId-000000000000",
        "partitionKey": "4d1ad2b9-24f8-4b9d-a088-76e9947c317a",
        "approximateArrivalTimestamp": "2012-04-23T18:25:43.511Z",
        "sequenceNumber": "49546986683135544286507457936321625675700192471156785154",
        "subsequenceNumber": ""
      }
    },
    {
      "data": "SGVsbG8gV29ybGQ=",
      "recordId": "record2",
      "approximateArrivalTimestamp": 151077216000,
      "kinesisRecordMetadata": {
        "shardId": "shardId-000000000001",
        "partitionKey": "4d1ad2b9-24f8-4b9d-a088-76e9947c318a",
        "approximateArrivalTimestamp": "2012-04-23T19:25:43.511Z",
        "sequenceNumber": "49546986683135544286507457936321625675700192471156785155",
        "subsequenceNumber": ""
      }
    }
  ]
}
```

For more information, see Amazon Kinesis Data Firehose data transformation in the Kinesis Data Firehose Developer Guide.

# Using AWS Lambda with Amazon Kinesis

You can use an AWS Lambda function to process records in an Amazon Kinesis data stream.

A Kinesis data stream is a set of shards. Each shard contains a sequence of data records. A **consumer** is an application that processes the data from a Kinesis data stream. You can map a Lambda function to a shared-throughput consumer (standard iterator), or to a dedicated-throughput consumer with enhanced fan-out.

For standard iterators, Lambda polls each shard in your Kinesis stream for records using HTTP protocol. The event source mapping shares read throughput with other consumers of the shard.

To minimize latency and maximize read throughput, you can create a data stream consumer with enhanced fan-out. Stream consumers get a dedicated connection to each shard that doesn't impact other applications reading from the stream. The dedicated throughput can help if you have many applications reading the same data, or if you're reprocessing a stream with large records. Kinesis pushes records to Lambda over HTTP/2.

For details about Kinesis data streams, see Reading Data from Amazon Kinesis Data Streams.

Lambda reads records from the data stream and invokes your function synchronously (p. 225) with an event that contains stream records. Lambda reads records in batches and invokes your function to process records from the batch. Each batch contains records from a single shard/data stream.

**Example Kinesis record event**

```
{
    "Records": [
        {
            "kinesis": {
                "kinesisSchemaVersion": "1.0",
                "partitionKey": "1",
                "sequenceNumber":
 "49590338271490256608559692538361571095921575989136588898",
                "data": "SGVsbG8sIHRoaXMgaXMgYSB0ZXN0Lg==",
                "approximateArrivalTimestamp": 1545084650.987
            },
            "eventSource": "aws:kinesis",
            "eventVersion": "1.0",
            "eventID":
 "shardId-000000000006:49590338271490256608559692538361571095921575989136588898",
            "eventName": "aws:kinesis:record",
            "invokeIdentityArn": "arn:aws:iam::123456789012:role/lambda-role",
            "awsRegion": "us-east-2",
            "eventSourceARN": "arn:aws:kinesis:us-east-2:123456789012:stream/lambda-stream"
        },
        {
            "kinesis": {
                "kinesisSchemaVersion": "1.0",
                "partitionKey": "1",
                "sequenceNumber":
 "49590338271490256608559692540925702759324208523137515618",
                "data": "VGhpcyBpcyBvbmx5IGEgdGVzdC4=",
                "approximateArrivalTimestamp": 1545084711.166
            },
            "eventSource": "aws:kinesis",
            "eventVersion": "1.0",
            "eventID":
 "shardId-000000000006:49590338271490256608559692540925702759324208523137515618",
            "eventName": "aws:kinesis:record",
            "invokeIdentityArn": "arn:aws:iam::123456789012:role/lambda-role",
```

```
            "awsRegion": "us-east-2",
            "eventSourceARN": "arn:aws:kinesis:us-east-2:123456789012:stream/lambda-stream"
        }
    ]
}
```

By default, Lambda invokes your function as soon as records are available. If the batch that Lambda reads from the event source has only one record in it, Lambda sends only one record to the function. To avoid invoking the function with a small number of records, you can tell the event source to buffer records for up to 5 minutes by configuring a *batching window*. Before invoking the function, Lambda continues to read records from the event source until it has gathered a full batch, the batching window expires, or the batch reaches the payload limit of 6 MB. For more information, see Batching behavior (p. 237).

If your function returns an error, Lambda retries the batch until processing succeeds or the data expires. To avoid stalled shards, you can configure the event source mapping to retry with a smaller batch size, limit the number of retries, or discard records that are too old. To retain discarded events, you can configure the event source mapping to send details about failed batches to an SQS queue or SNS topic.

You can also increase concurrency by processing multiple batches from each shard in parallel. Lambda can process up to 10 batches in each shard simultaneously. If you increase the number of concurrent batches per shard, Lambda still ensures in-order processing at the shard level.

Configure the `ParallelizationFactor` setting to process one shard of a Kinesis or DynamoDB data stream with more than one Lambda invocation simultaneously. You can specify the number of concurrent batches that Lambda polls from a shard via a parallelization factor from 1 (default) to 10. For example, when you set `ParallelizationFactor` to 2, you can have 200 concurrent Lambda invocations at maximum to process 100 Kinesis data shards. This helps scale up the processing throughput when the data volume is volatile and the `IteratorAge` is high. Note that parallelization factor will not work if you are using Kinesis aggregation. For more information, see New AWS Lambda scaling controls for Kinesis and DynamoDB event sources. Also, see the Serverless Data Processing on AWS workshop for complete tutorials.

**Sections**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- Execution role permissions (p. 615)
- Configuring a stream as an event source (p. 616)
- Event source mapping API (p. 617)
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- AWS SAM template for a Kinesis application (p. 632)


# Configuring your data stream and function

Your Lambda function is a consumer application for your data stream. It processes one batch of records at a time from each shard. You can map a Lambda function to a data stream (standard iterator), or to a consumer of a stream (enhanced fan-out).

For standard iterators, Lambda polls each shard in your Kinesis stream for records at a base rate of once per second. When more records are available, Lambda keeps processing batches until the function catches up with the stream. The event source mapping shares read throughput with other consumers of the shard.

To minimize latency and maximize read throughput, create a data stream consumer with enhanced fan-out. Enhanced fan-out consumers get a dedicated connection to each shard that doesn't impact other applications reading from the stream. Stream consumers use HTTP/2 to reduce latency by pushing records to Lambda over a long-lived connection and by compressing request headers. You can create a stream consumer with the Kinesis RegisterStreamConsumer API.

```
aws kinesis register-stream-consumer --consumer-name con1 \
--stream-arn arn:aws:kinesis:us-east-2:123456789012:stream/lambda-stream
```

You should see the following output:

```
{
    "Consumer": {
        "ConsumerName": "con1",
        "ConsumerARN": "arn:aws:kinesis:us-east-2:123456789012:stream/lambda-stream/
consumer/con1:1540591608",
        "ConsumerStatus": "CREATING",
        "ConsumerCreationTimestamp": 1540591608.0
    }
}
```

To increase the speed at which your function processes records, add shards to your data stream. Lambda processes records in each shard in order. It stops processing additional records in a shard if your function returns an error. With more shards, there are more batches being processed at once, which lowers the impact of errors on concurrency.

If your function can't scale up to handle the total number of concurrent batches, request a quota increase (p. 796) or reserve concurrency (p. 180) for your function.

# Execution role permissions

Lambda needs the following permissions to manage resources that are related to your Kinesis data stream. Add them to your function's execution role (p. 52).

- kinesis:DescribeStream
- kinesis:DescribeStreamSummary
- kinesis:GetRecords
- kinesis:GetShardIterator
- kinesis:ListShards
- kinesis:ListStreams
- kinesis:SubscribeToShard

The `AWSLambdaKinesisExecutionRole` managed policy includes these permissions. For more information, see Lambda execution role (p. 52).

To send records of failed batches to an SQS queue or SNS topic, your function needs additional permissions. Each destination service requires a different permission, as follows:

- **Amazon SQS** – sqs:SendMessage

- **Amazon SNS** – sns:Publish

# Configuring a stream as an event source

Create an event source mapping to tell Lambda to send records from your data stream to a Lambda function. You can create multiple event source mappings to process the same data with multiple Lambda functions, or to process items from multiple data streams with a single function. When processing items from multiple data streams, each batch will only contain records from a single shard/stream.

To configure your function to read from Kinesis in the Lambda console, create a **Kinesis** trigger.

### To create a trigger

1. Open the Functions page of the Lambda console.
2. Choose the name of a function.
3. Under **Function overview**, choose **Add trigger**.
4. Choose a trigger type.
5. Configure the required options, and then choose **Add**.

Lambda supports the following options for Kinesis event sources.

### Event source options

- **Kinesis stream** – The Kinesis stream to read records from.
- **Consumer** (optional) – Use a stream consumer to read from the stream over a dedicated connection.
- **Batch size** – The number of records to send to the function in each batch, up to 10,000. Lambda passes all of the records in the batch to the function in a single call, as long as the total size of the events doesn't exceed the payload limit (p. 796) for synchronous invocation (6 MB).
- **Batch window** – Specify the maximum amount of time to gather records before invoking the function, in seconds.
- **Starting position** – Process only new records, all existing records, or records created after a certain date.
  - **Latest** – Process new records that are added to the stream.
  - **Trim horizon** – Process all records in the stream.
  - **At timestamp** – Process records starting from a specific time.

  After processing any existing records, the function is caught up and continues to process new records.
- **On-failure destination** – An SQS queue or SNS topic for records that can't be processed. When Lambda discards a batch of records that's too old or has exhausted all retries, Lambda sends details about the batch to the queue or topic.
- **Retry attempts** – The maximum number of times that Lambda retries when the function returns an error. This doesn't apply to service errors or throttles where the batch didn't reach the function.
- **Maximum age of record** – The maximum age of a record that Lambda sends to your function.
- **Split batch on error** – When the function returns an error, split the batch into two before retrying. Your original batch size setting remains unchanged.
- **Concurrent batches per shard** – Concurrently process multiple batches from the same shard.
- **Enabled** – Set to true to enable the event source mapping. Set to false to stop processing records. Lambda keeps track of the last record processed and resumes processing from that point when it's reenabled.

**Note**
Kinesis charges for each shard and, for enhanced fan-out, data read from the stream. For pricing details, see Amazon Kinesis pricing.

To manage the event source configuration later, choose the trigger in the designer.

# Event source mapping API

To manage an event source with the AWS Command Line Interface (AWS CLI) or an AWS SDK, you can use the following API operations:

- CreateEventSourceMapping (p. 893)
- ListEventSourceMappings (p. 1006)
- GetEventSourceMapping (p. 952)
- UpdateEventSourceMapping (p. 1078)
- DeleteEventSourceMapping (p. 925)

To create the event source mapping with the AWS CLI, use the `create-event-source-mapping` command. The following example uses the AWS CLI to map a function named `my-function` to a Kinesis data stream. The data stream is specified by an Amazon Resource Name (ARN), with a batch size of 500, starting from the timestamp in Unix time.

```
aws lambda create-event-source-mapping --function-name my-function \
--batch-size 500 --starting-position AT_TIMESTAMP --starting-position-timestamp 1541139109
 \
--event-source-arn arn:aws:kinesis:us-east-2:123456789012:stream/lambda-stream
```

You should see the following output:

```
{
    "UUID": "2b733gdc-8ac3-cdf5-af3a-1827b3b11284",
    "BatchSize": 500,
    "MaximumBatchingWindowInSeconds": 0,
    "ParallelizationFactor": 1,
    "EventSourceArn": "arn:aws:kinesis:us-east-2:123456789012:stream/lambda-stream",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "LastModified": 1541139209.351,
    "LastProcessingResult": "No records processed",
    "State": "Creating",
    "StateTransitionReason": "User action",
    "DestinationConfig": {},
    "MaximumRecordAgeInSeconds": 604800,
    "BisectBatchOnFunctionError": false,
    "MaximumRetryAttempts": 10000
}
```

To use a consumer, specify the consumer's ARN instead of the stream's ARN.

Configure additional options to customize how batches are processed and to specify when to discard records that can't be processed. The following example updates an event source mapping to send a failure record to an SQS queue after two retry attempts, or if the records are more than an hour old.

```
aws lambda update-event-source-mapping --uuid f89f8514-cdd9-4602-9e1f-01a5b77d449b \
--maximum-retry-attempts 2  --maximum-record-age-in-seconds 3600
--destination-config '{"OnFailure": {"Destination": "arn:aws:sqs:us-
east-2:123456789012:dlq"}}'
```

You should see this output:

```
{
    "UUID": "f89f8514-cdd9-4602-9e1f-01a5b77d449b",
    "BatchSize": 100,
    "MaximumBatchingWindowInSeconds": 0,
    "ParallelizationFactor": 1,
    "EventSourceArn": "arn:aws:kinesis:us-east-2:123456789012:stream/lambda-stream",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "LastModified": 1573243620.0,
    "LastProcessingResult": "PROBLEM: Function call failed",
    "State": "Updating",
    "StateTransitionReason": "User action",
    "DestinationConfig": {},
    "MaximumRecordAgeInSeconds": 604800,
    "BisectBatchOnFunctionError": false,
    "MaximumRetryAttempts": 10000
}
```

Updated settings are applied asynchronously and aren't reflected in the output until the process completes. Use the `get-event-source-mapping` command to view the current status.

```
aws lambda get-event-source-mapping --uuid f89f8514-cdd9-4602-9e1f-01a5b77d449b
```

You should see this output:

```
{
    "UUID": "f89f8514-cdd9-4602-9e1f-01a5b77d449b",
    "BatchSize": 100,
    "MaximumBatchingWindowInSeconds": 0,
    "ParallelizationFactor": 1,
    "EventSourceArn": "arn:aws:kinesis:us-east-2:123456789012:stream/lambda-stream",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "LastModified": 1573244760.0,
    "LastProcessingResult": "PROBLEM: Function call failed",
    "State": "Enabled",
    "StateTransitionReason": "User action",
    "DestinationConfig": {
        "OnFailure": {
            "Destination": "arn:aws:sqs:us-east-2:123456789012:dlq"
        }
    },
    "MaximumRecordAgeInSeconds": 3600,
    "BisectBatchOnFunctionError": false,
    "MaximumRetryAttempts": 2
}
```

To process multiple batches concurrently, use the `--parallelization-factor` option.

```
aws lambda update-event-source-mapping --uuid 2b733gdc-8ac3-cdf5-af3a-1827b3b11284 \
--parallelization-factor 5
```

# Error handling

The event source mapping that reads records from your Kinesis stream, invokes your function synchronously, and retries on errors. If Lambda throttles the function or returns an error without invoking the function, Lambda retries until the records expire or exceed the maximum age that you configure on the event source mapping.

If the function receives the records but returns an error, Lambda retries until the records in the batch expire, exceed the maximum age, or reach the configured retry quota. For function errors, you can also configure the event source mapping to split a failed batch into two batches. Retrying with smaller batches isolates bad records and works around timeout issues. Splitting a batch does not count towards the retry quota.

If the error handling measures fail, Lambda discards the records and continues processing batches from the stream. With the default settings, this means that a bad record can block processing on the affected shard for up to one week. To avoid this, configure your function's event source mapping with a reasonable number of retries and a maximum record age that fits your use case.

To retain a record of discarded batches, configure a failed-event destination. Lambda sends a document to the destination queue or topic with details about the batch.

### To configure a destination for failed-event records

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Under **Function overview**, choose **Add destination**.
4. For **Source**, choose **Stream invocation**.
5. For **Stream**, choose a stream that is mapped to the function.
6. For **Destination type**, choose the type of resource that receives the invocation record.
7. For **Destination**, choose a resource.
8. Choose **Save**.

The following example shows an invocation record for a Kinesis stream.

### Example invocation record

```
{
    "requestContext": {
        "requestId": "c9b8fa9f-5a7f-xmpl-af9c-0c604cde93a5",
        "functionArn": "arn:aws:lambda:us-east-2:123456789012:function:myfunction",
        "condition": "RetryAttemptsExhausted",
        "approximateInvokeCount": 1
    },
    "responseContext": {
        "statusCode": 200,
        "executedVersion": "$LATEST",
        "functionError": "Unhandled"
    },
    "version": "1.0",
    "timestamp": "2019-11-14T00:38:06.021Z",
    "KinesisBatchInfo": {
        "shardId": "shardId-000000000001",
        "startSequenceNumber": "49601189658422359378836298521827638475320189012309704722",
        "endSequenceNumber": "49601189658422359378836298522902373528957594348623495186",
        "approximateArrivalOfFirstRecord": "2019-11-14T00:38:04.835Z",
        "approximateArrivalOfLastRecord": "2019-11-14T00:38:05.580Z",
        "batchSize": 500,
        "streamArn": "arn:aws:kinesis:us-east-2:123456789012:stream/mystream"
    }
}
```

You can use this information to retrieve the affected records from the stream for troubleshooting. The actual records aren't included, so you must process this record and retrieve them from the stream before they expire and are lost.

# Amazon CloudWatch metrics

Lambda emits the `IteratorAge` metric when your function finishes processing a batch of records. The metric indicates how old the last record in the batch was when processing finished. If your function is processing new events, you can use the iterator age to estimate the latency between when a record is added and when the function processes it.

An increasing trend in iterator age can indicate issues with your function. For more information, see Working with Lambda function metrics (p. 727).

# Time windows

Lambda functions can run continuous stream processing applications. A stream represents unbounded data that flows continuously through your application. To analyze information from this continuously updating input, you can bound the included records using a window defined in terms of time.

Tumbling windows are distinct time windows that open and close at regular intervals. By default, Lambda invocations are stateless—you cannot use them for processing data across multiple continuous invocations without an external database. However, with tumbling windows, you can maintain your state across invocations. This state contains the aggregate result of the messages previously processed for the current window. Your state can be a maximum of 1 MB per shard. If it exceeds that size, Lambda terminates the window early.

Each record in a stream belongs to a specific window. Lambda will process each record at least once, but doesn't guarantee that each record will be processed only once. In rare cases, such as error handling, some records might be processed more than once. Records are always processed in order the first time. If records are processed more than once, they might be processed out of order.

## Aggregation and processing

Your user managed function is invoked both for aggregation and for processing the final results of that aggregation. Lambda aggregates all records received in the window. You can receive these records in multiple batches, each as a separate invocation. Each invocation receives a state. Thus, when using tumbling windows, your Lambda function response must contain a `state` property. If the response does not contain a `state` property, Lambda considers this a failed invocation. To satisfy this condition, your function can return a `TimeWindowEventResponse` object, which has the following JSON shape:

**Example `TimeWindowEventResponse` values**

```
{
    "state": {
        "1": 282,
        "2": 715
    },
    "batchItemFailures": []
}
```

> **Note**
> For Java functions, we recommend using a `Map<String, String>` to represent the state.

At the end of the window, the flag `isFinalInvokeForWindow` is set to `true` to indicate that this is the final state and that it's ready for processing. After processing, the window completes and your final invocation completes, and then the state is dropped.

At the end of your window, Lambda uses final processing for actions on the aggregation results. Your final processing is synchronously invoked. After successful invocation, your function checkpoints the

sequence number and stream processing continues. If invocation is unsuccessful, your Lambda function suspends further processing until a successful invocation.

**Example KinesisTimeWindowEvent**

```
{
    "Records": [
        {
            "kinesis": {
                "kinesisSchemaVersion": "1.0",
                "partitionKey": "1",
                "sequenceNumber":
 "49590338271490256608559692538361571095921575989136588898",
                "data": "SGVsbG8sIHRoaXMgaXMgYSB0ZXN0Lg==",
                "approximateArrivalTimestamp": 1607497475.000
            },
            "eventSource": "aws:kinesis",
            "eventVersion": "1.0",
            "eventID":
 "shardId-000000000006:49590338271490256608559692538361571095921575989136588898",
            "eventName": "aws:kinesis:record",
            "invokeIdentityArn": "arn:aws:iam::123456789012:role/lambda-kinesis-role",
            "awsRegion": "us-east-1",
            "eventSourceARN": "arn:aws:kinesis:us-east-1:123456789012:stream/lambda-stream"
        }
    ],
    "window": {
        "start": "2020-12-09T07:04:00Z",
        "end": "2020-12-09T07:06:00Z"
    },
    "state": {
        "1": 282,
        "2": 715
    },
    "shardId": "shardId-000000000006",
    "eventSourceARN": "arn:aws:kinesis:us-east-1:123456789012:stream/lambda-stream",
    "isFinalInvokeForWindow": false,
    "isWindowTerminatedEarly": false
}
```

# Configuration

You can configure tumbling windows when you create or update an event source mapping (p. 236). To configure a tumbling window, specify the window in seconds. The following example AWS Command Line Interface (AWS CLI) command creates a streaming event source mapping that has a tumbling window of 120 seconds. The Lambda function defined for aggregation and processing is named `tumbling-window-example-function`.

```
aws lambda create-event-source-mapping --event-source-arn arn:aws:kinesis:us-
east-1:123456789012:stream/lambda-stream --function-name "arn:aws:lambda:us-
east-1:123456789018:function:tumbling-window-example-function" --region us-east-1 --
starting-position TRIM_HORIZON --tumbling-window-in-seconds 120
```

Lambda determines tumbling window boundaries based on the time when records were inserted into the stream. All records have an approximate timestamp available that Lambda uses in boundary determinations.

Tumbling window aggregations do not support resharding. When the shard ends, Lambda considers the window closed, and the child shards start their own window in a fresh state.

Tumbling windows fully support the existing retry policies `maxRetryAttempts` and `maxRecordAge`.

**Example Handler.py – Aggregation and processing**

The following Python function demonstrates how to aggregate and then process your final state:

```
def lambda_handler(event, context):
    print('Incoming event: ', event)
    print('Incoming state: ', event['state'])

#Check if this is the end of the window to either aggregate or process.
    if event['isFinalInvokeForWindow']:
        # logic to handle final state of the window
        print('Destination invoke')
    else:
        print('Aggregate invoke')

#Check for early terminations
    if event['isWindowTerminatedEarly']:
        print('Window terminated early')

    #Aggregation logic
    state = event['state']
    for record in event['Records']:
        state[record['kinesis']['partitionKey']] = state.get(record['kinesis']
['partitionKey'], 0) + 1

    print('Returning state: ', state)
    return {'state': state}
```

# Reporting batch item failures

When consuming and processing streaming data from an event source, by default Lambda checkpoints to the highest sequence number of a batch only when the batch is a complete success. Lambda treats all other results as a complete failure and retries processing the batch up to the retry limit. To allow for partial successes while processing batches from a stream, turn on `ReportBatchItemFailures`. Allowing partial successes can help to reduce the number of retries on a record, though it doesn't entirely prevent the possibility of retries in a successful record.

To turn on `ReportBatchItemFailures`, include the enum value **`ReportBatchItemFailures`** in the `FunctionResponseTypes` list. This list indicates which response types are enabled for your function. You can configure this list when you create or update an event source mapping (p. 236).

## Report syntax

When configuring reporting on batch item failures, the `StreamsEventResponse` class is returned with a list of batch item failures. You can use a `StreamsEventResponse` object to return the sequence number of the first failed record in the batch. You can also create your own custom class using the correct response syntax. The following JSON structure shows the required response syntax:

```
{
  "batchItemFailures": [
        {
            "itemIdentifier": "<id>"
        }
    ]
}
```

**Note**
If the `batchItemFailures` array contains multiple items, Lambda uses the record with the lowest sequence number as the checkpoint. Lambda then retries all records starting from that checkpoint.

## Success and failure conditions

Lambda treats a batch as a complete success if you return any of the following:

- An empty `batchItemFailure` list
- A null `batchItemFailure` list
- An empty `EventResponse`
- A null `EventResponse`

Lambda treats a batch as a complete failure if you return any of the following:

- An empty string `itemIdentifier`
- A null `itemIdentifier`
- An `itemIdentifier` with a bad key name

Lambda retries failures based on your retry strategy.

## Bisecting a batch

If your invocation fails and `BisectBatchOnFunctionError` is turned on, the batch is bisected regardless of your `ReportBatchItemFailures` setting.

When a partial batch success response is received and both `BisectBatchOnFunctionError` and `ReportBatchItemFailures` are turned on, the batch is bisected at the returned sequence number and Lambda retries only the remaining records.

Java

**Example Handler.java – return new StreamsEventResponse()**

```
import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.services.lambda.runtime.RequestHandler;
import com.amazonaws.services.lambda.runtime.events.KinesisEvent;
import com.amazonaws.services.lambda.runtime.events.StreamsEventResponse;

import java.io.Serializable;
import java.util.ArrayList;
import java.util.List;

public class ProcessKinesisRecords implements RequestHandler<KinesisEvent,
 StreamsEventResponse> {

    @Override
    public StreamsEventResponse handleRequest(KinesisEvent input, Context context) {

        List<StreamsEventResponse.BatchItemFailure> batchItemFailures = new
 ArrayList<>();
        String curRecordSequenceNumber = "";

        for (KinesisEvent.KinesisEventRecord kinesisEventRecord : input.getRecords()) {
            try {
                //Process your record
                KinesisEvent.Record kinesisRecord = kinesisEventRecord.getKinesis();
                curRecordSequenceNumber = kinesisRecord.getSequenceNumber();

            } catch (Exception e) {
```

```
                /* Since we are working with streams, we can return the failed item
 immediately.
                   Lambda will immediately begin to retry processing from this failed
 item onwards. */
                batchItemFailures.add(new
 StreamsEventResponse.BatchItemFailure(curRecordSequenceNumber));
                return new StreamsEventResponse(batchItemFailures);
            }
        }

       return new StreamsEventResponse(batchItemFailures);
    }
}
```

Python

**Example Handler.py – return batchItemFailures[]**

```
def handler(event, context):
    records = event.get("Records")
    curRecordSequenceNumber = ""

    for record in records:
        try:
            # Process your record
            curRecordSequenceNumber = record["kinesis"]["sequenceNumber"]
        except Exception as e:
            # Return failed record's sequence number
            return {"batchItemFailures":[{"itemIdentifier": curRecordSequenceNumber}]}

    return {"batchItemFailures":[]}
```

# Amazon Kinesis configuration parameters

All Lambda event source types share the same CreateEventSourceMapping (p. 893) and UpdateEventSourceMapping (p. 1078) API operations. However, only some of the parameters apply to Kinesis.

**Event source parameters that apply to Kinesis**

| Parameter | Required | Default | Notes |
|---|---|---|---|
| BatchSize | N | 100 | Maximum: 10,000 |
| BisectBatchOnFunctionError | N | false | |
| DestinationConfig | N | | Amazon SQS queue or Amazon SNS topic destination for discarded records |
| Enabled | N | true | |
| EventSourceArn | Y | | ARN of the data stream or a stream consumer |
| FunctionName | Y | | |
| MaximumBatchingWindowInSeconds | N | 0 | |

| Parameter | Required | Default | Notes |
|---|---|---|---|
| MaximumRecordAgeInSeconds | N | -1 | -1 means infinite: Lambda doesn't discard records<br><br>Minimum: -1<br><br>Maximum: 604,800 |
| MaximumRetryAttempts | N | -1 | -1 means infinite: failed records are retried until the record expires<br><br>Minimum: -1<br><br>Maximum: 10,000 |
| ParallelizationFactor | N | 1 | Maximum: 10 |
| StartingPosition | Y | | AT_TIMESTAMP, TRIM_HORIZON, or LATEST |
| StartingPositionTimestamp | N | | Only valid if StartingPosition is set to AT_TIMESTAMP. The time from which to start reading, in Unix time seconds |
| TumblingWindowInSeconds | N | | Minimum: 0<br><br>Maximum: 900 |

# Tutorial: Using AWS Lambda with Amazon Kinesis

In this tutorial, you create a Lambda function to consume events from a Kinesis stream.

1. Custom app writes records to the stream.
2. AWS Lambda polls the stream and, when it detects new records in the stream, invokes your Lambda function.
3. AWS Lambda runs the Lambda function by assuming the execution role you specified at the time you created the Lambda function.

## Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

## Create the execution role

Create the execution role (p. 52) that gives your function permission to access AWS resources.

### To create an execution role

1. Open the roles page in the IAM console.
2. Choose **Create role**.
3. Create a role with the following properties.
   - **Trusted entity** – **AWS Lambda**.
   - **Permissions** – **AWSLambdaKinesisExecutionRole**.
   - **Role name** – **`lambda-kinesis-role`**.

The **AWSLambdaKinesisExecutionRole** policy has the permissions that the function needs to read items from Kinesis and write logs to CloudWatch Logs.

## Create the function

The following example code receives a Kinesis event input and processes the messages that it contains. For illustration, the code writes some of the incoming event data to CloudWatch Logs.

> **Note**
> For sample code in other languages, see Sample function code (p. 629).

### Example index.js

```
console.log('Loading function');

exports.handler = function(event, context) {
    //console.log(JSON.stringify(event, null, 2));
    event.Records.forEach(function(record) {
        // Kinesis data is base64 encoded so decode here
        var payload = Buffer.from(record.kinesis.data, 'base64').toString('ascii');
        console.log('Decoded payload:', payload);
    });
};
```

### To create the function

1. Copy the sample code into a file named `index.js`.
2. Create a deployment package.

   ```
   zip function.zip index.js
   ```

3. Create a Lambda function with the `create-function` command.

   ```
   aws lambda create-function --function-name ProcessKinesisRecords \
   ```

```
--zip-file fileb://function.zip --handler index.handler --runtime nodejs12.x \
--role arn:aws:iam::123456789012:role/lambda-kinesis-role
```

## Test the Lambda function

Invoke your Lambda function manually using the `invoke` AWS Lambda CLI command and a sample Kinesis event.

### To test the Lambda function

1. Copy the following JSON into a file and save it as `input.txt`.

```
{
    "Records": [
        {
            "kinesis": {
                "kinesisSchemaVersion": "1.0",
                "partitionKey": "1",
                "sequenceNumber":
 "49590338271490256608559692538361571095921575989136588898",
                "data": "SGVsbG8sIHRoaXMgaXMgYSB0ZXN0Lg==",
                "approximateArrivalTimestamp": 1545084650.987
            },
            "eventSource": "aws:kinesis",
            "eventVersion": "1.0",
            "eventID":
 "shardId-000000000006:49590338271490256608559692538361571095921575989136588898",
            "eventName": "aws:kinesis:record",
            "invokeIdentityArn": "arn:aws:iam::123456789012:role/lambda-kinesis-role",
            "awsRegion": "us-east-2",
            "eventSourceARN": "arn:aws:kinesis:us-east-2:123456789012:stream/lambda-
stream"
        }
    ]
}
```

2. Use the `invoke` command to send the event to the function.

```
aws lambda invoke --function-name ProcessKinesisRecords --payload file://input.txt
 out.txt
```

   The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

   The response is saved to `out.txt`.

## Create a Kinesis stream

Use the `create-stream` command to create a stream.

```
aws kinesis create-stream --stream-name lambda-stream --shard-count 1
```

Run the following `describe-stream` command to get the stream ARN.

```
aws kinesis describe-stream --stream-name lambda-stream
```

You should see the following output:

```
{
    "StreamDescription": {
        "Shards": [
            {
                "ShardId": "shardId-000000000000",
                "HashKeyRange": {
                    "StartingHashKey": "0",
                    "EndingHashKey": "340282366920746074317682119384634633455"
                },
                "SequenceNumberRange": {
                    "StartingSequenceNumber":
 "49591073947768692513481539594623130411957558361251844610"
                }
            }
        ],
        "StreamARN": "arn:aws:kinesis:us-west-2:123456789012:stream/lambda-stream",
        "StreamName": "lambda-stream",
        "StreamStatus": "ACTIVE",
        "RetentionPeriodHours": 24,
        "EnhancedMonitoring": [
            {
                "ShardLevelMetrics": []
            }
        ],
        "EncryptionType": "NONE",
        "KeyId": null,
        "StreamCreationTimestamp": 1544828156.0
    }
}
```

You use the stream ARN in the next step to associate the stream with your Lambda function.

## Add an event source in AWS Lambda

Run the following AWS CLI `add-event-source` command.

```
aws lambda create-event-source-mapping --function-name ProcessKinesisRecords \
--event-source  arn:aws:kinesis:us-west-2:123456789012:stream/lambda-stream \
--batch-size 100 --starting-position LATEST
```

Note the mapping ID for later use. You can get a list of event source mappings by running the `list-event-source-mappings` command.

```
aws lambda list-event-source-mappings --function-name ProcessKinesisRecords \
--event-source arn:aws:kinesis:us-west-2:123456789012:stream/lambda-stream
```

In the response, you can verify the status value is `enabled`. Event source mappings can be disabled to pause polling temporarily without losing any records.

## Test the setup

To test the event source mapping, add event records to your Kinesis stream. The `--data` value is a string that the CLI encodes to base64 prior to sending it to Kinesis. You can run the same command more than once to add multiple records to the stream.

```
aws kinesis put-record --stream-name lambda-stream --partition-key 1 \
--data "Hello, this is a test."
```

Lambda uses the execution role to read records from the stream. Then it invokes your Lambda function, passing in batches of records. The function decodes data from each record and logs it, sending the output to CloudWatch Logs. View the logs in the CloudWatch console.

## Clean up your resources

You can now delete the resources that you created for this tutorial, unless you want to retain them. By deleting AWS resources that you're no longer using, you prevent unnecessary charges to your AWS account.

**To delete the execution role**

1. Open the Roles page of the IAM console.
2. Select the execution role that you created.
3. Choose **Delete role**.
4. Choose **Yes, delete**.

**To delete the Lambda function**

1. Open the Functions page of the Lambda console.
2. Select the function that you created.
3. Choose **Actions**, then choose **Delete**.
4. Choose **Delete**.

**To delete the Kinesis stream**

1. Sign in to the AWS Management Console and open the Kinesis console at https://console.aws.amazon.com/kinesis.
2. Select the stream you created.
3. Choose **Actions**, **Delete**.
4. Enter `delete` in the text box.
5. Choose **Delete**.

# Sample function code

To process events from Amazon Kinesis, iterate through the records included in the event object and decode the Base64-encoded data included in each.

> **Note**
> The code on this page does not support aggregated records. You can disable aggregation in the Kinesis Producer Library configuration, or use the Kinesis Record Aggregation library to deaggregate records.

Sample code is available for the following languages.

**Topics**

- Node.js 12.x (p. 630)
- Java 11 (p. 630)
- C# (p. 631)
- Python 3 (p. 631)
- Go (p. 632)

## Node.js 12.x

The following example code receives a Kinesis event input and processes the messages that it contains. For illustration, the code writes some of the incoming event data to CloudWatch Logs.

**Example index.js**

```
console.log('Loading function');

exports.handler = function(event, context) {
    //console.log(JSON.stringify(event, null, 2));
    event.Records.forEach(function(record) {
        // Kinesis data is base64 encoded so decode here
        var payload = Buffer.from(record.kinesis.data, 'base64').toString('ascii');
        console.log('Decoded payload:', payload);
    });
};
```

Zip up the sample code to create a deployment package. For instructions, see Deploy Node.js Lambda functions with .zip file archives (p. 288).

## Java 11

The following is example Java code that receives Kinesis event record data as input and processes it. For illustration, the code writes some of the incoming event data to CloudWatch Logs.

In the code, `recordHandler` is the handler. The handler uses the predefined `KinesisEvent` class that is defined in the `aws-lambda-java-events` library.

**Example ProcessKinesisEvents.java**

```
package example;

import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.services.lambda.runtime.RequestHandler;
import com.amazonaws.services.lambda.runtime.events.KinesisEvent;
import com.amazonaws.services.lambda.runtime.events.KinesisEvent.KinesisEventRecord;

public class ProcessKinesisRecords implements RequestHandler<KinesisEvent, Void>{
  @Override
  public Void handleRequest(KinesisEvent event, Context context)
  {
    for(KinesisEventRecord rec : event.getRecords()) {
      System.out.println(new String(rec.getKinesis().getData().array()));
  }
  return null;
  }
}
```

If the handler returns normally without exceptions, Lambda considers the input batch of records as processed successfully and begins reading new records in the stream. If the handler throws an exception, Lambda considers the input batch of records as not processed and invokes the function with the same batch of records again.

**Dependencies**

- `aws-lambda-java-core`
- `aws-lambda-java-events`

- `aws-java-sdk`

Build the code with the Lambda library dependencies to create a deployment package. For instructions, see Deploy Java Lambda functions with .zip or JAR file archives (p. 386).

## C#

The following is example C# code that receives Kinesis event record data as input and processes it. For illustration, the code writes some of the incoming event data to CloudWatch Logs.

In the code, `HandleKinesisRecord` is the handler. The handler uses the predefined `KinesisEvent` class that is defined in the `Amazon.Lambda.KinesisEvents` library.

**Example ProcessingKinesisEvents.cs**

```
using System;
using System.IO;
using System.Text;

using Amazon.Lambda.Core;
using Amazon.Lambda.KinesisEvents;

namespace KinesisStreams
{
    public class KinesisSample
    {
     [LambdaSerializer(typeof(JsonSerializer))]
        public void HandleKinesisRecord(KinesisEvent kinesisEvent)
        {
            Console.WriteLine($"Beginning to process {kinesisEvent.Records.Count}
 records...");

            foreach (var record in kinesisEvent.Records)
            {
                Console.WriteLine($"Event ID: {record.EventId}");
                Console.WriteLine($"Event Name: {record.EventName}");

                string recordData = GetRecordContents(record.Kinesis);
                Console.WriteLine($"Record Data:");
                Console.WriteLine(recordData);
            }
            Console.WriteLine("Stream processing complete.");
        }

        private string GetRecordContents(KinesisEvent.Record streamRecord)
        {
            using (var reader = new StreamReader(streamRecord.Data, Encoding.ASCII))
            {
                return reader.ReadToEnd();
            }
        }
    }
}
```

Replace the `Program.cs` in a .NET Core project with the above sample. For instructions, see Deploy C# Lambda functions with .zip file archives (p. 458).

## Python 3

The following is example Python code that receives Kinesis event record data as input and processes it. For illustration, the code writes to some of the incoming event data to CloudWatch Logs.

**Example ProcessKinesisRecords.py**

```
from __future__ import print_function
#import json
import base64
def lambda_handler(event, context):
    for record in event['Records']:
       #Kinesis data is base64 encoded so decode here
       payload=base64.b64decode(record["kinesis"]["data"])
       print("Decoded payload: " + str(payload))
```

Zip up the sample code to create a deployment package. For instructions, see Deploy Python Lambda functions with .zip file archives (p. 330).

## Go

The following is example Go code that receives Kinesis event record data as input and processes it. For illustration, the code writes to some of the incoming event data to CloudWatch Logs.

**Example ProcessKinesisRecords.go**

```
import (
    "strings"
    "github.com/aws/aws-lambda-go/events"
)

func handler(ctx context.Context, kinesisEvent events.KinesisEvent) {
    for _, record := range kinesisEvent.Records {
        kinesisRecord := record.Kinesis
        dataBytes := kinesisRecord.Data
        dataText := string(dataBytes)

        fmt.Printf("%s Data = %s \n", record.EventName, dataText)
    }
}
```

Build the executable with `go build` and create a deployment package. For instructions, see Deploy Go Lambda functions with .zip file archives (p. 427).

# AWS SAM template for a Kinesis application

You can build this application using AWS SAM. To learn more about creating AWS SAM templates, see AWS SAM template basics in the *AWS Serverless Application Model Developer Guide*.

Below is a sample AWS SAM template for the Lambda application from the tutorial (p. 625). The function and handler in the template are for the Node.js code. If you use a different code sample, update the values accordingly.

**Example template.yaml - Kinesis stream**

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Resources:
  LambdaFunction:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs12.x
      Timeout: 10
```

```
      Tracing: Active
      Events:
        Stream:
          Type: Kinesis
          Properties:
            Stream: !GetAtt stream.Arn
            BatchSize: 100
            StartingPosition: LATEST
  stream:
    Type: AWS::Kinesis::Stream
    Properties:
      ShardCount: 1
Outputs:
  FunctionName:
    Description: "Function name"
    Value: !Ref LambdaFunction
  StreamARN:
    Description: "Stream ARN"
    Value: !GetAtt stream.Arn
```

The template creates a Lambda function, a Kinesis stream, and an event source mapping. The event source mapping reads from the stream and invokes the function.

To use an HTTP/2 stream consumer (p. 614), create the consumer in the template and configure the event source mapping to read from the consumer instead of from the stream.

**Example template.yaml - Kinesis stream consumer**

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Description: A function that processes data from a Kinesis stream.
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs12.x
      Timeout: 10
      Tracing: Active
      Events:
        Stream:
          Type: Kinesis
          Properties:
            Stream: !GetAtt streamConsumer.ConsumerARN
            StartingPosition: LATEST
            BatchSize: 100
  stream:
    Type: "AWS::Kinesis::Stream"
    Properties:
      ShardCount: 1
  streamConsumer:
    Type: "AWS::Kinesis::StreamConsumer"
    Properties:
      StreamARN: !GetAtt stream.Arn
      ConsumerName: "TestConsumer"
Outputs:
  FunctionName:
    Description: "Function name"
    Value: !Ref function
  StreamARN:
    Description: "Stream ARN"
    Value: !GetAtt stream.Arn
  ConsumerARN:
    Description: "Stream consumer ARN"
```

```
    Value: !GetAtt streamConsumer.ConsumerARN
```

For information on how to package and deploy your serverless application using the package and deploy commands, see Deploying serverless applications in the *AWS Serverless Application Model Developer Guide*.

# Using AWS Lambda with Amazon Lex

You can use Amazon Lex to integrate a conversation bot into your application. The Amazon Lex bot provides a conversational interface with your users. Amazon Lex provides prebuilt integration with Lambda, which enables you to use a Lambda function with your Amazon Lex bot.

When you configure an Amazon Lex bot, you can specify a Lambda function to perform validation, fulfillment, or both. For validation, Amazon Lex invokes the Lambda function after each response from the user. The Lambda function can validate the response and provide corrective feedback to the user, if necessary. For fulfillment, Amazon Lex invokes the Lambda function to fulfill the user request after the bot successfully collects all of the required information and receives confirmation from the user.

You can manage the concurrency (p. 180) of your Lambda function to control the maximum number of simultaneous bot conversations that you serve. The Amazon Lex API returns an HTTP 429 status code (Too Many Requests) if the function is at maximum concurrency.

The API returns an HTTP 424 status code (Dependency Failed Exception) if the Lambda function throws an exception.

The Amazon Lex bot invokes your Lambda function synchronously (p. 225). The event parameter contains information about the bot and the value of each slot in the dialog. The `invocationSource` parameter indicates whether the Lambda function should validate the inputs (DialogCodeHook) or fulfill the intent (FulfillmentCodeHook).

**Example Amazon Lex message event**

```
{
  "messageVersion": "1.0",
  "invocationSource": "FulfillmentCodeHook",
  "userId": "ABCD1234",
  "sessionAttributes": {
     "key1": "value1",
     "key2": "value2",
  },
  "bot": {
    "name": "OrderFlowers",
    "alias": "prod",
    "version": "1"
  },
  "outputDialogMode": "Text",
  "currentIntent": {
    "name": "OrderFlowers",
    "slots": {
      "FlowerType": "lilies",
      "PickupDate": "2030-11-08",
      "PickupTime": "10:00"
    },
    "confirmationStatus": "Confirmed"
  }
}
```

Amazon Lex expects a response from a Lambda function in the following format. The `dialogAction` field is required. The `sessionAttributes` and the `recentIntentSummaryView` fields are optional.

**Example Amazon Lex message event**

```
{
  "sessionAttributes": {
    "key1": "value1",
    "key2": "value2"
```

```
    ...
  },
  "recentIntentSummaryView": [
    {
       "intentName": "Name",
       "checkpointLabel": "Label",
       "slots": {
         "slot name": "value",
         "slot name": "value"
        },
        "confirmationStatus": "None, Confirmed, or Denied (intent confirmation, if
 configured)",
        "dialogActionType": "ElicitIntent, ElicitSlot, ConfirmIntent, Delegate, or Close",
        "fulfillmentState": "Fulfilled or Failed",
        "slotToElicit": "Next slot to elicit
    }
  ],
  "dialogAction": {
    "type": "Close",
    "fulfillmentState": "Fulfilled",
    "message": {
      "contentType": "PlainText",
      "content": "Thanks, your pizza has been ordered."
    },
    "responseCard": {
      "version": integer-value,
      "contentType": "application/vnd.amazonaws.card.generic",
      "genericAttachments": [
          {
             "title":"card-title",
             "subTitle":"card-sub-title",
             "imageUrl":"URL of the image to be shown",
             "attachmentLinkUrl":"URL of the attachment to be associated with the card",
             "buttons":[
                 {
                    "text":"button-text",
                    "value":"Value sent to server on button click"
                 }
             ]
          }
      ]
    }
  }
}
```

Note that the additional fields required for `dialogAction` vary based on the value of the `type` field. For more information about the event and response fields, see Lambda event and response format in the *Amazon Lex Developer Guide*. For an example tutorial that shows how to use Lambda with Amazon Lex, see Exercise 1: Create Amazon Lex bot using a blueprint in the *Amazon Lex Developer Guide*.

# Roles and permissions

You need to configure a service-linked role as your function's execution role (p. 52). Amazon Lex defines the service-linked role with predefined permissions. When you create an Amazon Lex bot using the console, the service-linked role is created automatically. To create a service-linked role with the AWS CLI, use the `create-service-linked-role` command.

```
aws iam create-service-linked-role --aws-service-name lex.amazonaws.com
```

This command creates the following role.

```
{
```

```
  "Role": {
      "AssumeRolePolicyDocument": {
          "Version": "2012-10-17",
          "Statement": [
              {
                  "Action": "sts:AssumeRole",
                  "Effect": "Allow",
                  "Principal": {
                      "Service": "lex.amazonaws.com"
                  }
              }
          ]
      },
      "RoleName": "AWSServiceRoleForLexBots",
      "Path": "/aws-service-role/lex.amazonaws.com/",
      "Arn": "arn:aws:iam::account-id:role/aws-service-role/lex.amazonaws.com/
AWSServiceRoleForLexBots"
}
```

If your Lambda function uses other AWS services, you need to add the corresponding permissions to the service-linked role.

You use a resource-based permissions policy to allow the Amazon Lex intent to invoke your Lambda function. If you use the Amazon Lex console, the permissions policy is created automatically. From the AWS CLI, use the Lambda `add-permission` command to set the permission. The following example sets permission for the `OrderFlowers` intent.

```
aws lambda add-permission \
    --function-name OrderFlowersCodeHook \
    --statement-id LexGettingStarted-OrderFlowersBot \
    --action lambda:InvokeFunction \
    --principal lex.amazonaws.com \
    --source-arn "arn:aws:lex:us-east-1:123456789012 ID:intent:OrderFlowers:*"
```

# Using Lambda with Amazon MQ

Amazon MQ is a managed message broker service for Apache ActiveMQ and RabbitMQ. A *message broker* enables software applications and components to communicate using various programming languages, operating systems, and formal messaging protocols through either topic or queue event destinations.

Amazon MQ can also manage Amazon Elastic Compute Cloud (Amazon EC2) instances on your behalf by installing ActiveMQ or RabbitMQ brokers and by providing different network topologies and other infrastructure needs.

You can use a Lambda function to process records from your Amazon MQ message broker. Lambda invokes your function through an event source mapping (p. 236), a Lambda resource that reads messages from your broker and invokes the function synchronously (p. 225).

The Amazon MQ event source mapping has the following configuration restrictions:

- Cross account – Lambda does not support cross-account processing. You cannot use Lambda to process records from an Amazon MQ message broker that is in a different AWSaccount.
- Authentication – For ActiveMQ, only the ActiveMQ SimpleAuthenticationPlugin is supported. For RabbitMQ, only the PLAIN authentication mechanism is supported. Users must use AWS Secrets Manager to manage their credentials. For more information about ActiveMQ authentication, see Integrating ActiveMQ brokers with LDAP in the *Amazon MQ Developer Guide*.
- Connection quota – Brokers have a maximum number of allowed connections per wire-level protocol. This quota is based on the broker instance type. For more information, see the Brokers section of **Quotas in Amazon MQ** in the *Amazon MQ Developer Guide*.
- Connectivity – You can create brokers in a public or private virtual private cloud (VPC). For private VPCs, your Lambda function needs access to the VPC to receive messages. For more information, see the section called “Event source mapping API” (p. 642) later in this topic.
- Event destinations – Only queue destinations are supported. However, you can use a virtual topic, which behaves as a topic internally while interacting with Lambda as a queue. For more information, see Virtual Destinations on the Apache ActiveMQ website, and Virtual Hosts on the RabbitMQ website.
- Network topology – For ActiveMQ, only one single-instance or standby broker is supported per event source mapping. For RabbitMQ, only one single-instance broker or cluster deployment is supported per event source mapping. Single-instance brokers require a failover endpoint. For more information about these broker deployment modes, see Active MQ Broker Architecture and Rabbit MQ Broker Architecturein the *Amazon MQ Developer Guide*.
- Protocols – Supported protocols depend on the type of Amazon MQ integration.
  - For ActiveMQ integrations, Lambda consumes messages using the OpenWire/Java Message Service (JMS) protocol. No other protocols are supported for consuming messages. Within the JMS protocol, only `TextMessage` and `BytesMessage` are supported. For more information about the OpenWire protocol, see OpenWire on the Apache ActiveMQ website.
  - For RabbitMQ integrations, Lambda consumes messages using the AMQP 0-9-1 protocol. No other protocols are supported for consuming messages. For more information about RabbitMQ's implementation of the AMQP 0-9-1 protocol, see AMQP 0-9-1 Complete Reference Guide on the RabbitMQ website.

Lambda automatically supports the latest versions of ActiveMQ and RabbitMQ that Amazon MQ supports. For the latest supported versions, see Amazon MQ release notes in the *Amazon MQ Developer Guide*.

> **Note**
> By default, Amazon MQ has a weekly maintenance window for brokers. During that window of time, brokers are unavailable. For brokers without standby, Lambda cannot process any messages during that window.

**Sections**


- Lambda consumer group (p. 639)
- Execution role permissions (p. 641)
- Configuring a broker as an event source (p. 641)
- Event source mapping API (p. 642)
- Event source mapping errors (p. 644)
- Amazon MQ and RabbitMQ configuration parameters (p. 645)


# Lambda consumer group

To interact with Amazon MQ, Lambda creates a consumer group which can read from your Amazon MQ brokers. The consumer group is created with the same ID as the event source mapping UUID.

For Amazon MQ event sources, Lambda batches records together and sends them to your function in a single payload. To control behavior, you can configure the batching window and batch size. Lambda pulls messages until it processes the payload size maximum of 6 MB, the batching window expires, or the number of records reaches the full batch size. For more information, see Batching behavior (p. 237).

Lambda converts your batch into a single payload, and then invokes your function. Messages are neither persisted nor deserialized. Instead, the consumer group retrieves them as a BLOB of bytes, and then base64-encodes them into a JSON payload. If your function returns an error for any of the messages in a batch, Lambda retries the whole batch of messages until processing succeeds or the messages expire.

> **Note**
> While Lambda functions typically have a maximum timeout limit of 15 minutes, event source mappings for Amazon MSK, self-managed Apache Kafka, and Amazon MQ for ActiveMQ and RabbitMQ only support functions with maximum timeout limits of 14 minutes. This constraint ensures that the event source mapping can properly handle function errors and retries.

You can monitor a given function's concurrency usage using the `ConcurrentExecutions` metric in Amazon CloudWatch. For more information about concurrency, see the section called “Reserved concurrency” (p. 180).

### Example Amazon MQ record events

ActiveMQ

```
{
   "eventSource": "aws:amq",
   "eventSourceArn": "arn:aws:mq:us-
west-2:111122223333:broker:test:b-9bcfa592-423a-4942-879d-eb284b418fc8",
   "messages": [
      {
        "messageID": "ID:b-9bcfa592-423a-4942-879d-eb284b418fc8-1.mq.us-
west-2.amazonaws.com-37557-1234520418293-4:1:1:1:1",
        "messageType": "jms/text-message",
        "deliveryMode": 1,
        "replyTo": null,
        "type": null,
        "expiration": "60000",
        "priority": 1,
        "correlationId": "myJMSCoID",
        "redelivered": false,
        "destination": {
          "physicalname": "testQueue"
        },
        "data":"QUJDOkFBQUE=",
```

```
        "timestamp": 1598827811958,
        "brokerInTime": 1598827811958,
        "brokerOutTime": 1598827811959
      },
      {
        "messageID": "ID:b-9bcfa592-423a-4942-879d-eb284b418fc8-1.mq.us-
west-2.amazonaws.com-37557-1234520418293-4:1:1:1:1",
        "messageType": "jms/bytes-message",
        "deliveryMode": 1,
        "replyTo": null,
        "type": null,
        "expiration": "60000",
        "priority": 2,
        "correlationId": "myJMSCoID1",
        "redelivered": false,
        "destination": {
          "physicalname": "testQueue"
        },
        "data":"LQaGQ82S48k=",
        "timestamp": 1598827811958,
        "brokerInTime": 1598827811958,
        "brokerOutTime": 1598827811959
      }
   ]
}
```

RabbitMQ

```
{
  "eventSource": "aws:rmq",
  "eventSourceArn": "arn:aws:mq:us-
west-2:111122223333:broker:pizzaBroker:b-9bcfa592-423a-4942-879d-eb284b418fc8",
  "rmqMessagesByQueue": {
    "pizzaQueue::/": [
      {
        "basicProperties": {
          "contentType": "text/plain",
          "contentEncoding": null,
          "headers": {
            "header1": {
              "bytes": [
                118,
                97,
                108,
                117,
                101,
                49
              ]
            },
            "header2": {
              "bytes": [
                118,
                97,
                108,
                117,
                101,
                50
              ]
            },
            "numberInHeader": 10
          },
          "deliveryMode": 1,
          "priority": 34,
```

```
          "correlationId": null,
          "replyTo": null,
          "expiration": "60000",
          "messageId": null,
          "timestamp": "Jan 1, 1970, 12:33:41 AM",
          "type": null,
          "userId": "AIDACKCEVSQ6C2EXAMPLE",
          "appId": null,
          "clusterId": null,
          "bodySize": 80
        },
        "redelivered": false,
        "data": "eyJ0aW1lb3V0IjowLCJkYXRhIjoiQ1pybWYwR3c4T3Y0YnFMUXhENEUifQ=="
      }
    ]
  }
}
```

**Note**
In the RabbitMQ example, `pizzaQueue` is the name of the RabbitMQ queue, and `/` is the name of the virtual host. When receiving messages, the event source lists messages under `pizzaQueue::/`.

# Execution role permissions

To read records from an Amazon MQ broker, your Lambda function needs the following permissions added to its execution role (p. 52):

- mq:DescribeBroker
- secretsmanager:GetSecretValue
- ec2:CreateNetworkInterface
- ec2:DeleteNetworkInterface
- ec2:DescribeNetworkInterfaces
- ec2:DescribeSecurityGroups
- ec2:DescribeSubnets
- ec2:DescribeVpcs
- logs:CreateLogGroup
- logs:CreateLogStream
- logs:PutLogEvents

**Note**
When using an encrypted customer managed key, add the `kms:Decrypt` permission as well.

# Configuring a broker as an event source

Create an event source mapping (p. 236) to tell Lambda to send records from an Amazon MQ broker to a Lambda function. You can create multiple event source mappings to process the same data with multiple functions, or to process items from multiple sources with a single function.

To configure your function to read from Amazon MQ, create an **MQ** trigger in the Lambda console.

**To create a trigger**

1. Open the Functions page of the Lambda console.

2. Choose the name of a function.
3. Under **Function overview**, choose **Add trigger**.
4. Choose a trigger type.
5. Configure the required options, and then choose **Add**.

Lambda supports the following options for Amazon MQ event sources:

- **MQ broker** – Select an Amazon MQ broker.
- **Batch size** – Set the maximum number of messages to retrieve in a single batch.
- **Queue name** – Enter the Amazon MQ queue to consume.
- **Source access configuration** – Enter virtual host information and the Secrets Manager secret that stores your broker credentials.
- **Enable trigger** – Disable the trigger to stop processing records.

To enable or disable the trigger (or delete it), choose the **MQ** trigger in the designer. To reconfigure the trigger, use the event source mapping API operations.

# Event source mapping API

To manage an event source with the AWS Command Line Interface (AWS CLI) or an AWS SDK, you can use the following API operations:

- CreateEventSourceMapping (p. 893)
- ListEventSourceMappings (p. 1006)
- GetEventSourceMapping (p. 952)
- UpdateEventSourceMapping (p. 1078)
- DeleteEventSourceMapping (p. 925)

To create the event source mapping with the AWS Command Line Interface (AWS CLI), use the `create-event-source-mapping` command.

By default, Amazon MQ brokers are created with the `PubliclyAccessible` flag set to false. It is only when `PubliclyAccessible` is set to true that the broker receives a public IP address.

For full access with your event source mapping, your broker must either use a public endpoint or provide access to the VPC. Note that when you add Amazon MQ as a trigger, Lambda assumes the VPC settings of the Amazon MQ broker, not the Lambda function's VPC settings. To meet the Amazon Virtual Private Cloud (Amazon VPC) access requirements, you can do one of the following:

- Configure one NAT gateway per public subnet. For more information, see Internet and service access for VPC-connected functions (p. 197).
- Create a connection between your Amazon VPC and Lambda. Your Amazon VPC must also connect to AWS Security Token Service (AWS STS) and Secrets Manager endpoints. For more information, see Configuring interface VPC endpoints for Lambda (p. 198).

The Amazon VPC security group rules that you configure should have the following settings at minimum:

- Inbound rules – For a broker without public accessibility, allow all traffic on all ports for the security group that's specified as your source. For a broker with public accessibility, allow all traffic on all ports for all destinations.

- Outbound rules – Allow all traffic on all ports for all destinations.

The Amazon VPC configuration is discoverable through the Amazon MQ API and does not need to be configured in the `create-event-source-mapping` setup.

The following example AWS CLI command creates an event source which maps a Lambda function named `MQ-Example-Function` to an Amazon MQ RabbitMQ-based broker named `ExampleMQBroker`. The command also provides the virtual host name and a Secrets Manager secret ARN that stores the broker credentials.

```
aws lambda create-event-source-mapping \
--event-source-arn arn:aws:mq:us-east-1:123456789012:broker:ExampleMQBroker:b-24cacbb4-b295-49b7-8543-7ce7ce9dfb98 \
--function-name arn:aws:lambda:us-east-1:123456789012:function:MQ-Example-Function \
--queues ExampleQueue \
--source-access-configuration Type=VIRTUAL_HOST,URI="/"
 Type=BASIC_AUTH,URI=arn:aws:secretsmanager:us-east-1:123456789012:secret:ExampleMQBrokerUserPassword-xPBMTt \
```

You should see the following output:

```
{
    "UUID": "91eaeb7e-c976-1234-9451-8709db01f137",
    "BatchSize": 100,
    "EventSourceArn": "arn:aws:mq:us-east-1:123456789012:broker:ExampleMQBroker:b-b4d492ef-bdc3-45e3-a781-cd1a3102ecca",
    "FunctionArn": "arn:aws:lambda:us-east-1:123456789012:function:MQ-Example-Function",
    "LastModified": 1601927898.741,
    "LastProcessingResult": "No records processed",
    "State": "Creating",
    "StateTransitionReason": "USER_INITIATED",
    "Queues": [
        "ExampleQueue"
    ],
    "SourceAccessConfigurations": [
        {
            "Type": "BASIC_AUTH",
            "URI": "arn:aws:secretsmanager:us-east-1:123456789012:secret:ExampleMQBrokerUserPassword-xPBMTt"
        }
    ]
}
```

Using the `update-event-source-mapping` command, you can configure additional options such as how Lambda processes batches and to specify when to discard records that cannot be processed. The following example command updates an event source mapping to have a batch size of 2.

```
aws lambda update-event-source-mapping \
--uuid 91eaeb7e-c976-1234-9451-8709db01f137 \
--batch-size 2
```

You should see the following output:

```
{
    "UUID": "91eaeb7e-c976-1234-9451-8709db01f137",
    "BatchSize": 2,
    "EventSourceArn": "arn:aws:mq:us-east-1:123456789012:broker:ExampleMQBroker:b-b4d492ef-bdc3-45e3-a781-cd1a3102ecca",
    "FunctionArn": "arn:aws:lambda:us-east-1:123456789012:function:MQ-Example-Function",
```

```
    "LastModified": 1601928393.531,
    "LastProcessingResult": "No records processed",
    "State": "Updating",
    "StateTransitionReason": "USER_INITIATED"
}
```

Lambda updates these settings asynchronously. The output will not reflect changes until this process completes. To view the current status of your resource, use the `get-event-source-mapping` command.

```
aws lambda get-event-source-mapping \
--uuid 91eaeb7e-c976-4939-9451-8709db01f137
```

You should see the following output:

```
{
    "UUID": "91eaeb7e-c976-4939-9451-8709db01f137",
    "BatchSize": 2,
    "EventSourceArn": "arn:aws:mq:us-east-1:123456789012:broker:ExampleMQBroker:b-b4d492ef-
bdc3-45e3-a781-cd1a3102ecca",
    "FunctionArn": "arn:aws:lambda:us-east-1:123456789012:function:MQ-Example-Function",
    "LastModified": 1601928393.531,
    "LastProcessingResult": "No records processed",
    "State": "Enabled",
    "StateTransitionReason": "USER_INITIATED"
}
```

# Event source mapping errors

When a Lambda function encounters an unrecoverable error, your Amazon MQ consumer stops processing records. Any other consumers can continue processing, provided that they do not encounter the same error. To determine the potential cause of a stopped consumer, check the `StateTransitionReason` field in the return details of your `EventSourceMapping` for one of the following codes:

**`ESM_CONFIG_NOT_VALID`**

The event source mapping configuration is not valid.

**`EVENT_SOURCE_AUTHN_ERROR`**

Lambda failed to authenticate the event source.

**`EVENT_SOURCE_AUTHZ_ERROR`**

Lambda does not have the required permissions to access the event source.

**`FUNCTION_CONFIG_NOT_VALID`**

The function's configuration is not valid.

Records also go unprocessed if Lambda drops them due to their size. The size limit for Lambda records is 6 MB. To redeliver messages upon function error, you can use a dead-letter queue (DLQ). For more information, see Message Redelivery and DLQ Handling on the Apache ActiveMQ website and Reliability Guide on the RabbitMQ website.

**Note**
Lambda does not support custom redelivery policies. Instead, Lambda uses a policy with the default values from the Redelivery Policy page on the Apache ActiveMQ website, with `maximumRedeliveries` set to 5.

# Amazon MQ and RabbitMQ configuration parameters

All Lambda event source types share the same CreateEventSourceMapping (p. 893) and UpdateEventSourceMapping (p. 1078) API operations. However, only some of the parameters apply to Amazon MQ and RabbitMQ.

**Event source parameters that apply to Amazon MQ and RabbitMQ**

| Parameter | Required | Default | Notes |
|---|---|---|---|
| BatchSize | N | 100 | Maximum: 10,000 |
| Enabled | N | true | |
| FunctionName | Y | | |
| Queues | N | | The name of the Amazon MQ broker destination queue to consume. |
| SourceAccessConfigurations | N | | For ActiveMQ, BASIC_AUTH credentials. For RabbitMQ, can contain both BASIC_AUTH credentials and VIRTUAL_HOST information. |

# Using Lambda with Amazon MSK

Amazon Managed Streaming for Apache Kafka (Amazon MSK) is a fully managed service that you can use to build and run applications that use Apache Kafka to process streaming data. Amazon MSK simplifies the setup, scaling, and management of clusters running Kafka. Amazon MSK also makes it easier to configure your application for multiple Availability Zones and for security with AWS Identity and Access Management (IAM). Amazon MSK supports multiple open-source versions of Kafka.

Amazon MSK as an event source operates similarly to using Amazon Simple Queue Service (Amazon SQS) or Amazon Kinesis. Lambda internally polls for new messages from the event source and then synchronously invokes the target Lambda function. Lambda reads the messages in batches and provides these to your function as an event payload. The maximum batch size is configurable. (The default is 100 messages.)

For an example of how to configure Amazon MSK as an event source, see Using Amazon MSK as an event source for AWS Lambda on the AWS Compute Blog. For a complete tutorial, see Amazon MSK Lambda Integration in the Amazon MSK Labs.

For Kafka-based event sources, Lambda supports processing control parameters, such as batching windows and batch size. For more information, see Batching behavior (p. 237).

Lambda reads the messages sequentially for each partition. After Lambda processes each batch, it commits the offsets of the messages in that batch. If your function returns an error for any of the messages in a batch, Lambda retries the whole batch of messages until processing succeeds or the messages expire.

> **Note**
> While Lambda functions typically have a maximum timeout limit of 15 minutes, event source mappings for Amazon MSK, self-managed Apache Kafka, and Amazon MQ for ActiveMQ and RabbitMQ only support functions with maximum timeout limits of 14 minutes. This constraint ensures that the event source mapping can properly handle function errors and retries.

Lambda sends the batch of messages in the event parameter when it invokes your function. The event payload contains an array of messages. Each array item contains details of the Amazon MSK topic and partition identifier, together with a timestamp and a base64-encoded message.

```
{
   "eventSource":"aws:kafka",
   "eventSourceArn":"arn:aws:kafka:sa-east-1:123456789012:cluster/vpc-2priv-2pub/751d2973-
a626-431c-9d4e-d7975eb44dd7-2",
   "bootstrapServers":"b-2.demo-cluster-1.a1bcde.c1.kafka.us-
east-1.amazonaws.com:9092,b-1.demo-cluster-1.a1bcde.c1.kafka.us-east-1.amazonaws.com:9092",
   "records":{
      "mytopic-0":[
         {
            "topic":"mytopic",
            "partition":0,
            "offset":15,
            "timestamp":1545084650987,
            "timestampType":"CREATE_TIME",
            "key":"abcDEFghiJKLmnoPQRstuVWXyz1234==",
            "value":"SGVsbG8sIHRoaXMgaXMgYSB0ZXN0Lg==",
            "headers":[
               {
                  "headerKey":[
                     104,
                     101,
                     97,
                     100,
                     101,
```

```
                    114,
                    86,
                    97,
                    108,
                    117,
                    101
                ]
            }
        ]
    }
  ]
 }
}
```

**Topics**


- MSK cluster authentication (p. 647)
- Managing API access and permissions (p. 650)
- Authentication and authorization errors (p. 651)
- Network configuration (p. 652)
- Adding Amazon MSK as an event source (p. 653)
- Auto scaling of the Amazon MSK event source (p. 654)
- Amazon CloudWatch metrics (p. 655)
- Amazon MSK configuration parameters (p. 655)


# MSK cluster authentication

Lambda needs permission to access the Amazon MSK cluster, retrieve records, and perform other tasks. Amazon MSK supports several options for controlling client access to the MSK cluster.

**Cluster access options**


- Unauthenticated access (p. 647)
- SASL/SCRAM authentication (p. 647)
- IAM role-based authentication (p. 648)
- Mutual TLS authentication (p. 648)
- Configuring the mTLS secret (p. 602)
- How Lambda chooses a bootstrap broker (p. 649)


## Unauthenticated access

If no clients access the cluster over the internet, you can use unauthenticated access.

## SASL/SCRAM authentication

Amazon MSK supports Simple Authentication and Security Layer/Salted Challenge Response Authentication Mechanism (SASL/SCRAM) authentication with Transport Layer Security (TLS) encryption. For Lambda to connect to the cluster, you store the authentication credentials (user name and password) in an AWS Secrets Manager secret.

For more information about using Secrets Manager, see User name and password authentication with AWS Secrets Manager in the *Amazon Managed Streaming for Apache Kafka Developer Guide*.

Amazon MSK doesn't support SASL/PLAIN authentication.

## IAM role-based authentication

You can use IAM to authenticate the identity of clients that connect to the MSK cluster. If IAM auth is active on your MSK cluster, and you don't provide a secret for auth, Lambda automatically defaults to using IAM auth. To create and deploy IAM user or role-based policies, use the IAM console or API. For more information, see IAM access control in the *Amazon Managed Streaming for Apache Kafka Developer Guide*.

To allow Lambda to connect to the MSK cluster, read records, and perform other required actions, add the following permissions to your function's execution role (p. 52).

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "kafka-cluster:Connect",
                "kafka-cluster:DescribeGroup",
                "kafka-cluster:AlterGroup",
                "kafka-cluster:DescribeTopic",
                "kafka-cluster:ReadData",
                "kafka-cluster:DescribeClusterDynamicConfiguration"
            ],
            "Resource": [
                "arn:aws:kafka:region:account-id:cluster/cluster-name/cluster-uuid",
                "arn:aws:kafka:region:account-id:topic/cluster-name/cluster-uuid/topic-
name",
                "arn:aws:kafka:region:account-id:group/cluster-name/cluster-uuid/consumer-
group-id"
            ]
        }
    ]
}
```

You can scope these permissions to a specific cluster, topic, and group. For more information, see the Amazon MSK Kafka actions in the *Amazon Managed Streaming for Apache Kafka Developer Guide*.

## Mutual TLS authentication

Mutual TLS (mTLS) provides two-way authentication between the client and server. The client sends a certificate to the server for the server to verify the client, and the server sends a certificate to the client for the client to verify the server.

For Amazon MSK, Lambda acts as the client. You configure a client certificate (as a secret in Secrets Manager) to authenticate Lambda with the brokers in your MSK cluster. The client certificate must be signed by a CA in the server's trust store. The MSK cluster sends a server certificate to Lambda to authenticate the brokers with Lambda. The server certificate must be signed by a certificate authority (CA) that's in the AWS trust store.

For instructions on how to generate a client certificate, see Introducing mutual TLS authentication for Amazon MSK as an event source.

Amazon MSK doesn't support self-signed server certificates, because all brokers in Amazon MSK use public certificates signed by Amazon Trust Services CAs, which Lambda trusts by default.

For more information about mTLS for Amazon MSK, see Mutual TLS Authentication in the *Amazon Managed Streaming for Apache Kafka Developer Guide*.

## Configuring the mTLS secret

The CLIENT_CERTIFICATE_TLS_AUTH secret requires a certificate field and a private key field. For an encrypted private key, the secret requires a private key password. Both the certificate and private key must be in PEM format.

**Note**
Lambda supports the PBES1 (but not PBES2) private key encryption algorithms.

The certificate field must contain a list of certificates, beginning with the client certificate, followed by any intermediate certificates, and ending with the root certificate. Each certificate must start on a new line with the following structure:

```
-----BEGIN CERTIFICATE-----
        <certificate contents>
-----END CERTIFICATE-----
```

Secrets Manager supports secrets up to 65,536 bytes, which is enough space for long certificate chains.

The private key must be in PKCS #8 format, with the following structure:

```
-----BEGIN PRIVATE KEY-----
         <private key contents>
-----END PRIVATE KEY-----
```

For an encrypted private key, use the following structure:

```
-----BEGIN ENCRYPTED PRIVATE KEY-----
          <private key contents>
-----END ENCRYPTED PRIVATE KEY-----
```

The following example shows the contents of a secret for mTLS authentication using an encrypted private key. For an encrypted private key, you include the private key password in the secret.

```
{
 "privateKeyPassword": "testpassword",
 "certificate": "-----BEGIN CERTIFICATE-----
MIIE5DCCAsygAwIBAgIRAPJdwaFaNRrytHBto0j5BA0wDQYJKoZIhvcNAQELBQAw
...
j0Lh4/+1HfgyE2KlmII36dg4IMzNjAFEBZiCRoPimO40s1cRqtFHXoal0QQbIlxk
cmUuiAii9R0=
-----END CERTIFICATE-----
-----BEGIN CERTIFICATE-----
MIIFgjCCA2qgAwIBAgIQdjNZd6uFf9hbNC5RdfmHrzANBgkqhkiG9w0BAQsFADBb
...
rQoiowbbk5wXCheYSANQIfTZ6weQTgiCHCCbuuMKNVS95FkXm0vqVD/YpXKwA/no
c8PH3PSoAaRwMMgOSA2ALJvbRz8mpg==
-----END CERTIFICATE-----",
 "privateKey": "-----BEGIN ENCRYPTED PRIVATE KEY-----
MIIFKzBVBgkqhkiG9w0BBQ0wSDAnBgkqhkiG9w0BBQwwGgQUiAFcK5hT/X7Kjmgp
...
QrSekqF+kWzmB6nAfSzgO9IaoAaytLvNgGTckWeUkWn/V0Ck+LdGUXzAC4RxZnoQ
zp2mwJn2NYB7AZ7+imp0azDZb+8YG2aUCiyqb6PnnA==
-----END ENCRYPTED PRIVATE KEY-----"
}
```

## How Lambda chooses a bootstrap broker

Lambda chooses a bootstrap broker based on the authentication methods available on your cluster, and whether you provide a secret for authentication. If you provide a secret for mTLS or SASL/SCRAM,

Lambda automatically chooses that auth method. If you don't provide a secret, Lambda selects the strongest auth method that's active on your cluster. The following is the order of priority in which Lambda selects a broker, from strongest to weakest auth:

- mTLS (secret provided for mTLS)
- SASL/SCRAM (secret provided for SASL/SCRAM)
- SASL IAM (no secret provided, and IAM auth active)
- Unauthenticated TLS (no secret provided, and IAM auth not active)
- Plaintext (no secret provided, and both IAM auth and unauthenticated TLS are not active)

**Note**
If Lambda can't connect to the most secure broker type, Lambda doesn't attempt to connect to a different (weaker) broker type. If you want Lambda to choose a weaker broker type, deactivate all stronger auth methods on your cluster.

# Managing API access and permissions

In addition to accessing the Amazon MSK cluster, your function needs permissions to perform various Amazon MSK API actions. You add these permissions to the function's execution role. If your users need access to any of the Amazon MSK API actions, add the required permissions to the identity policy for the IAM user or role.

## Required Lambda function execution role permissions

Your Lambda function's execution role (p. 52) must have the following permissions to access the MSK cluster on your behalf. You can either add the AWS managed policy `AWSLambdaMSKExecutionRole` to your execution role, or create a custom policy with permission to perform the following actions:

- kafka:DescribeCluster
- kafka:DescribeClusterV2
- kafka:GetBootstrapBrokers
- ec2:CreateNetworkInterface
- ec2:DescribeNetworkInterfaces
- ec2:DescribeVpcs
- ec2:DeleteNetworkInterface
- ec2:DescribeSubnets
- ec2:DescribeSecurityGroups
- logs:CreateLogGroup
- logs:CreateLogStream
- logs:PutLogEvents

**Note**
Lambda eventually plans to remove the `kafka:DescribeCluster` permission from this policy. You should migrate any applications using `kafka:DescribeCluster` to use `kafka:DescribeClusterV2` instead.

## Adding permissions to your execution role

Follow these steps to add the AWS managed policy `AWSLambdaMSKExecutionRole` to your execution role using the IAM console.

**To add an AWS managed policy**

1. Open the Policies page of the IAM console.
2. In the search box, enter the policy name (`AWSLambdaMSKExecutionRole`).
3. Select the policy from the list, and then choose **Policy actions**, **Attach**.
4. On the **Attach policy** page, select your execution role from the list, and then choose **Attach policy**.

## Granting users access with an IAM policy

By default, IAM users and roles don't have permission to perform Amazon MSK API operations. To grant access to users in your organization or account, you can add or update an identity-based policy. For more information, see Amazon MSK Identity-Based Policy Examples in the *Amazon Managed Streaming for Apache Kafka Developer Guide*.

## Using SASL/SCRAM authentication

Amazon MSK supports Simple Authentication and Security Layer/Salted Challenge Response Authentication Mechanism (SASL/SCRAM) authentication with TLS encryption. You can control access to your Amazon MSK clusters by setting up user name and password authentication using an AWS Secrets Manager secret. For more information, see Username and password authentication with AWS Secrets Manager in the *Amazon Managed Streaming for Apache Kafka Developer Guide*.

Note that Amazon MSK does not support SASL/PLAIN authentication.

# Authentication and authorization errors

If any of the permissions required to consume data from the Amazon MSK cluster are missing, Lambda displays one of the following error messages in the event source mapping under **LastProcessingResult**.

**Error messages**

- Cluster failed to authorize Lambda (p. 651)
- SASL authentication failed (p. 652)
- Server failed to authenticate Lambda (p. 652)
- Provided certificate or private key is invalid (p. 652)

## Cluster failed to authorize Lambda

For SASL/SCRAM or mTLS, this error indicates that the provided user doesn't have all of the following required Kafka access control list (ACL) permissions:

- DescribeConfigs Cluster
- Describe Group
- Read Group
- Describe Topic
- Read Topic

For IAM access control, your function's execution role is missing one or more of the permissions required to access the group or topic. Review the list of required permissions in the section called “ IAM role-based authentication” (p. 648).

When you create either Kafka ACLs or an IAM policy with the required Kafka cluster permissions, specify the topic and group as resources. The topic name must match the topic in the event source mapping. The group name must match the event source mapping's UUID.

After you add the required permissions to the execution role, it might take several minutes for the changes to take effect.

### SASL authentication failed

For SASL/SCRAM, this error indicates that the provided user name and password aren't valid.

For IAM access control, the execution role is missing the `kafka-cluster:Connect` permission for the MSK cluster. Add this permission to the role and specify the cluster's Amazon Resource Name (ARN) as a resource.

You might see this error occurring intermittently. The cluster rejects connections after the number of TCP connections exceeds the Amazon MSK service quota. Lambda backs off and retries until a connection is successful. After Lambda connects to the cluster and polls for records, the last processing result changes to `OK`.

### Server failed to authenticate Lambda

This error indicates that the Amazon MSK Kafka brokers failed to authenticate with Lambda. This can occur for any of the following reasons:

- You didn't provide a client certificate for mTLS authentication.
- You provided a client certificate, but the brokers aren't configured to use mTLS.
- A client certificate isn't trusted by the brokers.

### Provided certificate or private key is invalid

This error indicates that the Amazon MSK consumer couldn't use the provided certificate or private key. Make sure that the certificate and key use PEM format, and that the private key encryption uses a PBES1 algorithm.

## Network configuration

Lambda must have access to the Amazon Virtual Private Cloud (Amazon VPC) resources associated with your Amazon MSK cluster. We recommend that you deploy AWS PrivateLink VPC endpoints for Lambda and AWS Security Token Service (AWS STS). The poller needs access to AWS STS to assume the execution role associated with the Lambda function. Lambda must have access to the Lambda VPC endpoint to invoke the function. If you configured a secret in Secrets Manager to authenticate Lambda with the brokers, also deploy a VPC endpoint for Secrets Manager.

Alternatively, ensure that the VPC associated with your MSK cluster includes one NAT gateway per public subnet. For more information, see Internet and service access for VPC-connected functions (p. 197).

Configure your Amazon VPC security groups with the following rules (at minimum):

- Inbound rules – Allow all traffic on the Amazon MSK broker port (9092 for plaintext, 9094 for TLS, 9096 for SASL, 9098 for IAM) for the security groups specified for your event source.
- Outbound rules – Allow all traffic on port 443 for all destinations. Allow all traffic on the Amazon MSK broker port (9092 for plaintext, 9094 for TLS, 9096 for SASL, 9098 for IAM) for the security groups specified for your event source.
- If you are using VPC endpoints instead of a NAT gateway, the security groups associated with the VPC endpoints must allow all inbound traffic on port 443 from the event source's security groups.

**Note**
Your Amazon VPC configuration is discoverable through the Amazon MSK API. You don't need to configure it during setup using the **create-event-source-mapping** command.

For more information about configuring the network, see Setting up AWS Lambda with an Apache Kafka cluster within a VPC on the AWS Compute Blog.

# Adding Amazon MSK as an event source

To create an event source mapping (p. 236), add Amazon MSK as a Lambda function trigger (p. 12) using the Lambda console, an AWS SDK, or the AWS Command Line Interface (AWS CLI). Note that when you add Amazon MSK as a trigger, Lambda assumes the VPC settings of the Amazon MSK cluster, not the Lambda function's VPC settings.

This section describes how to create an event source mapping using the Lambda console and the AWS CLI.

## Prerequisites

- An Amazon MSK cluster and a Kafka topic. For more information, see Getting Started Using Amazon MSK in the *Amazon Managed Streaming for Apache Kafka Developer Guide*.
- An execution role (p. 52) with permission to access the AWS resources that your MSK cluster uses.

## Customizable consumer group ID

When setting up Kafka as an event source, you can specify a consumer group ID. This consumer group ID is an existing identifier for the Kafka consumer group that you want your Lambda function to join. You can use this feature to seamlessly migrate any ongoing Kafka record processing setups from other consumers to Lambda.

If you specify a consumer group ID and there are other active pollers within that consumer group, Kafka distributes messages across all consumers. In other words, Lambda doesn't receive all message for the Kafka topic. If you want Lambda to handle all messages in the topic, turn off any other pollers in that consumer group.

Additionally, if you specify a consumer group ID, and Kafka finds a valid existing consumer group with the same ID, Lambda ignores the `StartingPosition` parameter for your event source mapping. Instead, Lambda begins processing records according to the committed offset of the consumer group. If you specify a consumer group ID, and Kafka cannot find an existing consumer group, then Lambda configures your event source with the specified `StartingPosition`.

The consumer group ID that you specify must be unique among all your Kafka event sources. After creating a Kafka event source mapping with the consumer group ID specified, you cannot update this value.

## Adding an Amazon MSK trigger (console)

Follow these steps to add your Amazon MSK cluster and a Kafka topic as a trigger for your Lambda function.

**To add an Amazon MSK trigger to your Lambda function (console)**

1. Open the Functions page of the Lambda console.
2. Choose the name of your Lambda function.
3. Under **Function overview**, choose **Add trigger**.

4. Under **Trigger configuration**, do the following:
   a. Choose the **MSK** trigger type.
   b. For **MSK cluster**, select your cluster.
   c. For **Batch size**, enter the maximum number of messages to receive in a single batch.
   d. For **Batch window**, enter the maximum amount of seconds that Lambda spends gathering records before invoking the function.
   e. For **Topic name**, enter the name of a Kafka topic.
   f. (Optional) For **Consumer group ID**, enter the ID of a Kafka consumer group to join.
   g. (Optional) For **Starting position**, choose **Latest** to start reading the stream from the latest record. Or, choose **Trim horizon** to start at the earliest available record.
   h. (Optional) For **Authentication**, choose the secret key for authenticating with the brokers in your MSK cluster.
   i. To create the trigger in a disabled state for testing (recommended), clear **Enable trigger**. Or, to enable the trigger immediately, select **Enable trigger**.
5. To create the trigger, choose **Add**.

## Adding an Amazon MSK trigger (AWS CLI)

Use the following example AWS CLI commands to create and view an Amazon MSK trigger for your Lambda function.

### Creating a trigger using the AWS CLI

The following example uses the `create-event-source-mapping` AWS CLI command to map a Lambda function named `my-kafka-function` to a Kafka topic named `AWSKafkaTopic`. The topic's starting position is set to `LATEST`.

```
aws lambda create-event-source-mapping \
  --event-source-arn arn:aws:kafka:us-west-2:arn:aws:kafka:us-west-2:111111111111:cluster/
my-cluster/fc2f5bdf-fd1b-45ad-85dd-15b4a5a6247e-2 \
  --topics AWSKafkaTopic \
  --starting-position LATEST \
  --function-name my-kafka-function
```

For more information, see the CreateEventSourceMapping (p. 893) API reference documentation.

### Viewing the status using the AWS CLI

The following example uses the `get-event-source-mapping` AWS CLI command to describe the status of the event source mapping that you created.

```
aws lambda get-event-source-mapping \
  --uuid 6d9bce8e-836b-442c-8070-74e77903c815
```

# Auto scaling of the Amazon MSK event source

When you initially create an Amazon MSK event source, Lambda allocates one consumer to process all partitions in the Kafka topic. Each consumer has multiple processors running in parallel to handle increased workloads. Additionally, Lambda automatically scales up or down the number of consumers, based on workload. To preserve message ordering in each partition, the maximum number of consumers is one consumer per partition in the topic.

In one-minute intervals, Lambda evaluates the consumer offset lag of all the partitions in the topic. If the lag is too high, the partition is receiving messages faster than Lambda can process them. If necessary, Lambda adds or removes consumers from the topic. The scaling process of adding or removing consumers occurs within three minutes of evaluation.

If your target Lambda function is overloaded, Lambda reduces the number of consumers. This action reduces the workload on the function by reducing the number of messages that consumers can retrieve and send to the function.

To monitor the throughput of your Kafka topic, view the Offset lag metric (p. 655) Lambda emits while your function processes records.

To check how many function invocations occur in parallel, you can also monitor the concurrency metrics (p. 729) for your function.

# Amazon CloudWatch metrics

Lambda emits the `OffsetLag` metric while your function processes records. The value of this metric is the difference in offset between the last record written to the Kafka event source topic and the last record that your function's consumer group processed. You can use `OffsetLag` to estimate the latency between when a record is added and when your consumer group processes it.

An increasing trend in `OffsetLag` can indicate issues with pollers in your function's consumer group. For more information, see Working with Lambda function metrics (p. 727).

# Amazon MSK configuration parameters

All Lambda event source types share the same CreateEventSourceMapping (p. 893) and UpdateEventSourceMapping (p. 1078) API operations. However, only some of the parameters apply to Amazon MSK.

**Event source parameters that apply to Amazon MSK**

| Parameter | Required | Default | Notes |
|---|---|---|---|
| AmazonManagedKafkaEventSourceConfig | N | Contains the ConsumerGroupId field, which defaults to a unique value. | Can set only on Create |
| BatchSize | N | 100 | Maximum: 10,000 |
| Enabled | N | Enabled | |
| EventSourceArn | Y | | Can set only on Create |
| FunctionName | Y | | |
| SourceAccessConfigurations | N | No credentials | SASL/SCRAM or CLIENT_CERTIFICATE_TLS_AUTH (MutualTLS) authentication credentials for your event source |
| StartingPosition | Y | | TRIM_HORIZON or LATEST<br><br>Can set only on Create |

| Parameter | Required | Default | Notes |
| --- | --- | --- | --- |
| Topics | Y | | Kafka topic name<br>Can set only on Create |

# Using AWS Lambda with Amazon RDS

You can use AWS Lambda to process event notifications from an Amazon Relational Database Service (Amazon RDS) database. Amazon RDS sends notifications to an Amazon Simple Notification Service (Amazon SNS) topic, which you can configure to invoke a Lambda function. Amazon SNS wraps the message from Amazon RDS in its own event document and sends it to your function.

**Example Amazon RDS message in an Amazon SNS event**

```
{
      "Records": [
        {
          "EventVersion": "1.0",
          "EventSubscriptionArn": "arn:aws:sns:us-east-2:123456789012:rds-lambda:21be56ed-
a058-49f5-8c98-aedd2564c486",
          "EventSource": "aws:sns",
          "Sns": {
            "SignatureVersion": "1",
            "Timestamp": "2019-01-02T12:45:07.000Z",
            "Signature": "tcc6faL2yUC6dgZdmrwh1Y4cGa/ebXEkAi6RibDsvpi+tE/1+82j...65r==",
            "SigningCertUrl": "https://sns.us-east-2.amazonaws.com/
SimpleNotificationService-ac565b8b1a6c5d002d285f9598aa1d9b.pem",
            "MessageId": "95df01b4-ee98-5cb9-9903-4c221d41eb5e",
            "Message": "{\"Event Source\":\"db-instance\",\"Event Time\":\"2019-01-02
 12:45:06.000\",\"Identifier Link\":\"https://console.aws.amazon.com/rds/home?region=eu-
west-1#dbinstance:id=dbinstanceid\",\"Source ID\":\"dbinstanceid\",\"Event ID\":\"http://
docs.amazonwebservices.com/AmazonRDS/latest/UserGuide/USER_Events.html#RDS-EVENT-0002\",
\"Event Message\":\"Finished DB Instance backup\"}",
            "MessageAttributes": {},
            "Type": "Notification",
            "UnsubscribeUrl": "https://sns.us-east-2.amazonaws.com/?
Action=Unsubscribe&amp;SubscriptionArn=arn:aws:sns:us-east-2:123456789012:test-
lambda:21be56ed-a058-49f5-8c98-aedd2564c486",
            "TopicArn":"arn:aws:sns:us-east-2:123456789012:sns-lambda",
            "Subject": "RDS Notification Message"
          }
        }
      ]
    }
```

**Topics**


- Tutorial: Configuring a Lambda function to access Amazon RDS in an Amazon VPC (p. 657)
- Configuring the function (p. 661)


## Tutorial: Configuring a Lambda function to access Amazon RDS in an Amazon VPC

In this tutorial, you do the following:

- Launch an Amazon RDS MySQL database engine instance in your default Amazon VPC. In the MySQL instance, you create a database (ExampleDB) with a sample table (Employee) in it. For more information about Amazon RDS, see Amazon RDS.
- Create a Lambda function to access the ExampleDB database, create a table (Employee), add a few records, and retrieve the records from the table.
- Invoke the Lambda function and verify the query results. This is how you verify that your Lambda function was able to access the RDS MySQL instance in the VPC.

For details on using Lambda with Amazon VPC, see Configuring a Lambda function to access resources in a VPC (p. 191).

## Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

## Create the execution role

Create the execution role (p. 52) that gives your function permission to access AWS resources.

**To create an execution role**

1. Open the roles page in the IAM console.
2. Choose **Create role**.
3. Create a role with the following properties.
   - **Trusted entity** – Lambda.
   - **Permissions** – **AWSLambdaVPCAccessExecutionRole**.
   - **Role name** – **`lambda-vpc-role`**.

The **AWSLambdaVPCAccessExecutionRole** has the permissions that the function needs to manage network connections to a VPC.

## Create an Amazon RDS database instance

In this tutorial, the example Lambda function creates a table (Employee), inserts a few records, and then retrieves the records. The table that the Lambda function creates has the following schema:

```
Employee(EmpID, Name)
```

Where `EmpID` is the primary key. Now, you need to add a few records to this table.

First, you launch an RDS MySQL instance in your default VPC with ExampleDB database. If you already have an RDS MySQL instance running in your default VPC, skip this step.

You can launch an RDS MySQL instance using one of the following methods:

- Follow the instructions at Creating a MySQL DB instance and connecting to a database on a MySQL DB instance in the *Amazon RDS User Guide*.
- Use the following AWS CLI command:

```
aws rds create-db-instance --db-name ExampleDB --engine MySQL \
--db-instance-identifier MySQLForLambdaTest --backup-retention-period 3 \
--db-instance-class db.t2.micro --allocated-storage 5 --no-publicly-accessible \
--master-username username --master-user-password password
```

Write down the database name, user name, and password. You also need the host address (endpoint) of the DB instance, which you can get from the RDS console. You might need to wait until the instance status is available and the Endpoint value appears in the console.

## Create a deployment package

The following example Python code runs a SELECT query against the Employee table in the MySQL RDS instance that you created in the VPC. The code creates a table in the ExampleDB database, adds sample records, and retrieves those records.

The following method for handling database credentials is for illustrative purposes only. In a production environment, we recommend using AWS Secrets Manager instead of environment variables to store database credentials. For more information, see Configuring database access for a Lambda function.

**Example app.py**

```
import sys
import logging
import rds_config
import pymysql
#rds settings
rds_host  = "rds-instance-endpoint"
name = rds_config.db_username
password = rds_config.db_password
db_name = rds_config.db_name

logger = logging.getLogger()
logger.setLevel(logging.INFO)

try:
    conn = pymysql.connect(host=rds_host, user=name, passwd=password, db=db_name,
 connect_timeout=5)
except pymysql.MySQLError as e:
    logger.error("ERROR: Unexpected error: Could not connect to MySQL instance.")
    logger.error(e)
    sys.exit()

logger.info("SUCCESS: Connection to RDS MySQL instance succeeded")
def handler(event, context):
    """
    This function fetches content from MySQL RDS instance
    """

    item_count = 0

    with conn.cursor() as cur:
        cur.execute("create table Employee ( EmpID  int NOT NULL, Name varchar(255) NOT
 NULL, PRIMARY KEY (EmpID))")
        cur.execute('insert into Employee (EmpID, Name) values(1, "Joe")')
        cur.execute('insert into Employee (EmpID, Name) values(2, "Bob")')
        cur.execute('insert into Employee (EmpID, Name) values(3, "Mary")')
```

```
        conn.commit()
        cur.execute("select * from Employee")
        for row in cur:
            item_count += 1
            logger.info(row)
            #print(row)
    conn.commit()

    return "Added %d items from RDS MySQL table" %(item_count)
```

Executing `pymysql.connect()` outside of the handler allows your function to re-use the database connection for better performance.

A second file contains connection information for the function.

**Example rds_config.py**

```
#config file containing credentials for RDS MySQL instance
db_username = "username"
db_password = "password"
db_name = "ExampleDB"
```

A deployment package is a .zip file containing your Lambda function code and dependencies. The sample function code has the following dependencies:

**Dependencies**

- `pymysql` – The Lambda function code uses this library to access your MySQL instance (see PyMySQL) .

**To create a deployment package**

- Install dependencies with Pip and create a deployment package. For instructions, see Deploy Python Lambda functions with .zip file archives (p. 330).

## Create the Lambda function

Create the Lambda function with the `create-function` command. You can find the subnet IDs and security group ID for your default VPC in the Amazon VPC console.

```
aws lambda create-function --function-name  CreateTableAddRecordsAndRead --runtime
 python3.8 \
--zip-file fileb://app.zip --handler app.handler \
--role arn:aws:iam::123456789012:role/lambda-vpc-role \
--vpc-config SubnetIds=subnet-0532bb6758ce7c71f,subnet-
d6b7fda068036e11f,SecurityGroupIds=sg-0897d5f549934c2fb
```

## Test the Lambda function

In this step, you invoke the Lambda function manually using the `invoke` command. When the Lambda function runs, it runs the SELECT query against the Employee table in the RDS MySQL instance and prints the results, which also go to the CloudWatch Logs.

1. Invoke the Lambda function with the `invoke` command.

   ```
   aws lambda invoke --function-name CreateTableAddRecordsAndRead output.txt
   ```

2. Verify that the Lambda function executed successfully as follows:

   - Review the output.txt file.
   - Review the results in the AWS Lambda console.
   - Verify the results in CloudWatch Logs.

Now that you have created a Lambda function that accesses a database in your VPC, you can have the function invoked in response to events. For information about configuring event sources and examples, see Using AWS Lambda with other services (p. 496).

## Clean up your resources

You can now delete the resources that you created for this tutorial, unless you want to retain them. By deleting AWS resources that you're no longer using, you prevent unnecessary charges to your AWS account.

### To delete the Lambda function

1. Open the Functions page of the Lambda console.
2. Select the function that you created.
3. Choose **Actions**, then choose **Delete**.
4. Choose **Delete**.

### To delete the execution role

1. Open the Roles page of the IAM console.
2. Select the execution role that you created.
3. Choose **Delete role**.
4. Choose **Yes, delete**.

### To delete the MySQL DB instance

1. Open the Databases page of the Amazon RDS console.
2. Select the database you created.
3. Choose **Actions**, **Delete**.
4. Clear the **Create final snapshot** check box.
5. Enter **`delete me`** in the text box.
6. Choose **Delete**.

# Configuring the function

The following section shows additional configurations and topics we recommend as part of this tutorial.

- If too many function instances run concurrently, one or more instances may fail to obtain a database connection. You can use reserved concurrency to limit the maximum concurrency of the function. Set the reserved concurrency to be less than the number of database connections. Reserved concurrency also reserves those instances for this function, which may not be ideal. If you are invoking the Lambda functions from your application, we recommend you write code that limits the number of concurrent instances. For more information, see Managing concurrency for a Lambda function.
- For more information on configuring an Amazon RDS database to send notifications, see Using Amazon RDS event notifications.

- For more information on using Amazon SNS as trigger, see Using AWS Lambda with Amazon SNS (p. 689).

# Using AWS Lambda with Amazon S3

You can use Lambda to process event notifications from Amazon Simple Storage Service. Amazon S3 can send an event to a Lambda function when an object is created or deleted. You configure notification settings on a bucket, and grant Amazon S3 permission to invoke a function on the function's resource-based permissions policy.

> **Warning**
> If your Lambda function uses the same bucket that triggers it, it could cause the function to run in a loop. For example, if the bucket triggers a function each time an object is uploaded, and the function uploads an object to the bucket, then the function indirectly triggers itself. To avoid this, use two buckets, or configure the trigger to only apply to a prefix used for incoming objects.

Amazon S3 invokes your function asynchronously (p. 228) with an event that contains details about the object. The following example shows an event that Amazon S3 sent when a deployment package was uploaded to Amazon S3.

**Example Amazon S3 notification event**

```
{
  "Records": [
    {
      "eventVersion": "2.1",
      "eventSource": "aws:s3",
      "awsRegion": "us-east-2",
      "eventTime": "2019-09-03T19:37:27.192Z",
      "eventName": "ObjectCreated:Put",
      "userIdentity": {
        "principalId": "AWS:AIDAINPONIXQXHT3IKHL2"
      },
      "requestParameters": {
        "sourceIPAddress": "205.255.255.255"
      },
      "responseElements": {
        "x-amz-request-id": "D82B88E5F771F645",
        "x-amz-id-2":
 "vlR7PnpV2Ce81l0PRw6jlUpck7Jo5ZsQjryTjKlc5aLWGVHPZLj5NeC6qMa0emYBDXOo6QBU0Wo="
      },
      "s3": {
        "s3SchemaVersion": "1.0",
        "configurationId": "828aa6fc-f7b5-4305-8584-487c791949c1",
        "bucket": {
          "name": "DOC-EXAMPLE-BUCKET",
          "ownerIdentity": {
            "principalId": "A3I5XTEXAMAI3E"
          },
          "arn": "arn:aws:s3:::lambda-artifacts-deafc19498e3f2df"
        },
        "object": {
          "key": "b21b84d653bb07b05b1e6b33684dc11b",
          "size": 1305107,
          "eTag": "b21b84d653bb07b05b1e6b33684dc11b",
          "sequencer": "0C0F6F405D6ED209E1"
        }
      }
    }
  ]
}
```

To invoke your function, Amazon S3 needs permission from the function's resource-based policy (p. 68). When you configure an Amazon S3 trigger in the Lambda console, the console modifies the resource-

based policy to allow Amazon S3 to invoke the function if the bucket name and account ID match. If you configure the notification in Amazon S3, you use the Lambda API to update the policy. You can also use the Lambda API to grant permission to another account, or restrict permission to a designated alias.

If your function uses the AWS SDK to manage Amazon S3 resources, it also needs Amazon S3 permissions in its execution role (p. 52).

**Topics**


- Tutorial: Using an Amazon S3 trigger to invoke a Lambda function (p. 664)
- Tutorial: Using an Amazon S3 trigger to create thumbnail images (p. 669)
- AWS SAM template for an Amazon S3 application (p. 682)


# Tutorial: Using an Amazon S3 trigger to invoke a Lambda function

In this tutorial, you use the console to create a Lambda function and configure a trigger for Amazon Simple Storage Service (Amazon S3). The trigger invokes your function every time that you add an object to your Amazon S3 bucket.

We recommend that you complete this console-based tutorial before you try the tutorial to create thumbnail images (p. 669).

## Prerequisites

To use Lambda and other AWS services, you need an AWS account. If you do not have an account, visit aws.amazon.com and choose **Create an AWS Account**. For instructions, see How do I create and activate a new AWS account?

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

## Create a bucket and upload a sample object

Create an Amazon S3 bucket and upload a test file to your new bucket. Your Lambda function retrieves information about this file when you test the function from the console.

**To create an Amazon S3 bucket using the console**

1. Open the Amazon S3 console.
2. Choose **Create bucket**.
3. Under **General configuration**, do the following:
    a. For **Bucket name**, enter a unique name.
    b. For **AWS Region**, choose a Region. Note that you must create your Lambda function in the same Region.
4. Choose **Create bucket**.

After creating the bucket, Amazon S3 opens the **Buckets** page, which displays a list of all buckets in your account in the current Region.

**To upload a test object using the Amazon S3 console**

1. On the Buckets page of the Amazon S3 console, choose the name of the bucket that you created.

2. On the **Objects** tab, choose **Upload**.
3. Drag a test file from your local machine to the **Upload** page.
4. Choose **Upload**.

## Create the Lambda function

Use a function blueprint (p. 20) to create the Lambda function. A blueprint provides a sample function that demonstrates how to use Lambda with other AWS services. Also, a blueprint includes sample code and function configuration presets for a certain runtime. For this tutorial, you can choose the blueprint for the Node.js or Python runtime.

**To create a Lambda function from a blueprint in the console**

1. Open the Functions page of the Lambda console.
2. Choose **Create function**.
3. On the **Create function** page, choose **Use a blueprint**.
4. Under **Blueprints**, enter **`s3`** in the search box.
5. In the search results, do one of the following:
   - For a Node.js function, choose **s3-get-object**.
   - For a Python function, choose **s3-get-object-python**.
6. Choose **Configure**.
7. Under **Basic information**, do the following:
   a. For **Function name**, enter **`my-s3-function`**.
   b. For **Execution role**, choose **Create a new role from AWS policy templates**.
   c. For **Role name**, enter **`my-s3-function-role`**.
8. Under **S3 trigger**, choose the S3 bucket that you created previously.

   When you configure an S3 trigger using the Lambda console, the console modifies your function's resource-based policy (p. 68) to allow Amazon S3 to invoke the function.
9. Choose **Create function**.

## Review the function code

The Lambda function retrieves the source S3 bucket name and the key name of the uploaded object from the event parameter that it receives. The function uses the Amazon S3 `getObject` API to retrieve the content type of the object.

While viewing your function in the Lambda console, you can review the function code on the **Code** tab, under **Code source**. The code looks like the following:

Node.js

**Example index.js**

```
console.log('Loading function');

const aws = require('aws-sdk');

const s3 = new aws.S3({ apiVersion: '2006-03-01' });

exports.handler = async (event, context) => {
    //console.log('Received event:', JSON.stringify(event, null, 2));
```

```
    // Get the object from the event and show its content type
    const bucket = event.Records[0].s3.bucket.name;
    const key = decodeURIComponent(event.Records[0].s3.object.key.replace(/\+/g, ' '));
    const params = {
        Bucket: bucket,
        Key: key,
    };
    try {
        const { ContentType } = await s3.getObject(params).promise();
        console.log('CONTENT TYPE:', ContentType);
        return ContentType;
    } catch (err) {
        console.log(err);
        const message = `Error getting object ${key} from bucket ${bucket}. Make sure
 they exist and your bucket is in the same region as this function.`;
        console.log(message);
        throw new Error(message);
    }
};
```

Python

**Example lambda-function.py**

```
import json
import urllib.parse
import boto3

print('Loading function')

s3 = boto3.client('s3')


def lambda_handler(event, context):
    #print("Received event: " + json.dumps(event, indent=2))

    # Get the object from the event and show its content type
    bucket = event['Records'][0]['s3']['bucket']['name']
    key = urllib.parse.unquote_plus(event['Records'][0]['s3']['object']['key'],
 encoding='utf-8')
    try:
        response = s3.get_object(Bucket=bucket, Key=key)
        print("CONTENT TYPE: " + response['ContentType'])
        return response['ContentType']
    except Exception as e:
        print(e)
        print('Error getting object {} from bucket {}. Make sure they exist and your
 bucket is in the same region as this function.'.format(key, bucket))
        raise e
```

## Test in the console

Invoke the Lambda function manually using sample Amazon S3 event data.

**To test the Lambda function using the console**

1. On the **Code** tab, under **Code source**, choose the arrow next to **Test**, and then choose **Configure test events** from the dropdown list.

2. In the **Configure test event** window, do the following:

   a. Choose **Create new test event**.

   b. For **Event template**, choose **Amazon S3 Put** (**s3-put**).

   c. For **Event name**, enter a name for the test event. For example, **`mys3testevent`**.

   d. In the test event JSON, replace the S3 bucket name (`example-bucket`) and object key (`test/key`) with your bucket name and test file name. Your test event should look similar to the following:

```
{
  "Records": [
    {
      "eventVersion": "2.0",
      "eventSource": "aws:s3",
      "awsRegion": "us-west-2",
      "eventTime": "1970-01-01T00:00:00.000Z",
      "eventName": "ObjectCreated:Put",
      "userIdentity": {
        "principalId": "EXAMPLE"
      },
      "requestParameters": {
        "sourceIPAddress": "127.0.0.1"
      },
      "responseElements": {
        "x-amz-request-id": "EXAMPLE123456789",
        "x-amz-id-2": "EXAMPLE123/5678abcdefghijklambdaisawesome/
mnopqrstuvwxyzABCDEFGH"
      },
      "s3": {
        "s3SchemaVersion": "1.0",
        "configurationId": "testConfigRule",
        "bucket": {
          "name": "my-s3-bucket",
          "ownerIdentity": {
            "principalId": "EXAMPLE"
          },
          "arn": "arn:aws:s3:::example-bucket"
        },
        "object": {
          "key": "HappyFace.jpg",
          "size": 1024,
          "eTag": "0123456789abcdef0123456789abcdef",
          "sequencer": "0A1B2C3D4E5F678901"
        }
      }
    }
  ]
}
```

   e. Choose **Create**.

3. To invoke the function with your test event, under **Code source**, choose **Test**.

   The **Execution results** tab displays the response, function logs, and request ID, similar to the following:

```
Response
"image/jpeg"

Function Logs
START RequestId: 12b3cae7-5f4e-415e-93e6-416b8f8b66e6 Version: $LATEST
2021-02-18T21:40:59.280Z 12b3cae7-5f4e-415e-93e6-416b8f8b66e6 INFO INPUT BUCKET AND
 KEY:  { Bucket: 'my-s3-bucket', Key: 'HappyFace.jpg' }
```

```
2021-02-18T21:41:00.215Z 12b3cae7-5f4e-415e-93e6-416b8f8b66e6 INFO CONTENT TYPE: image/
jpeg
END RequestId: 12b3cae7-5f4e-415e-93e6-416b8f8b66e6
REPORT RequestId: 12b3cae7-5f4e-415e-93e6-416b8f8b66e6 Duration: 976.25 ms Billed
 Duration: 977 ms Memory Size: 128 MB Max Memory Used: 90 MB Init Duration: 430.47 ms


Request ID
12b3cae7-5f4e-415e-93e6-416b8f8b66e6
```

## Test with the S3 trigger

Invoke your function when you upload a file to the Amazon S3 source bucket.

**To test the Lambda function using the S3 trigger**

1. On the Buckets page of the Amazon S3 console, choose the name of the source bucket that you created earlier.
2. On the **Upload** page, upload a few .jpg or .png image files to the bucket.
3. Open the Functions page of the Lambda console.
4. Choose the name of your function (**my-s3-function**).
5. To verify that the function ran once for each file that you uploaded, choose the **Monitor** tab. This page shows graphs for the metrics that Lambda sends to CloudWatch. The count in the **Invocations** graph should match the number of files that you uploaded to the Amazon S3 bucket.




   For more information on these graphs, see Monitoring functions on the Lambda console (p. 719).
6. (Optional) To view the logs in the CloudWatch console, choose **View logs in CloudWatch**. Choose a log stream to view the logs output for one of the function invocations.

## Clean up your resources

You can now delete the resources that you created for this tutorial, unless you want to retain them. By deleting AWS resources that you're no longer using, you prevent unnecessary charges to your AWS account.

**To delete the Lambda function**

1. Open the Functions page of the Lambda console.
2. Select the function that you created.

3. Choose **Actions**, then choose **Delete**.
4. Choose **Delete**.

**To delete the IAM policy**

1. Open the Policies page of the AWS Identity and Access Management (IAM) console.
2. Select the policy that Lambda created for you. The policy name begins with **AWSLambdaS3ExecutionRole-**.
3. Choose **Policy actions**, **Delete**.
4. Choose **Delete**.

**To delete the execution role**

1. Open the Roles page of the IAM console.
2. Select the execution role that you created.
3. Choose **Delete role**.
4. Choose **Yes, delete**.

**To delete the S3 bucket**

1. Open the Amazon S3 console.
2. Select the bucket you created.
3. Choose **Delete**.
4. Enter the name of the bucket in the text box.
5. Choose **Confirm**.

## Next steps

Try the more advanced tutorial. In this tutorial, the S3 trigger invokes a function to create a thumbnail image (p. 669) for each image file that is uploaded to your S3 bucket. This tutorial requires a moderate level of AWS and Lambda domain knowledge. You use the AWS Command Line Interface (AWS CLI) to create resources, and you create a .zip file archive deployment package for your function and its dependencies.

# Tutorial: Using an Amazon S3 trigger to create thumbnail images

In this tutorial, you create a Lambda function and configure a trigger for Amazon Simple Storage Service (Amazon S3). Amazon S3 invokes the `CreateThumbnail` function for each image file that is uploaded to an S3 bucket. The function reads the image object from the source S3 bucket and creates a thumbnail image to save in a target S3 bucket.

> **Note**
> This tutorial requires a moderate level of AWS and Lambda domain knowledge, Docker operations, and AWS SAM. We recommend that you first try Tutorial: Using an Amazon S3 trigger to invoke a Lambda function (p. 664).

In this tutorial, you use the AWS Command Line Interface (AWS CLI) to create the following AWS resources:

### Lambda resources

- A Lambda function. You can choose Node.js, Python, or Java for the function code.
- A .zip file archive deployment package for the function.
- An access policy that grants Amazon S3 permission to invoke the function.

### AWS Identity and Access Management (IAM) resources

- An execution role with an associated permissions policy to grant permissions that your function needs.

### Amazon S3 resources

- A source S3 bucket with a notification configuration that invokes the function.
- A target S3 bucket where the function saves the resized images.

**Topics**

- Prerequisites (p. 670)
- Step 1. Create S3 buckets and upload a sample object (p. 671)
- Step 2. Create the IAM policy (p. 671)
- Step 3. Create the execution role (p. 672)
- Step 4. Create the function code (p. 672)
- Step 5. Create the deployment package (p. 677)
- Step 6. Create the Lambda function (p. 678)
- Step 7. Test the Lambda function (p. 679)
- Step 8. Configure Amazon S3 to publish events (p. 680)
- Step 9. Test using the S3 trigger (p. 681)
- Step 10. Clean up your resources (p. 681)

## Prerequisites

- AWS account

  To use Lambda and other AWS services, you need an AWS account. If you do not have an account, visit aws.amazon.com and choose **Create an AWS Account**. For instructions, see How do I create and activate a new AWS account?
- Command line

  To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

  You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

  For long commands, an escape character (\) is used to split a command over multiple lines.

  On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

- AWS CLI

  In this tutorial, you use AWS CLI commands to create and invoke the Lambda function. Install the AWS CLI and configure it with your AWS credentials.
- Language tools

  Install the language support tools and a package manager for the language that you want to use: Node.js, Python, or Java. For suggested tools, see Code authoring tools (p. 6).

## Step 1. Create S3 buckets and upload a sample object

Follow these steps to create S3 buckets and upload an object.

1. Open the Amazon S3 console.
2. Create two S3 buckets. The target bucket must be named ***source*-resized**, where *source* is the name of the source bucket. For example, a source bucket named `mybucket` and a target bucket named `mybucket-resized`.
3. In the source bucket, upload a .jpg object, for example, `HappyFace.jpg`.

   You must create this sample object before you test your Lambda function. When you test the function manually using the Lambda **invoke** command, you pass sample event data to the function that specifies the source bucket name and `HappyFace.jpg` as the newly created object.

## Step 2. Create the IAM policy

Create an IAM policy that defines the permissions for the Lambda function. The function must have permissions to:

- Get the object from the source S3 bucket.
- Put the resized object into the target S3 bucket.
- Write logs to Amazon CloudWatch Logs.

### To create an IAM policy

1. Open the Policies page in the IAM console.
2. Choose **Create policy**.
3. Choose the **JSON** tab, and then paste the following policy. Be sure to replace *mybucket* with the name of the source bucket that you created previously.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "logs:PutLogEvents",
                "logs:CreateLogGroup",
                "logs:CreateLogStream"
            ],
            "Resource": "arn:aws:logs:*:*:*"
        },
        {
            "Effect": "Allow",
            "Action": [
                "s3:GetObject"
```

```
            ],
            "Resource": "arn:aws:s3:::mybucket/*"
        },
        {
            "Effect": "Allow",
            "Action": [
                "s3:PutObject"
            ],
            "Resource": "arn:aws:s3:::mybucket-resized/*"
        }
    ]
}
```

4. Choose **Next: Tags**.
5. Choose **Next: Review**.
6. Under **Review policy**, for **Name**, enter **`AWSLambdaS3Policy`**.
7. Choose **Create policy**.

## Step 3. Create the execution role

Create the execution role (p. 52) that gives your Lambda function permission to access AWS resources.

**To create an execution role**

1. Open the Roles page in the IAM console.
2. Choose **Create role**.
3. Create a role with the following properties:

   - **Trusted entity** – **Lambda**
   - **Permissions policy** – **AWSLambdaS3Policy**
   - **Role name** – **`lambda-s3-role`**

## Step 4. Create the function code

In the following code examples, the Amazon S3 event contains the source S3 bucket name and the object key name. If the object is a .jpg or a .png image file, it reads the image from the source bucket, generates a thumbnail image, and then saves the thumbnail to the target S3 bucket.

Note the following:

- The code assumes that the target bucket exists and that its name is a concatenation of the source bucket name and `-resized`.
- For each thumbnail file created, the Lambda function code derives the object key name as a concatenation of `resized-` and the source object key name. For example, if the source object key name is `sample.jpg`, the code creates a thumbnail object that has the key `resized-sample.jpg`.

Node.js

Copy the following code example into a file named `index.js`.

**Example index.js**

```
// dependencies
const AWS = require('aws-sdk');
const util = require('util');
```

```
const sharp = require('sharp');

// get reference to S3 client
const s3 = new AWS.S3();

exports.handler = async (event, context, callback) => {

  // Read options from the event parameter.
  console.log("Reading options from event:\n", util.inspect(event, {depth: 5}));
  const srcBucket = event.Records[0].s3.bucket.name;
  // Object key may have spaces or unicode non-ASCII characters.
  const srcKey    = decodeURIComponent(event.Records[0].s3.object.key.replace(/\+/g, "
 "));
  const dstBucket = srcBucket + "-resized";
  const dstKey    = "resized-" + srcKey;

  // Infer the image type from the file suffix.
  const typeMatch = srcKey.match(/\.([^.]*)$/);
  if (!typeMatch) {
      console.log("Could not determine the image type.");
      return;
  }

  // Check that the image type is supported
  const imageType = typeMatch[1].toLowerCase();
  if (imageType != "jpg" && imageType != "png") {
      console.log(`Unsupported image type: ${imageType}`);
      return;
  }

  // Download the image from the S3 source bucket.

  try {
      const params = {
          Bucket: srcBucket,
          Key: srcKey
      };
      var origimage = await s3.getObject(params).promise();

  } catch (error) {
      console.log(error);
      return;
  }

  // set thumbnail width. Resize will set the height automatically to maintain aspect
 ratio.
  const width  = 200;

  // Use the sharp module to resize the image and save in a buffer.
  try {
      var buffer = await sharp(origimage.Body).resize(width).toBuffer();

  } catch (error) {
      console.log(error);
      return;
  }

  // Upload the thumbnail image to the destination bucket
  try {
      const destparams = {
          Bucket: dstBucket,
          Key: dstKey,
          Body: buffer,
          ContentType: "image"
      };
```

```
      const putResult = await s3.putObject(destparams).promise();

  } catch (error) {
      console.log(error);
      return;
  }

  console.log('Successfully resized ' + srcBucket + '/' + srcKey +
      ' and uploaded to ' + dstBucket + '/' + dstKey);
};
```

Python

Copy the following code example into a file named `lambda_function.py`.

**Example lambda_function.py**

```
import boto3
import os
import sys
import uuid
from urllib.parse import unquote_plus
from PIL import Image
import PIL.Image

s3_client = boto3.client('s3')

def resize_image(image_path, resized_path):
  with Image.open(image_path) as image:
      image.thumbnail(tuple(x / 2 for x in image.size))
      image.save(resized_path)

def lambda_handler(event, context):
  for record in event['Records']:
      bucket = record['s3']['bucket']['name']
      key = unquote_plus(record['s3']['object']['key'])
      tmpkey = key.replace('/', '')
      download_path = '/tmp/{}{}'.format(uuid.uuid4(), tmpkey)
      upload_path = '/tmp/resized-{}'.format(tmpkey)
      s3_client.download_file(bucket, key, download_path)
      resize_image(download_path, upload_path)
      s3_client.upload_file(upload_path, '{}-resized'.format(bucket), key)
```

Java

The Java code implements the `RequestHandler` interface provided in the `aws-lambda-java-core` library. When you create a Lambda function, you specify the class as the handler (in this code example, `example.handler`). For more information about using interfaces to provide a handler, see Handler interfaces (p. 384).

The handler uses `S3Event` as the input type, which provides convenient methods for your function code to read information from the incoming Amazon S3 event. Amazon S3 invokes your Lambda function asynchronously. Because you are implementing an interface that requires you to specify a return type, the handler uses `String` as the return type.

Copy the following code example into a file named `Handler.java`.

**Example Handler.java**

```
package example;
import java.awt.Color;
```

```
import java.awt.Graphics2D;
import java.awt.RenderingHints;
import java.awt.image.BufferedImage;
import java.io.ByteArrayInputStream;
import java.io.ByteArrayOutputStream;
import java.io.IOException;
import java.io.InputStream;
import java.util.regex.Matcher;
import java.util.regex.Pattern;

import javax.imageio.ImageIO;

import com.amazonaws.AmazonServiceException;
import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.services.lambda.runtime.RequestHandler;
import com.amazonaws.services.lambda.runtime.events.S3Event;
import com.amazonaws.services.s3.AmazonS3;
import com.amazonaws.services.s3.event.S3EventNotification.S3EventNotificationRecord;
import com.amazonaws.services.s3.model.GetObjectRequest;
import com.amazonaws.services.s3.model.ObjectMetadata;
import com.amazonaws.services.s3.model.S3Object;
import com.amazonaws.services.s3.AmazonS3ClientBuilder;

public class Handler implements
      RequestHandler<S3Event, String> {
  private static final float MAX_WIDTH = 100;
  private static final float MAX_HEIGHT = 100;
  private final String JPG_TYPE = (String) "jpg";
  private final String JPG_MIME = (String) "image/jpeg";
  private final String PNG_TYPE = (String) "png";
  private final String PNG_MIME = (String) "image/png";

  public String handleRequest(S3Event s3event, Context context) {
      try {
          S3EventNotificationRecord record = s3event.getRecords().get(0);

          String srcBucket = record.getS3().getBucket().getName();

          // Object key may have spaces or unicode non-ASCII characters.
          String srcKey = record.getS3().getObject().getUrlDecodedKey();

          String dstBucket = srcBucket + "-resized";
          String dstKey = "resized-" + srcKey;

          // Sanity check: validate that source and destination are different
          // buckets.
          if (srcBucket.equals(dstBucket)) {
              System.out
                      .println("Destination bucket must not match source bucket.");
              return "";
          }

          // Infer the image type.
          Matcher matcher = Pattern.compile(".*\\.([^\\.]*)").matcher(srcKey);
          if (!matcher.matches()) {
              System.out.println("Unable to infer image type for key "
                      + srcKey);
              return "";
          }
          String imageType = matcher.group(1);
          if (!(JPG_TYPE.equals(imageType)) && !(PNG_TYPE.equals(imageType))) {
              System.out.println("Skipping non-image " + srcKey);
              return "";
          }

          // Download the image from S3 into a stream
```

```
            AmazonS3 s3Client = AmazonS3ClientBuilder.defaultClient();
            S3Object s3Object = s3Client.getObject(new GetObjectRequest(
                    srcBucket, srcKey));
            InputStream objectData = s3Object.getObjectContent();

            // Read the source image
            BufferedImage srcImage = ImageIO.read(objectData);
            int srcHeight = srcImage.getHeight();
            int srcWidth = srcImage.getWidth();
            // Infer the scaling factor to avoid stretching the image
            // unnaturally
            float scalingFactor = Math.min(MAX_WIDTH / srcWidth, MAX_HEIGHT
                    / srcHeight);
            int width = (int) (scalingFactor * srcWidth);
            int height = (int) (scalingFactor * srcHeight);

            BufferedImage resizedImage = new BufferedImage(width, height,
                    BufferedImage.TYPE_INT_RGB);
            Graphics2D g = resizedImage.createGraphics();
            // Fill with white before applying semi-transparent (alpha) images
            g.setPaint(Color.white);
            g.fillRect(0, 0, width, height);
            // Simple bilinear resize
            g.setRenderingHint(RenderingHints.KEY_INTERPOLATION,
                    RenderingHints.VALUE_INTERPOLATION_BILINEAR);
            g.drawImage(srcImage, 0, 0, width, height, null);
            g.dispose();

            // Re-encode image to target format
            ByteArrayOutputStream os = new ByteArrayOutputStream();
            ImageIO.write(resizedImage, imageType, os);
            InputStream is = new ByteArrayInputStream(os.toByteArray());
            // Set Content-Length and Content-Type
            ObjectMetadata meta = new ObjectMetadata();
            meta.setContentLength(os.size());
            if (JPG_TYPE.equals(imageType)) {
                meta.setContentType(JPG_MIME);
            }
            if (PNG_TYPE.equals(imageType)) {
                meta.setContentType(PNG_MIME);
            }

            // Uploading to S3 destination bucket
            System.out.println("Writing to: " + dstBucket + "/" + dstKey);
            try {
                s3Client.putObject(dstBucket, dstKey, is, meta);
            }
            catch(AmazonServiceException e)
            {
                System.err.println(e.getErrorMessage());
                System.exit(1);
            }
            System.out.println("Successfully resized " + srcBucket + "/"
                    + srcKey + " and uploaded to " + dstBucket + "/" + dstKey);
            return "Ok";
        } catch (IOException e) {
            throw new RuntimeException(e);
        }
    }
}
```

# Step 5. Create the deployment package

The deployment package is a .zip file archive (p. 35) containing your Lambda function code and its dependencies.

Node.js

The sample function must include the sharp module in the deployment package.

**To create a deployment package**

1. Open a command line terminal or shell in a Linux environment. Ensure that the Node.js version in your local environment matches the Node.js version of your function.
2. Save the function code as `index.js` in a directory named `lambda-s3`.
3. Install the sharp library with npm. For Linux, use the following command:

   ```
   npm install sharp
   ```

   After this step, you have the following directory structure:

   ```
   lambda-s3
   |- index.js
   |- /node_modules/sharp
   # /node_modules/...
   ```

4. Create a deployment package with the function code and its dependencies. Set the -r (recursive) option for the zip command to compress the subfolders.

   ```
   zip -r function.zip .
   ```

Python

**Dependencies**

- Pillow

**To create a deployment package**

- We recommend using the AWS SAM CLI sam build command with the `--use-container` option to create deployment packages that contain libraries written in C or C++, such as the Pillow (PIL) library.

Java

**Dependencies**

- `aws-lambda-java-core`
- `aws-lambda-java-events`
- `aws-java-sdk`

**To create a deployment package**

- Build the code with the Lambda library dependencies to create a deployment package. For instructions, see Deploy Java Lambda functions with .zip or JAR file archives (p. 386).

# Step 6. Create the Lambda function

### To create the function

- Create a Lambda function with the **create-function** command.

  Node.js

  ```
  aws lambda create-function --function-name CreateThumbnail \
  --zip-file fileb://function.zip --handler index.handler --runtime nodejs12.x \
  --timeout 10 --memory-size 1024 \
  --role arn:aws:iam::123456789012:role/lambda-s3-role
  ```

  The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

  The **create-function** command specifies the function handler as `index.handler`. This handler name reflects the function name as `handler`, and the name of the file where the handler code is stored as `index.js`. For more information, see AWS Lambda function handler in Node.js (p. 285). The command specifies a runtime of `nodejs12.x`. For more information, see Lambda runtimes (p. 82).

  Python

  ```
  aws lambda create-function --function-name CreateThumbnail \
  --zip-file fileb://function.zip --handler lambda_function.lambda_handler --runtime
   python3.8 \
  --timeout 10 --memory-size 1024 \
  --role arn:aws:iam::123456789012:role/lambda-s3-role
  ```

  The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

  The **create-function** command specifies the function handler as `lambda_function.lambda_handler`. This handler name reflects the function name as `lambda_handler`, and the name of the file where the handler code is stored as `lambda_function.py`. For more information, see Lambda function handler in Python (p. 326). The command specifies a runtime of `python3.8`. For more information, see Lambda runtimes (p. 82).

  Java

  ```
  aws lambda create-function --function-name CreateThumbnail \
  --zip-file fileb://function.zip --handler example.handler --runtime java11 \
  --timeout 10 --memory-size 1024 \
  --role arn:aws:iam::123456789012:role/lambda-s3-role
  ```

  The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

  The **create-function** command specifies the function handler as `example.handler`. The function can use the abbreviated handler format of `package.Class` because the function implements a handler interface. For more information, see AWS Lambda function handler in Java (p. 382). The command specifies a runtime of `java11`. For more information, see Lambda runtimes (p. 82).

For the role parameter, replace *123456789012* with your AWS account ID. The preceding example command specifies a 10-second timeout value as the function configuration. Depending on the size of objects that you upload, you might need to increase the timeout value using the following AWS CLI command:

```
aws lambda update-function-configuration --function-name CreateThumbnail --timeout 30
```

## Step 7. Test the Lambda function

Invoke the Lambda function manually using sample Amazon S3 event data.

### To test the Lambda function

1. Save the following Amazon S3 sample event data in a file named `inputFile.txt`. Be sure to replace *sourcebucket* and *HappyFace.jpg* with your source S3 bucket name and a .jpg object key, respectively.

```
{
  "Records":[
    {
      "eventVersion":"2.0",
      "eventSource":"aws:s3",
      "awsRegion":"us-west-2",
      "eventTime":"1970-01-01T00:00:00.000Z",
      "eventName":"ObjectCreated:Put",
      "userIdentity":{
        "principalId":"AIDAJDPLRKLG7UEXAMPLE"
      },
      "requestParameters":{
        "sourceIPAddress":"127.0.0.1"
      },
      "responseElements":{
        "x-amz-request-id":"C3D13FE58DE4C810",
        "x-amz-id-2":"FMyUVURIY8/IgAtTv8xRjskZQpcIZ9KG4V5Wp6S7S/JRWeUWerMUE5JgHvANOjpD"
      },
      "s3":{
        "s3SchemaVersion":"1.0",
        "configurationId":"testConfigRule",
        "bucket":{
          "name":"sourcebucket",
          "ownerIdentity":{
            "principalId":"A3NL1KOZZKExample"
          },
          "arn":"arn:aws:s3:::sourcebucket"
        },
        "object":{
          "key":"HappyFace.jpg",
          "size":1024,
          "eTag":"d41d8cd98f00b204e9800998ecf8427e",
          "versionId":"096fKKXTRTtl3on89fVO.nfljtsv6qko"
        }
      }
    }
  ]
}
```

2. Invoke the function with the following **invoke** command. Note that the command requests asynchronous execution (`--invocation-type Event`). Optionally, you can invoke the function synchronously by specifying `RequestResponse` as the `invocation-type` parameter value.

```
aws lambda invoke
  --function-name CreateThumbnail \
    --invocation-type Event \
      --payload file://inputFile.txt outputfile.txt
```

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

3. Verify that the thumbnail is created in the target S3 bucket.

## Step 8. Configure Amazon S3 to publish events

Complete the configuration so that Amazon S3 can publish object-created events to Lambda and invoke your Lambda function. In this step, you do the following:

- Add permissions to the function access policy to allow Amazon S3 to invoke the function.
- Add a notification configuration to your source S3 bucket. In the notification configuration, you provide the following:
  - The event type for which you want Amazon S3 to publish events. For this tutorial, specify the `s3:ObjectCreated:*` event type so that Amazon S3 publishes events when objects are created.
  - The function to invoke.

### To add permissions to the function policy

1. Run the following **add-permission** command to grant Amazon S3 service principal (`s3.amazonaws.com`) permissions to perform the `lambda:InvokeFunction` action. Note that Amazon S3 is granted permission to invoke the function only if the following conditions are met:
   - An object-created event is detected on a specific S3 bucket.
   - The S3 bucket is owned by your AWS account. If you delete a bucket, it is possible for another AWS account to create a bucket with the same Amazon Resource Name (ARN).

```
aws lambda add-permission --function-name CreateThumbnail --principal s3.amazonaws.com
 \
--statement-id s3invoke --action "lambda:InvokeFunction" \
--source-arn arn:aws:s3:::sourcebucket \
--source-account account-id
```

2. Verify the function's access policy by running the **get-policy** command.

```
aws lambda get-policy --function-name CreateThumbnail
```

To have Amazon S3 publish object-created events to Lambda, add a notification configuration on the source S3 bucket.

**Important**
This procedure configures the S3 bucket to invoke your function every time that an object is created in the bucket. Be sure to configure this option only on the source bucket. Do not have your function create objects in the source bucket, or your function could cause itself to be invoked continuously in a loop (p. 663).

### To configure notifications

1. Open the Amazon S3 console.

2. Choose the name of the source S3 bucket.
3. Choose the **Properties** tab.
4. Under **Event notifications**, choose **Create event notification** to configure a notification with the following settings:

   - **Event name** – `lambda-trigger`
   - **Event types** – `All object create events`
   - **Destination** – `Lambda function`
   - **Lambda function** – `CreateThumbnail`

For more information on event configuration, see Enabling and configuring event notifications using the Amazon S3 console in the *Amazon Simple Storage Service User Guide*.

## Step 9. Test using the S3 trigger

Test the setup as follows:

1. Upload .jpg or .png objects to the source S3 bucket using the Amazon S3 console.
2. Verify for each image object that a thumbnail is created in the target S3 bucket using the `CreateThumbnail` Lambda function.
3. View logs in the CloudWatch console.

## Step 10. Clean up your resources

You can now delete the resources that you created for this tutorial, unless you want to retain them. By deleting AWS resources that you're no longer using, you prevent unnecessary charges to your AWS account.

### To delete the Lambda function

1. Open the Functions page of the Lambda console.
2. Select the function that you created.
3. Choose **Actions**, then choose **Delete**.
4. Choose **Delete**.

### To delete the policy that you created

1. Open the Policies page of the IAM console.
2. Select the policy that you created (**AWSLambdaS3Policy**).
3. Choose **Policy actions**, **Delete**.
4. Choose **Delete**.

### To delete the execution role

1. Open the Roles page of the IAM console.
2. Select the execution role that you created.
3. Choose **Delete role**.
4. Choose **Yes, delete**.

### To delete the S3 bucket

1. Open the Amazon S3 console.
2. Select the bucket you created.
3. Choose **Delete**.
4. Enter the name of the bucket in the text box.
5. Choose **Confirm**.

# AWS SAM template for an Amazon S3 application

You can build this application using AWS SAM. To learn more about creating AWS SAM templates, see AWS SAM template basics in the *AWS Serverless Application Model Developer Guide*.

Below is a sample AWS SAM template for the Lambda application from the tutorial (p. 664). Copy the text below to a .yaml file and save it next to the ZIP package you created previously. Note that the `Handler` and `Runtime` parameter values should match the ones you used when you created the function in the previous section.

### Example template.yaml

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Resources:
  CreateThumbnail:
    Type: AWS::Serverless::Function
    Properties:
      Handler: handler
      Runtime: runtime
      Timeout: 60
      Policies: AWSLambdaExecute
      Events:
        CreateThumbnailEvent:
          Type: S3
          Properties:
            Bucket: !Ref SrcBucket
            Events: s3:ObjectCreated:*

  SrcBucket:
    Type: AWS::S3::Bucket
```

For information on how to package and deploy your serverless application using the package and deploy commands, see Deploying serverless applications in the *AWS Serverless Application Model Developer Guide*.

# Using AWS Lambda with Amazon S3 batch operations

You can use Amazon S3 batch operations to invoke a Lambda function on a large set of Amazon S3 objects. Amazon S3 tracks the progress of batch operations, sends notifications, and stores a completion report that shows the status of each action.

To run a batch operation, you create an Amazon S3 batch operations job. When you create the job, you provide a manifest (the list of objects) and configure the action to perform on those objects.

When the batch job starts, Amazon S3 invokes the Lambda function synchronously (p. 225) for each object in the manifest. The event parameter includes the names of the bucket and the object.

The following example shows the event that Amazon S3 sends to the Lambda function for an object that is named **customerImage1.jpg** in the **examplebucket** bucket.

**Example Amazon S3 batch request event**

```
{
"invocationSchemaVersion": "1.0",
    "invocationId": "YXNkbGZqYWRmaiBhc2RmdW9hZHNmZGpmaGFzbGtkaGZza2RmaAo",
    "job": {
        "id": "f3cc4f60-61f6-4a2b-8a21-d07600c373ce"
    },
    "tasks": [
        {
            "taskId": "dGFza2lkZ29lc2hlcmUK",
            "s3Key": "customerImage1.jpg",
            "s3VersionId": "1",
            "s3BucketArn": "arn:aws:s3:us-east-1:0123456788:examplebucket"
        }
    ]
}
```

Your Lambda function must return a JSON object with the fields as shown in the following example. You can copy the `invocationId` and `taskId` from the event parameter. You can return a string in the `resultString`. Amazon S3 saves the `resultString` values in the completion report.

**Example Amazon S3 batch request response**

```
{
  "invocationSchemaVersion": "1.0",
  "treatMissingKeysAs" : "PermanentFailure",
  "invocationId" : "YXNkbGZqYWRmaiBhc2RmdW9hZHNmZGpmaGFzbGtkaGZza2RmaAo",
  "results": [
    {
      "taskId": "dGFza2lkZ29lc2hlcmUK",
      "resultCode": "Succeeded",
      "resultString": "["Alice", "Bob"]"
    }
  ]
}
```

# Invoking Lambda functions from Amazon S3 batch operations

You can invoke the Lambda function with an unqualified or qualified function ARN. If you want to use the same function version for the entire batch job, configure a specific function version in the `FunctionARN` parameter when you create your job. If you configure an alias or the $LATEST qualifier, the batch job immediately starts calling the new version of the function if the alias or $LATEST is updated during the job execution.

Note that you can't reuse an existing Amazon S3 event-based function for batch operations. This is because the Amazon S3 batch operation passes a different event parameter to the Lambda function and expects a return message with a specific JSON structure.

In the resource-based policy (p. 68) that you create for the Amazon S3 batch job, ensure that you set permission for the job to invoke your Lambda function.

In the execution role for the function, set a trust policy for Amazon S3 to assume the role when it runs your function.

If your function uses the AWS SDK to manage Amazon S3 resources, you need to add Amazon S3 permissions in the execution role.

When the job runs, Amazon S3 starts multiple function instances to process the Amazon S3 objects in parallel, up to the concurrency limit (p. 30) of the function. Amazon S3 limits the initial ramp-up of instances to avoid excess cost for smaller jobs.

If the Lambda function returns a `TemporaryFailure` response code, Amazon S3 retries the operation.

For more information about Amazon S3 batch operations, see Performing batch operations in the *Amazon S3 Developer Guide*.

For an example of how to use a Lambda function in Amazon S3 batch operations, see Invoking a Lambda function from Amazon S3 batch operations in the *Amazon S3 Developer Guide*.

# Transforming S3 Objects with S3 Object Lambda

With S3 Object Lambda you can add your own code to Amazon S3 GET, HEAD, and LIST requests to modify and process data before it is returned to an application. You can use custom code to modify the data returned by standard S3 GET, HEAD, or LIST requests to filter rows, dynamically resize images, redact confidential data, and more. Powered by AWS Lambda functions, your code runs on infrastructure that is fully managed by AWS, eliminating the need to create and store derivative copies of your data or to run proxies, all with no changes required to applications.

For more information, see Transforming objects with S3 Object Lambda.

**Tutorials**

- Transforming data for your application with Amazon S3 Object Lambda
- Detecting and redacting PII data with Amazon S3 Object Lambda and Amazon Comprehend

# Using AWS Lambda with Secrets Manager

Secrets Manager uses a Lambda function to rotate the secret for a secured service or database. You can customize the Lambda function to implement the service-specific details of rotating a secret.

Secrets Manager invokes the Lambda rotation function as a synchronous invocation. The event parameter contains the following fields:

```
{
  "Step" : "request.type",
  "SecretId" : "string",
  "ClientRequestToken" : "string"
}
```

For more information about using Lambda with Secrets Manager, see Understanding Your Lambda rotation function.

# Using AWS Lambda with Amazon SES

When you use Amazon SES to receive messages, you can configure Amazon SES to call your Lambda function when messages arrive. The service can then invoke your Lambda function by passing in the incoming email event, which in reality is an Amazon SES message in an Amazon SNS event, as a parameter.

**Example Amazon SES message event**

```
{
  "Records": [
    {
      "eventVersion": "1.0",
      "ses": {
        "mail": {
          "commonHeaders": {
            "from": [
              "Jane Doe <janedoe@example.com>"
            ],
            "to": [
              "johndoe@example.com"
            ],
            "returnPath": "janedoe@example.com",
            "messageId": "<0123456789example.com>",
            "date": "Wed, 7 Oct 2015 12:34:56 -0700",
            "subject": "Test Subject"
          },
          "source": "janedoe@example.com",
          "timestamp": "1970-01-01T00:00:00.000Z",
          "destination": [
            "johndoe@example.com"
          ],
          "headers": [
            {
              "name": "Return-Path",
              "value": "<janedoe@example.com>"
            },
            {
              "name": "Received",
              "value": "from mailer.example.com (mailer.example.com [203.0.113.1]) by
 inbound-smtp.us-west-2.amazonaws.com with SMTP id o3vrnil0e2ic for johndoe@example.com;
 Wed, 07 Oct 2015 12:34:56 +0000 (UTC)"
            },
            {
              "name": "DKIM-Signature",
              "value": "v=1; a=rsa-sha256; c=relaxed/relaxed; d=example.com;
 s=example; h=mime-version:from:date:message-id:subject:to:content-type;
 bh=jX3F0bCAI7sIbkHyy3mLYO28ieDQz2R0P8HwQkklFj4=; b=sQwJ+LMe9RjkesGu+vqU56asvMhrLRRYrWCbV"
            },
            {
              "name": "MIME-Version",
              "value": "1.0"
            },
            {
              "name": "From",
              "value": "Jane Doe <janedoe@example.com>"
            },
            {
              "name": "Date",
              "value": "Wed, 7 Oct 2015 12:34:56 -0700"
            },
            {
              "name": "Message-ID",
```

```
            "value": "<0123456789example.com>"
          },
          {
            "name": "Subject",
            "value": "Test Subject"
          },
          {
            "name": "To",
            "value": "johndoe@example.com"
          },
          {
            "name": "Content-Type",
            "value": "text/plain; charset=UTF-8"
          }
        ],
        "headersTruncated": false,
        "messageId": "o3vrnil0e2ic28tr"
      },
      "receipt": {
        "recipients": [
          "johndoe@example.com"
        ],
        "timestamp": "1970-01-01T00:00:00.000Z",
        "spamVerdict": {
          "status": "PASS"
        },
        "dkimVerdict": {
          "status": "PASS"
        },
        "processingTimeMillis": 574,
        "action": {
          "type": "Lambda",
          "invocationType": "Event",
          "functionArn": "arn:aws:lambda:us-west-2:111122223333:function:Example"
        },
        "spfVerdict": {
          "status": "PASS"
        },
        "virusVerdict": {
          "status": "PASS"
        }
      }
    },
    "eventSource": "aws:ses"
  }
 ]
}
```

For more information, see Lambda action in the *Amazon SES Developer Guide*.

# Using AWS Lambda with Amazon SNS

You can use a Lambda function to process Amazon Simple Notification Service (Amazon SNS) notifications. Amazon SNS supports Lambda functions as a target for messages sent to a topic. You can subscribe your function to topics in the same account or in other AWS accounts.

Amazon SNS invokes your function asynchronously (p. 228) with an event that contains a message and metadata.

**Example Amazon SNS message event**

```
{
  "Records": [
    {
      "EventVersion": "1.0",
      "EventSubscriptionArn": "arn:aws:sns:us-east-2:123456789012:sns-lambda:21be56ed-
a058-49f5-8c98-aedd2564c486",
      "EventSource": "aws:sns",
      "Sns": {
        "SignatureVersion": "1",
        "Timestamp": "2019-01-02T12:45:07.000Z",
        "Signature": "tcc6faL2yUC6dgZdmrwh1Y4cGa/ebXEkAi6RibDsvpi+tE/1+82j...65r==",
        "SigningCertUrl": "https://sns.us-east-2.amazonaws.com/SimpleNotificationService-
ac565b8b1a6c5d002d285f9598aa1d9b.pem",
        "MessageId": "95df01b4-ee98-5cb9-9903-4c221d41eb5e",
        "Message": "Hello from SNS!",
        "MessageAttributes": {
          "Test": {
            "Type": "String",
            "Value": "TestString"
          },
          "TestBinary": {
            "Type": "Binary",
            "Value": "TestBinary"
          }
        },
        "Type": "Notification",
        "UnsubscribeUrl": "https://sns.us-east-2.amazonaws.com/?
Action=Unsubscribe&amp;SubscriptionArn=arn:aws:sns:us-east-2:123456789012:test-
lambda:21be56ed-a058-49f5-8c98-aedd2564c486",
        "TopicArn":"arn:aws:sns:us-east-2:123456789012:sns-lambda",
        "Subject": "TestInvoke"
      }
    }
  ]
}
```

For asynchronous invocation, Lambda queues the message and handles retries. If Amazon SNS can't reach Lambda or the message is rejected, Amazon SNS retries at increasing intervals over several hours. For details, see Reliability in the Amazon SNS FAQs.

To perform cross-account Amazon SNS deliveries to Lambda, you must authorize Amazon SNS to invoke your Lambda function. In turn, Amazon SNS must allow the AWS account with the Lambda function to subscribe to the Amazon SNS topic. For example, if the Amazon SNS topic is in account A and the Lambda function is in account B, both accounts must grant permissions to the other to access their respective resources. Since not all the options for setting up cross-account permissions are available from the AWS Management Console, you must use the AWS Command Line Interface (AWS CLI) for setup.

For more information, see Fanout to Lambda functions in the *Amazon Simple Notification Service Developer Guide*.

### Input types for Amazon SNS events

For input type examples for Amazon SNS events in Java, .NET, and Go, see the following on the AWS GitHub repository:

- SNSEvent.java
- SNSEvent.cs
- sns.go

### Topics

- Tutorial: Using AWS Lambda with Amazon Simple Notification Service (p. 690)
- Sample function code (p. 694)

# Tutorial: Using AWS Lambda with Amazon Simple Notification Service

You can use a Lambda function in one AWS account to subscribe to an Amazon SNS topic in a separate AWS account. In this tutorial, you use the AWS Command Line Interface to perform AWS Lambda operations such as creating a Lambda function, creating an Amazon SNS topic and granting permissions to allow these two resources to access each other.

## Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

In the tutorial, you use two accounts. The AWS CLI commands illustrate this by using two named profiles, each configured for use with a different account. If you use profiles with different names, or the default profile and one named profile, modify the commands as needed.

## Create an Amazon SNS topic (account A)

In **Account A**, create the source Amazon SNS topic.

```
aws sns create-topic --name sns-topic-for-lambda --profile accountA
```

After creating the topic, record its Amazon Resource Name (ARN). You need it later when you add permissions to the Lambda function to subscribe to the topic.

## Create the execution role (account B)

In **Account B**, create the execution role (p. 52) that gives your function permission to access AWS resources.

### To create an execution role

1. Open the roles page in the IAM console.
2. Choose **Create role**.
3. Create a role with the following properties.
   - **Trusted entity** – **AWS Lambda**.
   - **Permissions** – **AWSLambdaBasicExecutionRole**.
   - **Role name** – **`lambda-sns-role`**.

The **AWSLambdaBasicExecutionRole** policy has the permissions that the function needs to write logs to CloudWatch Logs.

## Create a Lambda function (account B)

In **Account B**, create the function that processes events from Amazon SNS. The following example code receives an Amazon SNS event input and processes the messages that it contains. For illustration, the code writes some of the incoming event data to CloudWatch Logs.

> **Note**
> For sample code in other languages, see Sample function code (p. 694).

### Example index.js

```
console.log('Loading function');

exports.handler = function(event, context, callback) {
// console.log('Received event:', JSON.stringify(event, null, 4));

    var message = event.Records[0].Sns.Message;
    console.log('Message received from SNS:', message);
    callback(null, "Success");
};
```

### To create the function

1. Copy the sample code into a file named `index.js`.
2. Create a deployment package.

```
zip function.zip index.js
```

3. Create a Lambda function with the `create-function` command.

```
aws lambda create-function --function-name Function-With-SNS \
--zip-file fileb://function.zip --handler index.handler --runtime nodejs12.x \
--role arn:aws:iam::<AccountB_ID>:role/lambda-sns-role  \
--timeout 60 --profile accountB
```

After creating the function, record its function ARN. You need it later when you add permissions to allow Amazon SNS to invoke your function.

## Set up cross-account permissions (account A and B)

In **Account A**, grant permission to **Account B** to subscribe to the topic:

```
aws sns add-permission --label lambda-access --aws-account-id <AccountB_ID> \
--topic-arn arn:aws:sns:us-east-2:<AccountA_ID>:sns-topic-for-lambda \
--action-name Subscribe ListSubscriptionsByTopic --profile accountA
```

In **Account B**, add the Lambda permission to allow invocation from Amazon SNS.

```
aws lambda add-permission --function-name Function-With-SNS \
--source-arn arn:aws:sns:us-east-2:<AccountA_ID>:sns-topic-for-lambda \
--statement-id function-with-sns --action "lambda:InvokeFunction" \
--principal sns.amazonaws.com --profile accountB
```

You should see the following output:

```
{
    "Statement": "{\"Condition\":{\"ArnLike\":{\"AWS:SourceArn\":
      \"arn:aws:sns:us-east-2:<AccountA_ID>:sns-topic-for-lambda\"}},
      \"Action\":[\"lambda:InvokeFunction\"],
      \"Resource\":\"arn:aws:lambda:us-east-2:<AccountB_ID>:function:Function-With-SNS\",
      \"Effect\":\"Allow\",\"Principal\":{\"Service\":\"sns.amazonaws.com\"},
      \"Sid\":\"function-with-sns1\"}"
}
```

Do not use the `--source-account` parameter to add a source account to the Lambda policy when adding the policy. Source account is not supported for Amazon SNS event sources and will result in access being denied.

> **Note**
> If the account with the SNS topic is hosted in an opt-in region, you need to specify the region in the principal. For example, if you're working with an SNS topic in the Asia Pacific (Hong Kong) region, you need to specify `sns.ap-east-1.amazonaws.com` instead of `sns.amazonaws.com` for the principal.

## Create a subscription (account B)

In **Account B**, subscribe the Lambda function to the topic. When a message is sent to the `sns-topic-for-lambda` topic in **Account A**, Amazon SNS invokes the `Function-With-SNS` function in **Account B**.

```
aws sns subscribe --protocol lambda \
--topic-arn arn:aws:sns:us-east-2:<AccountA_ID>:sns-topic-for-lambda \
--notification-endpoint arn:aws:lambda:us-east-2:<AccountB_ID>:function:Function-With-SNS \
--profile accountB
```

You should see the following output:

```
{
    "SubscriptionArn": "arn:aws:sns:us-east-2:<AccountA_ID>:sns-topic-for-
lambda:5d906xxxx-7c8x-45dx-a9dx-0484e31c98xx"
}
```

The output contains the ARN of the topic subscription.

## Test subscription (account A)

In **Account A**, test the subscription. Type `Hello World` into a text file and save it as `message.txt`. Then run the following command:

```
aws sns publish --message file://message.txt --subject Test \
--topic-arn arn:aws:sns:us-east-2:<AccountA_ID>:sns-topic-for-lambda \
--profile accountA
```

This will return a message id with a unique identifier, indicating the message has been accepted by the Amazon SNS service. Amazon SNS will then attempt to deliver it to the topic's subscribers. Alternatively, you could supply a JSON string directly to the `message` parameter, but using a text file allows for line breaks in the message.

To learn more about Amazon SNS, see What is Amazon Simple Notification Service.

## Clean up your resources

You can now delete the resources that you created for this tutorial, unless you want to retain them. By deleting AWS resources that you're no longer using, you prevent unnecessary charges to your AWS account.

In **Account A**, clean up your Amazon SNS topic.

### To delete the Amazon SNS topic

1. Open the Topics page of the Amazon SNS console.
2. Select the topic you created.
3. Choose **Delete**.
4. Enter **`delete me`** in the text box.
5. Choose **Delete**.

In **Account B**, clean up your execution role, Lambda function, and Amazon SNS subscription.

### To delete the execution role

1. Open the Roles page of the IAM console.
2. Select the execution role that you created.
3. Choose **Delete role**.
4. Choose **Yes, delete**.

### To delete the Lambda function

1. Open the Functions page of the Lambda console.
2. Select the function that you created.
3. Choose **Actions**, then choose **Delete**.
4. Choose **Delete**.

### To delete the Amazon SNS subscription

1. Open the Subscriptions page of the Amazon SNS console.

2. Select the subscription you created.
3. Choose **Delete**, **Delete**.

# Sample function code

Sample code is available for the following languages.

**Topics**


- Node.js 12.x (p. 694)
- Java 11 (p. 694)
- Go (p. 695)
- Python 3 (p. 695)


## Node.js 12.x

The following example processes messages from Amazon SNS, and logs their contents.

**Example index.js**

```
console.log('Loading function');

exports.handler = function(event, context, callback) {
// console.log('Received event:', JSON.stringify(event, null, 4));

    var message = event.Records[0].Sns.Message;
    console.log('Message received from SNS:', message);
    callback(null, "Success");
};
```

Zip up the sample code to create a deployment package. For instructions, see Deploy Node.js Lambda functions with .zip file archives (p. 288).

## Java 11

The following example processes messages from Amazon SNS, and logs their contents.

**Example LogEvent.java**

```
package example;

import java.text.SimpleDateFormat;
import java.util.Calendar;

import com.amazonaws.services.lambda.runtime.RequestHandler;
import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.services.lambda.runtime.events.SNSEvent;

public class LogEvent implements RequestHandler<SNSEvent, Object> {
    public Object handleRequest(SNSEvent request, Context context){
    String timeStamp = new SimpleDateFormat("yyyy-MM-
dd_HH:mm:ss").format(Calendar.getInstance().getTime());
    context.getLogger().log("Invocation started: " + timeStamp);
    context.getLogger().log(request.getRecords().get(0).getSNS().getMessage());

    timeStamp = new SimpleDateFormat("yyyy-MM-
dd_HH:mm:ss").format(Calendar.getInstance().getTime());
```

```
    context.getLogger().log("Invocation completed: " + timeStamp);
           return null;
     }
}
```

**Dependencies**

- `aws-lambda-java-core`
- `aws-lambda-java-events`

Build the code with the Lambda library dependencies to create a deployment package. For instructions, see Deploy Java Lambda functions with .zip or JAR file archives (p. 386).

## Go

The following example processes messages from Amazon SNS, and logs their contents.

**Example lambda_handler.go**

```
package main

import (
    "context"
    "fmt"
    "github.com/aws/aws-lambda-go/lambda"
    "github.com/aws/aws-lambda-go/events"
)

func handler(ctx context.Context, snsEvent events.SNSEvent) {
    for _, record := range snsEvent.Records {
        snsRecord := record.SNS
        fmt.Printf("[%s %s] Message = %s \n", record.EventSource, snsRecord.Timestamp,
 snsRecord.Message)
    }
}

func main() {
    lambda.Start(handler)
}
```

Build the executable with `go build` and create a deployment package. For instructions, see Deploy Go Lambda functions with .zip file archives (p. 427).

## Python 3

The following example processes messages from Amazon SNS, and logs their contents.

**Example lambda_handler.py**

```
from __future__ import print_function
import json
print('Loading function')

def lambda_handler(event, context):
    #print("Received event: " + json.dumps(event, indent=2))
    message = event['Records'][0]['Sns']['Message']
    print("From SNS: " + message)
    return message
```

Zip up the sample code to create a deployment package. For instructions, see Deploy Python Lambda functions with .zip file archives (p. 330).

# Using Lambda with Amazon SQS

You can use a Lambda function to process messages in an Amazon Simple Queue Service (Amazon SQS) queue. Lambda event source mappings (p. 236) support standard queues and first-in, first-out (FIFO) queues. With Amazon SQS, you can offload tasks from one component of your application by sending them to a queue and processing them asynchronously.

Lambda polls the queue and invokes your Lambda function synchronously (p. 225) with an event that contains queue messages. Lambda reads messages in batches and invokes your function once for each batch. When your function successfully processes a batch, Lambda deletes its messages from the queue. The following example shows an event for a batch of two messages.

**Example Amazon SQS message event (standard queue)**

```
{
    "Records": [
        {
            "messageId": "059f36b4-87a3-44ab-83d2-661975830a7d",
            "receiptHandle": "AQEBwJnKyrHigUMZj6rYigCgxlaS3SLy0a...",
            "body": "Test message.",
            "attributes": {
                "ApproximateReceiveCount": "1",
                "SentTimestamp": "1545082649183",
                "SenderId": "AIDAIENQZJOLO23YVJ4VO",
                "ApproximateFirstReceiveTimestamp": "1545082649185"
            },
            "messageAttributes": {},
            "md5OfBody": "e4e68fb7bd0e697a0ae8f1bb342846b3",
            "eventSource": "aws:sqs",
            "eventSourceARN": "arn:aws:sqs:us-east-2:123456789012:my-queue",
            "awsRegion": "us-east-2"
        },
        {
            "messageId": "2e1424d4-f796-459a-8184-9c92662be6da",
            "receiptHandle": "AQEBzWwaftRI0KuVm4tP+/7q1rGgNqicHq...",
            "body": "Test message.",
            "attributes": {
                "ApproximateReceiveCount": "1",
                "SentTimestamp": "1545082650636",
                "SenderId": "AIDAIENQZJOLO23YVJ4VO",
                "ApproximateFirstReceiveTimestamp": "1545082650649"
            },
            "messageAttributes": {},
            "md5OfBody": "e4e68fb7bd0e697a0ae8f1bb342846b3",
            "eventSource": "aws:sqs",
            "eventSourceARN": "arn:aws:sqs:us-east-2:123456789012:my-queue",
            "awsRegion": "us-east-2"
        }
    ]
}
```

By default, Lambda polls up to 10 messages in your queue at once and sends that batch to your function. To avoid invoking the function with a small number of records, you can tell the event source to buffer records for up to 5 minutes by configuring a batch window. Before invoking the function, Lambda continues to poll messages from the SQS standard queue until the batch window expires, the invocation payload size quota (p. 796) is reached, or the configured maximum batch size is reached.

> **Note**
> If you're using a batch window and your SQS queue contains very low traffic, Lambda might wait for up to 20 seconds before invoking your function. This is true even if you set a batch window lower than 20 seconds.

For FIFO queues, records contain additional attributes that are related to deduplication and sequencing.

**Example Amazon SQS message event (FIFO queue)**

```
{
    "Records": [
        {
            "messageId": "11d6ee51-4cc7-4302-9e22-7cd8afdaadf5",
            "receiptHandle": "AQEBBX8nesZEXmkhsmZeyIE8iQAMig7qw...",
            "body": "Test message.",
            "attributes": {
                "ApproximateReceiveCount": "1",
                "SentTimestamp": "1573251510774",
                "SequenceNumber": "18849496460467696128",
                "MessageGroupId": "1",
                "SenderId": "AIDAIO23YVJENQZJOL4VO",
                "MessageDeduplicationId": "1",
                "ApproximateFirstReceiveTimestamp": "1573251510774"
            },
            "messageAttributes": {},
            "md5OfBody": "e4e68fb7bd0e697a0ae8f1bb342846b3",
            "eventSource": "aws:sqs",
            "eventSourceARN": "arn:aws:sqs:us-east-2:123456789012:fifo.fifo",
            "awsRegion": "us-east-2"
        }
    ]
}
```

When Lambda reads a batch, the messages stay in the queue but are hidden for the length of the queue's visibility timeout. If your function successfully processes the batch, Lambda deletes the messages from the queue. By default, if your function encounters an error while processing a batch, all messages in that batch become visible in the queue again. For this reason, your function code must be able to process the same message multiple times without unintended side effects. You can modify this reprocessing behavior by including batch item failures in your function response.

**Sections**


- Scaling and processing (p. 698)
- Configuring a queue to use with Lambda (p. 699)
- Execution role permissions (p. 699)
- Configuring a queue as an event source (p. 699)
- Event source mapping APIs (p. 701)
- Reporting batch item failures (p. 701)
- Amazon SQS configuration parameters (p. 703)
- Tutorial: Using Lambda with Amazon SQS (p. 704)
- Tutorial: Using a cross-account Amazon SQS queue as an event source (p. 707)
- Sample Amazon SQS function code (p. 711)
- AWS SAM template for an Amazon SQS application (p. 714)


# Scaling and processing

For standard queues, Lambda uses long polling to poll a queue until it becomes active. When messages are available, Lambda reads up to five batches and sends them to your function. If messages are still available, Lambda increases the number of processes that are reading batches by up to 60 more instances per minute. The maximum number of batches that an event source mapping can process simultaneously is 1,000.

For FIFO queues, Lambda sends messages to your function in the order that it receives them. When you send a message to a FIFO queue, you specify a message group ID. Amazon SQS ensures that messages in the same group are delivered to Lambda in order. Lambda sorts the messages into groups and sends only one batch at a time for a group. If your function returns an error, the function attempts all retries on the affected messages before Lambda receives additional messages from the same group.

Your function can scale in concurrency to the number of active message groups. For more information, see SQS FIFO as an event source on the AWS Compute Blog.

# Configuring a queue to use with Lambda

Create an SQS queue to serve as an event source for your Lambda function. Then configure the queue to allow time for your Lambda function to process each batch of events—and for Lambda to retry in response to throttling errors as it scales up.

To allow your function time to process each batch of records, set the source queue's visibility timeout to at least six times the timeout that you configure (p. 163) on your function. The extra time allows for Lambda to retry if your function is throttled while processing a previous batch.

If your function fails to process a message multiple times, Amazon SQS can send it to a dead-letter queue. When your function returns an error, Lambda leaves it in the queue. After the visibility timeout occurs, Lambda receives the message again. To send messages to a second queue after a number of receives, configure a dead-letter queue on your source queue.

> **Note**
> Make sure that you configure the dead-letter queue on the source queue, not on the Lambda function. The dead-letter queue that you configure on a function is used for the function's asynchronous invocation queue (p. 228), not for event source queues.

If your function returns an error, or can't be invoked because it's at maximum concurrency, processing might succeed with additional attempts. To give messages a better chance to be processed before sending them to the dead-letter queue, set the `maxReceiveCount` on the source queue's redrive policy to at least **5**.

# Execution role permissions

Lambda needs the following permissions to manage messages in your Amazon SQS queue. Add them to your function's execution role (p. 52).

- sqs:ReceiveMessage
- sqs:DeleteMessage
- sqs:GetQueueAttributes

# Configuring a queue as an event source

Create an event source mapping to tell Lambda to send items from your queue to a Lambda function. You can create multiple event source mappings to process items from multiple queues with a single function. When Lambda invokes the target function, the event can contain multiple items, up to a configurable maximum *batch size*.

To configure your function to read from Amazon SQS in the Lambda console, create an **SQS** trigger.

**To create a trigger**

1. Open the Functions page of the Lambda console.

2. Choose the name of a function.
3. Under **Function overview**, choose **Add trigger**.
4. Choose the **SQS** trigger type.
5. Configure the required options, and then choose **Add**.

Lambda supports the following options for Amazon SQS event sources.

### Event source options

- **SQS queue** – The Amazon SQS queue to read records from.
- **Batch size** – The number of records to send to the function in each batch. For a standard queue, this can be up to 10,000 records. For a FIFO queue, the maximum is 10. For a batch size over 10, you must also set the `MaximumBatchingWindowInSeconds` parameter to at least 1 second. Lambda passes all of the records in the batch to the function in a single call, as long as the total size of the events doesn't exceed the invocation payload size quota (p. 796) for synchronous invocation (6 MB).

  Both Lambda and Amazon SQS generate metadata for each record. This additional metadata is counted towards the total payload size and can cause the total number of records sent in a batch to be lower than your configured batch size. The metadata fields that Amazon SQS sends can be variable in length. For more information about the Amazon SQS metadata fields, see the ReceiveMessage API operation documentation in the *Amazon Simple Queue Service API Reference*.
- **Batch window** – The maximum amount of time to gather records before invoking the function, in seconds. This applies only to standard queues.

  If you're using a batch window greater than 0 seconds, you must account for the increased processing time in your queue visibility timeout. We recommend setting your queue visibility timeout to six times your function timeout, plus the value of `MaximumBatchingWindowInSeconds`. This allows time for your Lambda function to process each batch of events and to retry in the event of a throttling error.

  > **Note**
  > If your batch window is greater than 0, and `(batch window) + (function timeout) > (queue visibility timeout)`, then your effective queue visibility timeout is `(batch window) + (function timeout) + 30s`.

  Lambda processes up to five batches at a time. This means that there are a maximum of five workers available to batch and process messages in parallel at any one time. If messages are still available, Lambda increases the number of processes that are reading batches by up to 60 more instances per minute. The maximum number of batches that an event source mapping can process simultaneously is 1,000. For more information, see Scaling and processing (p. 698).
- **Enabled** – The status of the event source mapping. Set to true to enable the event source mapping. Set to false to stop processing records.

> **Note**
> Amazon SQS has a perpetual free tier for requests. Beyond the free tier, Amazon SQS charges per million requests. While your event source mapping is active, Lambda makes requests to the queue to get items. For pricing details, see Amazon SQS pricing.

To manage the event source configuration later, in the Lambda console, choose the **SQS** trigger in the designer.

Configure your function timeout to allow enough time to process an entire batch of items. If items take a long time to process, choose a smaller batch size. A large batch size can improve efficiency for workloads that are very fast or have a lot of overhead. However, if your function returns an error, all items in the batch return to the queue. If you configure reserved concurrency (p. 180) on your function, set a minimum of five concurrent executions to reduce the chance of throttling errors when Lambda

invokes your function. To eliminate the chance of throttling errors, set the reserved concurrency value to 1,000, which is the maximum number of concurrent executions for an Amazon SQS event source.

# Event source mapping APIs

To manage an event source with the AWS Command Line Interface (AWS CLI) or an AWS SDK, you can use the following API operations:

- CreateEventSourceMapping (p. 893)
- ListEventSourceMappings (p. 1006)
- GetEventSourceMapping (p. 952)
- UpdateEventSourceMapping (p. 1078)
- DeleteEventSourceMapping (p. 925)

The following example uses the AWS CLI to map a function named `my-function` to an Amazon SQS queue that is specified by its Amazon Resource Name (ARN), with a batch size of 5 and a batch window of 60 seconds.

```
aws lambda create-event-source-mapping --function-name my-function --batch-size 5 \
--maximum-batching-window-in-seconds 60 \
--event-source-arn arn:aws:sqs:us-east-2:123456789012:my-queue
```

You should see the following output:

```
{
    "UUID": "2b733gdc-8ac3-cdf5-af3a-1827b3b11284",
    "BatchSize": 5,
    "MaximumBatchingWindowInSeconds": 60,
    "EventSourceArn": "arn:aws:sqs:us-east-2:123456789012:my-queue",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "LastModified": 1541139209.351,
    "State": "Creating",
    "StateTransitionReason": "USER_INITIATED"
}
```

# Reporting batch item failures

When your Lambda function encounters an error while processing a batch, all messages in that batch become visible in the queue again by default, including messages that Lambda processed successfully. As a result, your function can end up processing the same message several times.

To avoid reprocessing all messages in a failed batch, you can configure your event source mapping to make only the failed messages visible again. To do this, when configuring your event source mapping, include the value `ReportBatchItemFailures` in the `FunctionResponseTypes` list. This lets your function return a partial success, which can help reduce the number of unnecessary retries on records.

## Report syntax

After you include `ReportBatchItemFailures` in your event source mapping configuration, you can return a list of the failed message IDs in your function response. For example, suppose you have a batch of five messages, with message IDs `id1`, `id2`, `id3`, `id4`, and `id5`. Your function successfully processes `id1`, `id3`, and `id5`. To make messages `id2` and `id4` visible again in your queue, your response syntax should look like the following:

```
{
  "batchItemFailures": [
        {
            "itemIdentifier": "id2"
        },
        {
            "itemIdentifier": "id4"
        }
    ]
}
```

To return the list of failed message IDs in the batch, you can use a `SQSBatchResponse` class object or create your own custom class. Here is an example of a response that uses the `SQSBatchResponse` object.

```
import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.services.lambda.runtime.RequestHandler;
import com.amazonaws.services.lambda.runtime.events.SQSEvent;
import com.amazonaws.services.lambda.runtime.events.SQSBatchResponse;

import java.util.ArrayList;
import java.util.List;

public class ProcessSQSMessageBatch implements RequestHandler<SQSEvent, SQSBatchResponse> {
    @Override
    public SQSBatchResponse handleRequest(SQSEvent sqsEvent, Context context) {

        List<SQSBatchResponse.BatchItemFailure> batchItemFailures = new
 ArrayList<SQSBatchResponse.BatchItemFailure>();
        String messageId = "";
        for (SQSEvent.SQSMessage message : sqsEvent.getRecords()) {
            try {
                //process your message
                messageId = message.getMessageId();
            } catch (Exception e) {
                //Add failed message identifier to the batchItemFailures list
                batchItemFailures.add(new SQSBatchResponse.BatchItemFailure(messageId));
            }
        }
        return new SQSBatchResponse(batchItemFailures);
    }
}
```

To use this feature, your function must gracefully handle errors. Have your function logic catch all exceptions and report the messages that result in failure in `batchItemFailures` in your function response. If your function throws an exception, the entire batch is considered a complete failure.

**Note**
If you're using this feature with a FIFO queue, your function should stop processing messages after the first failure and return all failed and unprocessed messages in `batchItemFailures`. This helps preserve the ordering of messages in your queue.

## Success and failure conditions

Lambda treats a batch as a complete success if your function returns any of the following:

- An empty `batchItemFailures` list
- A null `batchItemFailures` list
- An empty `EventResponse`
- A null `EventResponse`

Lambda treats a batch as a complete failure if your function returns any of the following:

- An invalid JSON response
- An empty string `itemIdentifier`
- A null `itemIdentifier`
- An `itemIdentifier` with a bad key name
- An `itemIdentifier` value with a message ID that doesn't exist

## CloudWatch metrics

To determine whether your function is correctly reporting batch item failures, you can monitor the `NumberOfMessagesDeleted` and `ApproximateAgeOfOldestMessage` Amazon SQS metrics in Amazon CloudWatch.

- `NumberOfMessagesDeleted` tracks the number of messages removed from your queue. If this drops to 0, this is a sign that your function response is not correctly returning failed messages.
- `ApproximateAgeOfOldestMessage` tracks how long the oldest message has stayed in your queue. A sharp increase in this metric can indicate that your function is not correctly returning failed messages.

# Amazon SQS configuration parameters

All Lambda event source types share the same CreateEventSourceMapping (p. 893) and UpdateEventSourceMapping (p. 1078) API operations. However, only some of the parameters apply to Amazon SQS.

**Event source parameters that apply to Amazon SQS**

| Parameter | Required | Default | Notes |
|---|---|---|---|
| BatchSize | N | 10 | For standard queues, the maximum is 10,000. For FIFO queues, the maximum is 10. |
| Enabled | N | true | |
| EventSourceArn | Y | | The ARN of the data stream or a stream consumer |
| FunctionName | Y | | |
| FunctionResponseTypes | N | | To let your function report specific failures in a batch, include the value `ReportBatchItemFailures` in `FunctionResponseTypes`. For more information, see Reporting batch item failures (p. 701). |
| MaximumBatchingWindowInSeconds | N | 0 | |

# Tutorial: Using Lambda with Amazon SQS

In this tutorial, you create a Lambda function that consumes messages from an Amazon Simple Queue Service (Amazon SQS) queue.

## Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

## Create the execution role

Create an execution role (p. 52) that gives your function permission to access the required AWS resources.

### To create an execution role

1. Open the Roles page of the AWS Identity and Access Management (IAM) console.
2. Choose **Create role**.
3. Create a role with the following properties.
   - **Trusted entity** – **AWS Lambda**.
   - **Permissions** – **AWSLambdaSQSQueueExecutionRole**.
   - **Role name** – **`lambda-sqs-role`**.

The **AWSLambdaSQSQueueExecutionRole** policy has the permissions that the function needs to read items from Amazon SQS and to write logs to Amazon CloudWatch Logs.

## Create the function

Create a Lambda function that processes your Amazon SQS messages. The following Node.js 12 code example writes each message to a log in CloudWatch Logs.

> **Note**
> For code examples in other languages, see Sample Amazon SQS function code (p. 711).

### Example index.js

```
exports.handler = async function(event, context) {
```

```
  event.Records.forEach(record => {
    const { body } = record;
    console.log(body);
  });
  return {};
}
```

**To create the function**

> **Note**
> Following these steps creates a function in Node.js 12. For other languages, the steps are similar, but some details are different.

1. Save the code example as a file named `index.js`.
2. Create a deployment package.

```
zip function.zip index.js
```

3. Create the function using the `create-function` AWS Command Line Interface (AWS CLI) command.

```
aws lambda create-function --function-name ProcessSQSRecord \
--zip-file fileb://function.zip --handler index.handler --runtime nodejs12.x \
--role arn:aws:iam::123456789012:role/lambda-sqs-role
```

## Test the function

Invoke your Lambda function manually using the `invoke` AWS CLI command and a sample Amazon SQS event.

If the handler returns normally without exceptions, Lambda considers the message successfully processed and begins reading new messages in the queue. After successfully processing a message, Lambda automatically deletes it from the queue. If the handler throws an exception, Lambda considers the batch of messages not successfully processed, and Lambda invokes the function with the same batch of messages.

1. Save the following JSON as a file named `input.txt`.

```
{
    "Records": [
        {
            "messageId": "059f36b4-87a3-44ab-83d2-661975830a7d",
            "receiptHandle": "AQEBwJnKyrHigUMZj6rYigCgxlaS3SLy0a...",
            "body": "test",
            "attributes": {
                "ApproximateReceiveCount": "1",
                "SentTimestamp": "1545082649183",
                "SenderId": "AIDAIENQZJOLO23YVJ4VO",
                "ApproximateFirstReceiveTimestamp": "1545082649185"
            },
            "messageAttributes": {},
            "md5OfBody": "098f6bcd4621d373cade4e832627b4f6",
            "eventSource": "aws:sqs",
            "eventSourceARN": "arn:aws:sqs:us-east-2:123456789012:my-queue",
            "awsRegion": "us-east-2"
        }
    ]
}
```

The preceding JSON simulates an event that Amazon SQS might send to your Lambda function, where `"body"` contains the actual message from the queue.

2. Run the following `invoke` AWS CLI command.

```
aws lambda invoke --function-name ProcessSQSRecord \
--payload file://input.txt outputfile.txt
```

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

3. Verify the output in the file `outputfile.txt`.

## Create an Amazon SQS queue

Create an Amazon SQS queue that the Lambda function can use as an event source.

**To create a queue**

1. Open the Amazon SQS console.
2. Choose **Create queue**, and then configure the queue. For detailed instructions, see Creating an Amazon SQS queue (console) in the *Amazon Simple Queue Service Developer Guide*.
3. After creating the queue, record its Amazon Resource Name (ARN). You need this in the next step when you associate the queue with your Lambda function.

## Configure the event source

To create a mapping between your Amazon SQS queue and your Lambda function, run the following `create-event-source-mapping` AWS CLI command.

```
aws lambda create-event-source-mapping --function-name ProcessSQSRecord  --batch-size 10 \
--event-source-arn arn:aws:sqs:us-east-2:123456789012:my-queue
```

To get a list of your event source mappings, run the following command.

```
aws lambda list-event-source-mappings --function-name ProcessSQSRecord \
--event-source-arn arn:aws:sqs:us-east-2:123456789012:my-queue
```

## Test the setup

Now you can test the setup as follows:

1. Open the Amazon SQS console.
2. Choose the name of the queue that you created earlier.
3. Choose **Send and receive messages**.
4. Under **Message body**, enter a test message.
5. Choose **Send message**.

Lambda polls the queue for updates. When there is a new message, Lambda invokes your function with this new event data from the queue. Your function runs and creates logs in Amazon CloudWatch. You can view the logs in the CloudWatch console.

## Clean up your resources

You can now delete the resources that you created for this tutorial, unless you want to retain them. By deleting AWS resources that you're no longer using, you prevent unnecessary charges to your AWS account.

**To delete the execution role**

1. Open the Roles page of the IAM console.
2. Select the execution role that you created.
3. Choose **Delete role**.
4. Choose **Yes, delete**.

**To delete the Lambda function**

1. Open the Functions page of the Lambda console.
2. Select the function that you created.
3. Choose **Actions**, then choose **Delete**.
4. Choose **Delete**.

**To delete the Amazon SQS queue**

1. Sign in to the AWS Management Console and open the Amazon SQS console at https://console.aws.amazon.com/sqs/.
2. Select the queue you created.
3. Choose **Delete**.
4. Enter **`delete`** in the text box.
5. Choose **Delete**.

# Tutorial: Using a cross-account Amazon SQS queue as an event source

In this tutorial, you create a Lambda function that consumes messages from an Amazon Simple Queue Service (Amazon SQS) queue in a different AWS account. This tutorial involves two AWS accounts: **Account A** refers to the account that contains your Lambda function, and **Account B** refers to the account that contains the Amazon SQS queue.

## Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

## Create the execution role (Account A)

In **Account A**, create an execution role (p. 52) that gives your function permission to access the required AWS resources.

### To create an execution role

1. Open the Roles page in the AWS Identity and Access Management (IAM) console.
2. Choose **Create role**.
3. Create a role with the following properties.
   - **Trusted entity** – **AWS Lambda**
   - **Permissions** – **AWSLambdaSQSQueueExecutionRole**
   - **Role name** – **`cross-account-lambda-sqs-role`**

The **AWSLambdaSQSQueueExecutionRole** policy has the permissions that the function needs to read items from Amazon SQS and to write logs to Amazon CloudWatch Logs.

## Create the function (Account A)

In **Account A**, create a Lambda function that processes your Amazon SQS messages. The following Node.js 12 code example writes each message to a log in CloudWatch Logs.

> **Note**
> For code examples in other languages, see Sample Amazon SQS function code (p. 711).

### Example index.js

```
exports.handler = async function(event, context) {
  event.Records.forEach(record => {
    const { body } = record;
    console.log(body);
  });
  return {};
}
```

### To create the function

> **Note**
> Following these steps creates a function in Node.js 12. For other languages, the steps are similar, but some details are different.

1. Save the code example as a file named `index.js`.
2. Create a deployment package.

```
zip function.zip index.js
```

3. Create the function using the `create-function` AWS Command Line Interface (AWS CLI) command.

```
aws lambda create-function --function-name CrossAccountSQSExample \
--zip-file fileb://function.zip --handler index.handler --runtime nodejs12.x \
--role arn:aws:iam::<AccountA_ID>:role/cross-account-lambda-sqs-role
```

## Test the function (Account A)

In **Account A**, test your Lambda function manually using the `invoke` AWS CLI command and a sample Amazon SQS event.

If the handler returns normally without exceptions, Lambda considers the message to be successfully processed and begins reading new messages in the queue. After successfully processing a message, Lambda automatically deletes it from the queue. If the handler throws an exception, Lambda considers the batch of messages not successfully processed, and Lambda invokes the function with the same batch of messages.

1. Save the following JSON as a file named `input.txt`.

```
{
    "Records": [
        {
            "messageId": "059f36b4-87a3-44ab-83d2-661975830a7d",
            "receiptHandle": "AQEBwJnKyrHigUMZj6rYigCgxlaS3SLy0a...",
            "body": "test",
            "attributes": {
                "ApproximateReceiveCount": "1",
                "SentTimestamp": "1545082649183",
                "SenderId": "AIDAIENQZJOLO23YVJ4VO",
                "ApproximateFirstReceiveTimestamp": "1545082649185"
            },
            "messageAttributes": {},
            "md5OfBody": "098f6bcd4621d373cade4e832627b4f6",
            "eventSource": "aws:sqs",
            "eventSourceARN": "arn:aws:sqs:us-east-1:123456789012:example-queue",
            "awsRegion": "us-east-1"
        }
    ]
}
```

   The preceding JSON simulates an event that Amazon SQS might send to your Lambda function, where `"body"` contains the actual message from the queue.

2. Run the following `invoke` AWS CLI command.

```
aws lambda invoke --function-name CrossAccountSQSExample \
--payload file://input.txt outputfile.txt
```

   The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

3. Verify the output in the file `outputfile.txt`.

## Create an Amazon SQS queue (Account B)

In **Account B**, create an Amazon SQS queue that the Lambda function in **Account A** can use as an event source.

**To create a queue**

1. Open the Amazon SQS console.
2. Choose **Create queue**.
3. Create a queue with the following properties.

   - **Type** – **Standard**
   - **Name** – **LambdaCrossAccountQueue**
   - **Configuration** – Keep the default settings.
   - **Access policy** – Choose **Advanced**. Paste in the following JSON policy:

   ```
   {
      "Version": "2012-10-17",
      "Id": "Queue1_Policy_UUID",
      "Statement": [{
         "Sid":"Queue1_AllActions",
         "Effect": "Allow",
         "Principal": {
            "AWS": [
               "arn:aws:iam::<AccountA_ID>:role/cross-account-lambda-sqs-role"
            ]
         },
         "Action": "sqs:*",
         "Resource": "arn:aws:sqs:us-east-1:<AccountB_ID>:LambdaCrossAccountQueue"
       }
     ]
   }
   ```

   This policy grants the Lambda execution role in **Account A** permissions to consume messages from this Amazon SQS queue.
4. After creating the queue, record its Amazon Resource Name (ARN). You need this in the next step when you associate the queue with your Lambda function.

## Configure the event source (Account A)

In **Account A**, create an event source mapping between the Amazon SQS queue in **Account B**and your Lambda function by running the following `create-event-source-mapping` AWS CLI command.

```
aws lambda create-event-source-mapping --function-name CrossAccountSQSExample --batch-size
 10 \
--event-source-arn arn:aws:sqs:us-east-1:<AccountB_ID>:LambdaCrossAccountQueue
```

To get a list of your event source mappings, run the following command.

```
aws lambda list-event-source-mappings --function-name CrossAccountSQSExample \
--event-source-arn arn:aws:sqs:us-east-1:<AccountB_ID>:LambdaCrossAccountQueue
```

## Test the setup

You can now test the setup as follows:

1. In **Account B**, open the Amazon SQS console.
2. Choose **LambdaCrossAccountQueue**, which you created earlier.
3. Choose **Send and receive messages**.
4. Under **Message body**, enter a test message.

5. Choose **Send message**.

Your Lambda function in **Account A** should receive the message. Lambda will continue to poll the queue for updates. When there is a new message, Lambda invokes your function with this new event data from the queue. Your function runs and creates logs in Amazon CloudWatch. You can view the logs in the CloudWatch console.

## Clean up your resources

You can now delete the resources that you created for this tutorial, unless you want to retain them. By deleting AWS resources that you're no longer using, you prevent unnecessary charges to your AWS account.

In **Account A**, clean up your execution role and Lambda function.

### To delete the execution role

1. Open the Roles page of the IAM console.
2. Select the execution role that you created.
3. Choose **Delete role**.
4. Choose **Yes, delete**.

### To delete the Lambda function

1. Open the Functions page of the Lambda console.
2. Select the function that you created.
3. Choose **Actions**, then choose **Delete**.
4. Choose **Delete**.

In **Account B**, clean up the Amazon SQS queue.

### To delete the Amazon SQS queue

1. Sign in to the AWS Management Console and open the Amazon SQS console at https://console.aws.amazon.com/sqs/.
2. Select the queue you created.
3. Choose **Delete**.
4. Enter **`delete`** in the text box.
5. Choose **Delete**.

# Sample Amazon SQS function code

Sample code is available for the following languages.

**Topics**

- Node.js (p. 712)
- Java (p. 712)
- C# (p. 712)
- Go (p. 713)
- Python (p. 714)

## Node.js

The following is example code that receives an Amazon SQS event message as input and processes it. For illustration, the code writes some of the incoming event data to CloudWatch Logs.

**Example index.js (Node.js 12)**

```
exports.handler = async function(event, context) {
  event.Records.forEach(record => {
    const { body } = record;
    console.log(body);
  });
  return {};
}
```

Zip up the sample code to create a deployment package. For instructions, see Deploy Node.js Lambda functions with .zip file archives (p. 288).

## Java

The following is example Java code that receives an Amazon SQS event message as input and processes it. For illustration, the code writes some of the incoming event data to CloudWatch Logs.

In the code, `handleRequest` is the handler. The handler uses the predefined `SQSEvent` class that is defined in the `aws-lambda-java-events` library.

**Example Handler.java**

```
package example;

import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.services.lambda.runtime.RequestHandler;
import com.amazonaws.services.lambda.runtime.events.SQSEvent;
import com.amazonaws.services.lambda.runtime.events.SQSEvent.SQSMessage;

public class Handler implements RequestHandler<SQSEvent, Void>{
    @Override
    public Void handleRequest(SQSEvent event, Context context)
    {
        for(SQSMessage msg : event.getRecords()){
            System.out.println(new String(msg.getBody()));
        }
        return null;
    }
}
```

**Dependencies**

- `aws-lambda-java-core`
- `aws-lambda-java-events`

Build the code with the Lambda library dependencies to create a deployment package. For instructions, see Deploy Java Lambda functions with .zip or JAR file archives (p. 386).

## C#

The following is example C# code that receives an Amazon SQS event message as input and processes it. For illustration, the code writes some of the incoming event data to the console.

In the code, `handleRequest` is the handler. The handler uses the predefined `SQSEvent` class that is defined in the `AWS.Lambda.SQSEvents` library.

**Example ProcessingSQSRecords.cs**

```
[assembly: LambdaSerializer(typeof(Amazon.Lambda.Serialization.Json.JsonSerializer))]

namespace SQSLambdaFunction
{
    public class SQSLambdaFunction
    {
        public string HandleSQSEvent(SQSEvent sqsEvent, ILambdaContext context)
        {
            Console.WriteLine($"Beginning to process {sqsEvent.Records.Count} records...");

            foreach (var record in sqsEvent.Records)
            {
                Console.WriteLine($"Message ID: {record.MessageId}");
                Console.WriteLine($"Event Source: {record.EventSource}");

                Console.WriteLine($"Record Body:");
                Console.WriteLine(record.Body);
            }

            Console.WriteLine("Processing complete.");

            return $"Processed {sqsEvent.Records.Count} records.";
        }
    }
}
```

Replace the `Program.cs` in a .NET Core project with the above sample. For instructions, see Deploy C# Lambda functions with .zip file archives (p. 458).

## Go

The following is example Go code that receives an Amazon SQS event message as input and processes it. For illustration, the code writes some of the incoming event data to CloudWatch Logs.

In the code, `handler` is the handler. The handler uses the predefined `SQSEvent` class that is defined in the `aws-lambda-go-events` library.

**Example ProcessSQSRecords.go**

```
package main

import (
    "context"
    "fmt"

    "github.com/aws/aws-lambda-go/events"
    "github.com/aws/aws-lambda-go/lambda"
)

func handler(ctx context.Context, sqsEvent events.SQSEvent) error {
    for _, message := range sqsEvent.Records {
        fmt.Printf("The message %s for event source %s = %s \n", message.MessageId,
 message.EventSource, message.Body)
    }

    return nil
}
```

```
func main() {
    lambda.Start(handler)
}
```

Build the executable with `go build` and create a deployment package. For instructions, see Deploy Go Lambda functions with .zip file archives (p. 427).

## Python

The following is example Python code that accepts an Amazon SQS record as input and processes it. For illustration, the code writes to some of the incoming event data to CloudWatch Logs.

**Example ProcessSQSRecords.py**

```
from __future__ import print_function

def lambda_handler(event, context):
    for record in event['Records']:
        print("test")
        payload = record["body"]
        print(str(payload))
```

Zip up the sample code to create a deployment package. For instructions, see Deploy Python Lambda functions with .zip file archives (p. 330).

# AWS SAM template for an Amazon SQS application

You can build this application using AWS SAM. To learn more about creating AWS SAM templates, see AWS SAM template basics in the *AWS Serverless Application Model Developer Guide*.

Below is a sample AWS SAM template for the Lambda application from the tutorial (p. 704). Copy the text below to a .yaml file and save it next to the ZIP package you created previously. Note that the `Handler` and `Runtime` parameter values should match the ones you used when you created the function in the previous section.

**Example template.yaml**

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Description: Example of processing messages on an SQS queue with Lambda
Resources:
  MySQSQueueFunction:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs12.x
      Events:
        MySQSEvent:
          Type: SQS
          Properties:
            Queue: !GetAtt MySqsQueue.Arn
            BatchSize: 10
  MySqsQueue:
    Type: AWS::SQS::Queue
```

For information on how to package and deploy your serverless application using the package and deploy commands, see Deploying serverless applications in the *AWS Serverless Application Model Developer Guide*.

# Using AWS Lambda with AWS X-Ray

You can use AWS X-Ray to visualize the components of your application, identify performance bottlenecks, and troubleshoot requests that resulted in an error. Your Lambda functions send trace data to X-Ray, and X-Ray processes the data to generate a service map and searchable trace summaries.

If you've enabled X-Ray tracing in a service that invokes your function, Lambda sends traces to X-Ray automatically. The upstream service, such as Amazon API Gateway, or an application hosted on Amazon EC2 that is instrumented with the X-Ray SDK, samples incoming requests and adds a tracing header that tells Lambda to send traces or not.

> **Note**
> X-Ray tracing is currently not supported for Lambda functions with Amazon Managed Streaming for Apache Kafka (Amazon MSK), self-managed Apache Kafka, or Amazon MQ with ActiveMQ and RabbitMQ event source mappings.

To toggle active tracing on your Lambda function with the console, follow these steps:

**To turn on active tracing**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Configuration** and then choose **Monitoring and operations tools**.
4. Choose **Edit**.
5. Under **X-Ray**, toggle on **Active tracing**.
6. Choose **Save**.

> **Pricing**
> You can use X-Ray tracing for free each month up to a certain limit as part of the AWS Free Tier. Beyond that threshold, X-Ray charges for trace storage and retrieval. For more information, see AWS X-Ray pricing.

Your function needs permission to upload trace data to X-Ray. When you activate tracing in the Lambda console, Lambda adds the required permissions to your function's execution role (p. 52). Otherwise, add the AWSXRayDaemonWriteAccess policy to the execution role.

X-Ray doesn't trace all requests to your application. X-Ray applies a sampling algorithm to ensure that tracing is efficient, while still providing a representative sample of all requests. The sampling rate is 1 request per second and 5 percent of additional requests.

> **Note**
> You cannot configure the X-Ray sampling rate for your functions.

In X-Ray, a *trace* records information about a request that is processed by one or more *services*. Services record *segments* that contain layers of *subsegments*. Lambda records a segment for the Lambda service that handles the invocation request, and one for the work done by the function. The function segment comes with subsegments for `Initialization`, `Invocation` and `Overhead`. For more information see Lambda execution environment lifecycle (p. 100).

The `Initialization` subsegment represents the init phase of the Lambda execution environment lifecycle. During this phase, Lambda creates or unfreezes an execution environment with the resources you have configured, downloads the function code and all layers, initializes extensions, initializes the runtime, and runs the function's initialization code.

The `Invocation` subsegment represents the invoke phase where Lambda invokes the function handler. This begins with runtime and extension registration and it ends when the runtime is ready to send the response.

The `Overhead` subsegment represents the phase that occurs between the time when the runtime sends the response and the signal for the next invoke. During this time, the runtime finishes all tasks related to an invoke and prepares to freeze the sandbox.

> **Note**
> If your Lambda function uses provisioned concurrency (p. 183), your X-Ray trace might display a function initialization with a very long duration.
> Provisioned concurrency initializes function instances in advance, to reduce lag at the time of invocation. Over time, provisioned concurrency refreshes these instances by creating new instances to replace the old ones. For workloads with steady traffic, the new instances are initialized well in advance of their first invocation. The time gap gets recorded in the X-Ray trace as the initialization duration.

> **Important**
> In Lambda, you can use the X-Ray SDK to extend the `Invocation` subsegment with additional subsegments for downstream calls, annotations, and metadata. You can't access the function segment directly or record work done outside of the handler invocation scope.

See the following topics for a language-specific introduction to tracing in Lambda:

- Instrumenting Node.js code in AWS Lambda (p. 304)
- Instrumenting Python code in AWS Lambda (p. 349)
- Instrumenting Ruby code in AWS Lambda (p. 374)
- Instrumenting Java code in AWS Lambda (p. 410)
- Instrumenting Go code in AWS Lambda (p. 444)
- Instrumenting C# code in AWS Lambda (p. 476)

For a full list of services that support active instrumentation, see Supported AWS services in the AWS X-Ray Developer Guide.

**Sections**

- Execution role permissions (p. 716)
- The AWS X-Ray daemon (p. 716)
- Enabling active tracing with the Lambda API (p. 717)
- Enabling active tracing with AWS CloudFormation (p. 717)

# Execution role permissions

Lambda needs the following permissions to send trace data to X-Ray. Add them to your function's execution role (p. 52).

- xray:PutTraceSegments
- xray:PutTelemetryRecords

These permissions are included in the AWSXRayDaemonWriteAccess managed policy.

# The AWS X-Ray daemon

Instead of sending trace data directly to the X-Ray API, the X-Ray SDK uses a daemon process. The AWS X-Ray daemon is an application that runs in the Lambda environment and listens for UDP traffic that contains segments and subsegments. It buffers incoming data and writes it to X-Ray in batches, reducing the processing and memory overhead required to trace invocations.

The Lambda runtime allows the daemon to up to 3 percent of your function's configured memory or 16 MB, whichever is greater. If your function runs out of memory during invocation, the runtime terminates the daemon process first to free up memory.

The daemon process is fully managed by Lambda and cannot be configured by the user. All segments generated by function invocations are recorded in the same account as the Lambda function. The daemon cannot be configured to redirect them to any other account.

For more information, see The X-Ray daemon in the X-Ray Developer Guide.

# Enabling active tracing with the Lambda API

To manage tracing configuration with the AWS CLI or AWS SDK, use the following API operations:

- UpdateFunctionConfiguration (p. 1098)
- GetFunctionConfiguration (p. 967)
- CreateFunction (p. 904)

The following example AWS CLI command enables active tracing on a function named **my-function**.

```
aws lambda update-function-configuration --function-name my-function \
--tracing-config Mode=Active
```

Tracing mode is part of the version-specific configuration when you publish a version of your function. You can't change the tracing mode on a published version.

# Enabling active tracing with AWS CloudFormation

To activate tracing on an `AWS::Lambda::Function` resource in an AWS CloudFormation template, use the `TracingConfig` property.

**Example function-inline.yml – Tracing configuration**

```
Resources:
  function:
    Type: AWS::Lambda::Function
    Properties:
      TracingConfig:
        Mode: Active
      ...
```

For an AWS Serverless Application Model (AWS SAM) `AWS::Serverless::Function` resource, use the `Tracing` property.

**Example template.yml – Tracing configuration**

```
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      Tracing: Active
      ...
```

# Monitoring and troubleshooting Lambda applications

AWS Lambda integrates with other AWS services to help you monitor and troubleshoot your Lambda functions. Lambda automatically monitors Lambda functions on your behalf and reports metrics through Amazon CloudWatch. To help you monitor your code when it runs, Lambda automatically tracks the number of requests, the invocation duration per request, and the number of requests that result in an error.

You can use other AWS services to troubleshoot your Lambda functions. This section describes how to use these AWS services to monitor, trace, debug, and troubleshoot your Lambda functions and applications.

For more information about monitoring Lambda applications, see Monitoring and observability in the *Lambda operator guide*.

**Sections**


- Monitoring functions on the Lambda console (p. 719)
- Using Lambda Insights in Amazon CloudWatch (p. 721)
- Working with Lambda function metrics (p. 727)
- Accessing Amazon CloudWatch logs for AWS Lambda (p. 730)
- Using CodeGuru Profiler with your Lambda function (p. 731)
- Example workflows using other AWS services (p. 732)

# Monitoring functions on the Lambda console

Lambda monitors functions on your behalf and sends metrics to Amazon CloudWatch. The Lambda console creates monitoring graphs for these metrics and shows them on the **Monitoring** page for each Lambda function.

This page describes the basics of using the Lambda console to view function metrics, including total requests, duration, and error rates.

## Pricing

CloudWatch has a perpetual free tier. Beyond the free tier threshold, CloudWatch charges for metrics, dashboards, alarms, logs, and insights. For more information, see Amazon CloudWatch pricing.

## Using the Lambda console

You can monitor your Lambda functions and applications on the Lambda console.

**To monitor a function**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose the **Monitor** tab.

## Types of monitoring graphs

The following section describes the monitoring graphs on the Lambda console.

**Lambda monitoring graphs**

- **Invocations** – The number of times that the function was invoked.
- **Duration** – The average, minimum, and maximum amount of time your function code spends processing an event.
- **Error count and success rate (%)** – The number of errors and the percentage of invocations that completed without error.
- **Throttles** – The number of times that an invocation failed due to concurrency limits.
- **IteratorAge** – For stream event sources, the age of the last item in the batch when Lambda received it and invoked the function.
- **Async delivery failures** – The number of errors that occurred when Lambda attempted to write to a destination or dead-letter queue.
- **Concurrent executions** – The number of function instances that are processing events.

## Viewing graphs on the Lambda console

The following section describes how to view CloudWatch monitoring graphs on the Lambda console, and open the CloudWatch metrics dashboard.

**To view monitoring graphs for a function**

1. Open the Functions page of the Lambda console.
2. Choose a function.

3. Choose the **Monitor** tab.
4. On the **Metrics**, **Logs**, or **Traces** tab, choose from the predefined time ranges, or choose a custom time range.
5. To see the definition of a graph in CloudWatch, choose the three vertical dots (**Widget actions**), and then choose **View in metrics** to open the **Metrics** dashboard on the CloudWatch console.

# Viewing queries on the CloudWatch Logs console

The following section describes how to view and add reports from CloudWatch Logs Insights to a custom dashboard on the CloudWatch Logs console.

**To view reports for a function**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose the **Monitor** tab.
4. Choose **View logs in CloudWatch**.
5. Choose **View in Logs Insights**.
6. Choose from the predefined time ranges, or choose a custom time range.
7. Choose **Run query**.
8. (Optional) Choose **Save**.

# What's next?

- Learn about the metrics that Lambda records and sends to CloudWatch in Working with Lambda function metrics (p. 727).
- Learn how to use CloudWatch Lambda Insights to collect and aggregate Lambda function runtime performance metrics and logs in Using Lambda Insights in Amazon CloudWatch (p. 721).

# Using Lambda Insights in Amazon CloudWatch

Amazon CloudWatch Lambda Insights collects and aggregates Lambda function runtime performance metrics and logs for your serverless applications. This page describes how to enable and use Lambda Insights to diagnose issues with your Lambda functions.

**Sections**


- How Lambda Insights monitors serverless applications (p. 721)
- Pricing (p. 721)
- Supported runtimes (p. 721)
- Enabling Lambda Insights in the Lambda console (p. 721)
- Enabling Lambda Insights programmatically (p. 722)
- Using the Lambda Insights dashboard (p. 722)
- Example workflow to detect function anomalies (p. 724)
- Example workflow using queries to troubleshoot a function (p. 725)
- What's next? (p. 720)


## How Lambda Insights monitors serverless applications

CloudWatch Lambda Insights is a monitoring and troubleshooting solution for serverless applications running on AWS Lambda. The solution collects, aggregates, and summarizes system-level metrics including CPU time, memory, disk and network usage. It also collects, aggregates, and summarizes diagnostic information such as cold starts and Lambda worker shutdowns to help you isolate issues with your Lambda functions and resolve them quickly.

Lambda Insights uses a new CloudWatch Lambda Insights extension, which is provided as a Lambda layer (p. 156). When you enable this extension on a Lambda function for a supported runtime, it collects system-level metrics and emits a single performance log event for every invocation of that Lambda function. CloudWatch uses embedded metric formatting to extract metrics from the log events. For more information, see Using AWS Lambda extensions.

The Lambda Insights layer extends the `CreateLogStream` and `PutLogEvents` for the `/aws/lambda-insights/` log group.

## Pricing

When you enable Lambda Insights for your Lambda function, Lambda Insights reports 8 metrics per function and every function invocation sends about 1KB of log data to CloudWatch. You only pay for the metrics and logs reported for your function by Lambda Insights. There are no minimum fees or mandatory service usage polices. You do not pay for Lambda Insights if the function is not invoked. For a pricing example, see Amazon CloudWatch pricing.

## Supported runtimes

You can use Lambda Insights with any of the runtimes that support Lambda extensions (p. 101).

## Enabling Lambda Insights in the Lambda console

You can enable Lambda Insights enhanced monitoring on new and existing Lambda functions. When you enable Lambda Insights on a function in the Lambda console for a supported runtime, Lambda

adds the Lambda Insights extension as a layer to your function, and verifies or attempts to attach the `CloudWatchLambdaInsightsExecutionRolePolicy` policy to your function's execution role.

**To enable Lambda Insights in the Lambda console**

1. Open the Functions page of the Lambda console.
2. Choose your function.
3. Choose the **Configuration** tab.
4. On the **Monitoring tools** pane, choose **Edit**.
5. Under **Lambda Insights**, turn on **Enhanced monitoring**.
6. Choose **Save**.

# Enabling Lambda Insights programmatically

You can also enable Lambda Insights using the AWS Command Line Interface (AWS CLI), AWS Serverless Application Model (SAM) CLI, AWS CloudFormation, or the AWS Cloud Development Kit (AWS CDK). When you enable Lambda Insights programmatically on a function for a supported runtime, CloudWatch attaches the `CloudWatchLambdaInsightsExecutionRolePolicy` policy to your function's execution role.

For more information, see Getting started with Lambda Insights in the *Amazon CloudWatch User Guide*.

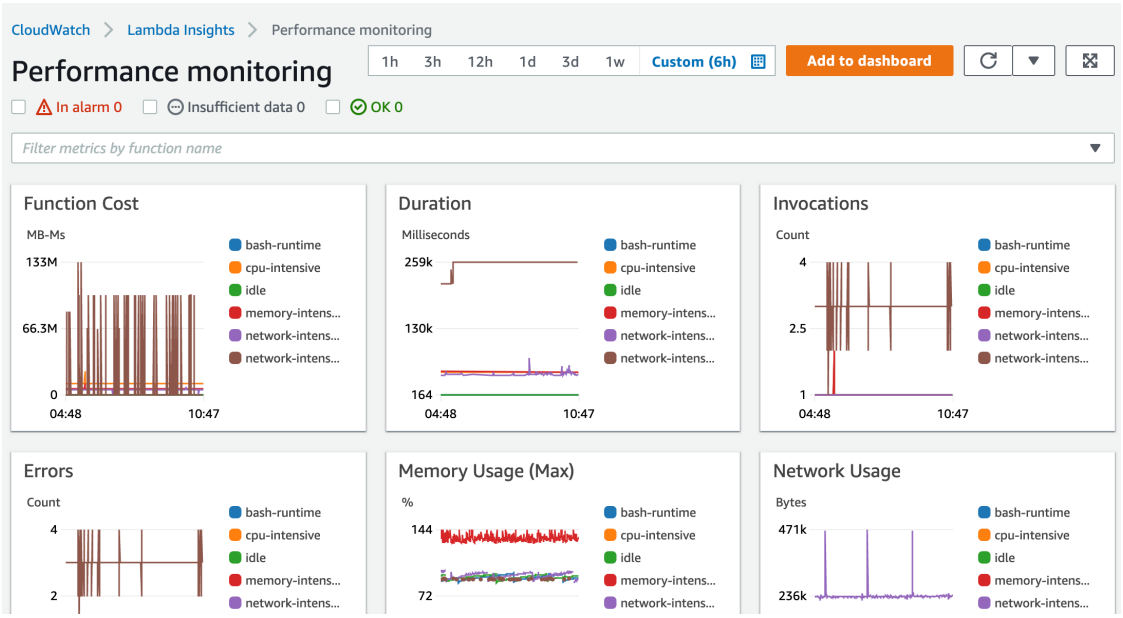
# Using the Lambda Insights dashboard

The Lambda Insights dashboard has two views in the CloudWatch console: the multi-function overview and the single-function view. The multi-function overview aggregates the runtime metrics for the Lambda functions in the current AWS account and Region. The single-function view shows the available runtime metrics for a single Lambda function.

You can use the Lambda Insights dashboard multi-function overview in the CloudWatch console to identify over- and under-utilized Lambda functions. You can use the Lambda Insights dashboard single-function view in the CloudWatch console to troubleshoot individual requests.

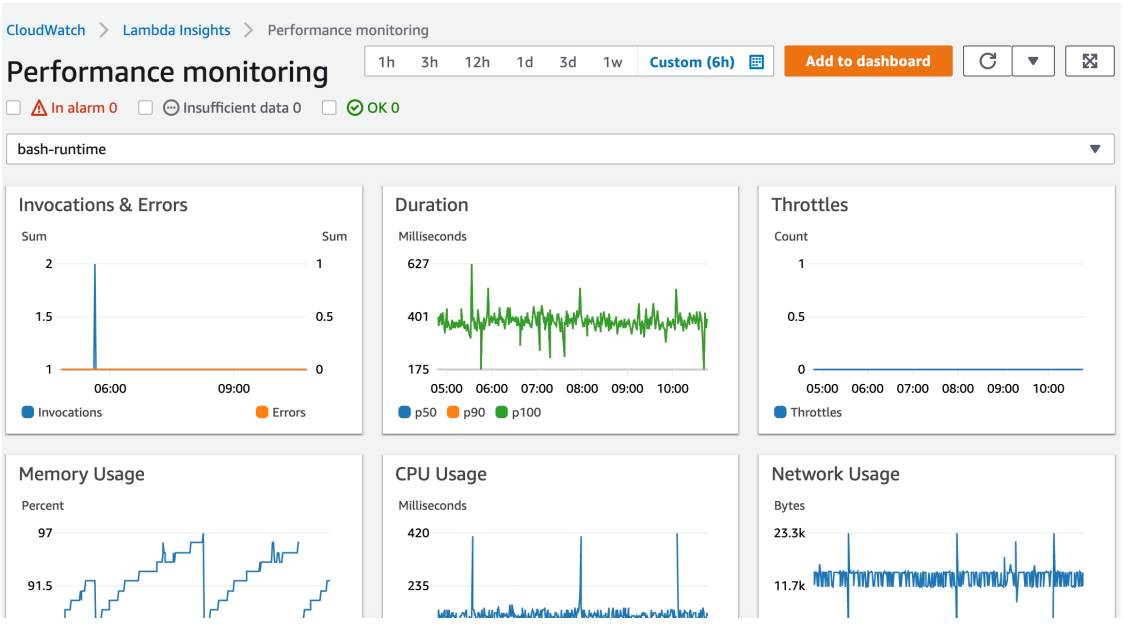
**To view the runtime metrics for all functions**

1. Open the Multi-function page in the CloudWatch console.
2. Choose from the predefined time ranges, or choose a custom time range.
3. (Optional) Choose **Add to dashboard** to add the widgets to your CloudWatch dashboard.




### To view the runtime metrics of a single function

1. Open the Single-function page in the CloudWatch console.
2. Choose from the predefined time ranges, or choose a custom time range.
3. (Optional) Choose **Add to dashboard** to add the widgets to your CloudWatch dashboard.




For more information, see Creating and working with widgets on CloudWatch dashboards.

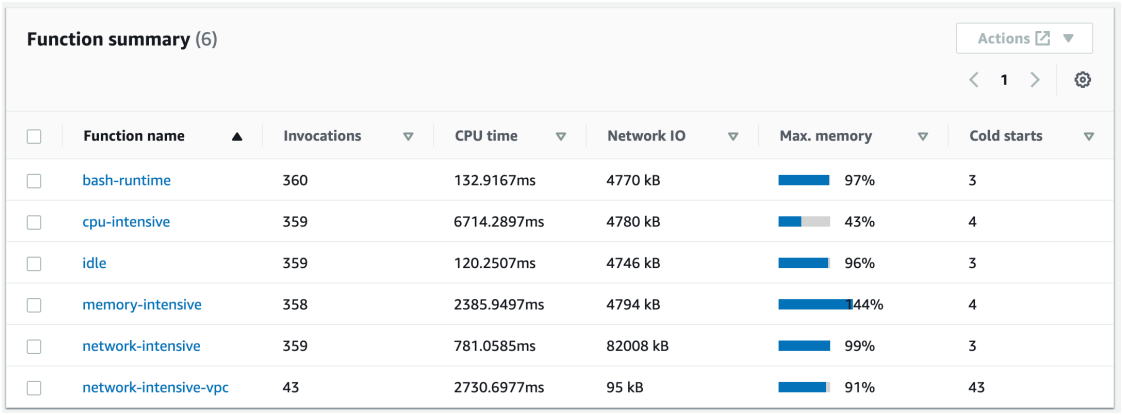
# Example workflow to detect function anomalies

You can use the multi-function overview on the Lambda Insights dashboard to identify and detect compute memory anomalies with your function. For example, if the multi-function overview indicates that a function is using a large amount of memory, you can view detailed memory utilization metrics in the **Memory Usage** pane. You can then go to the Metrics dashboard to enable anomaly detection or create an alarm.

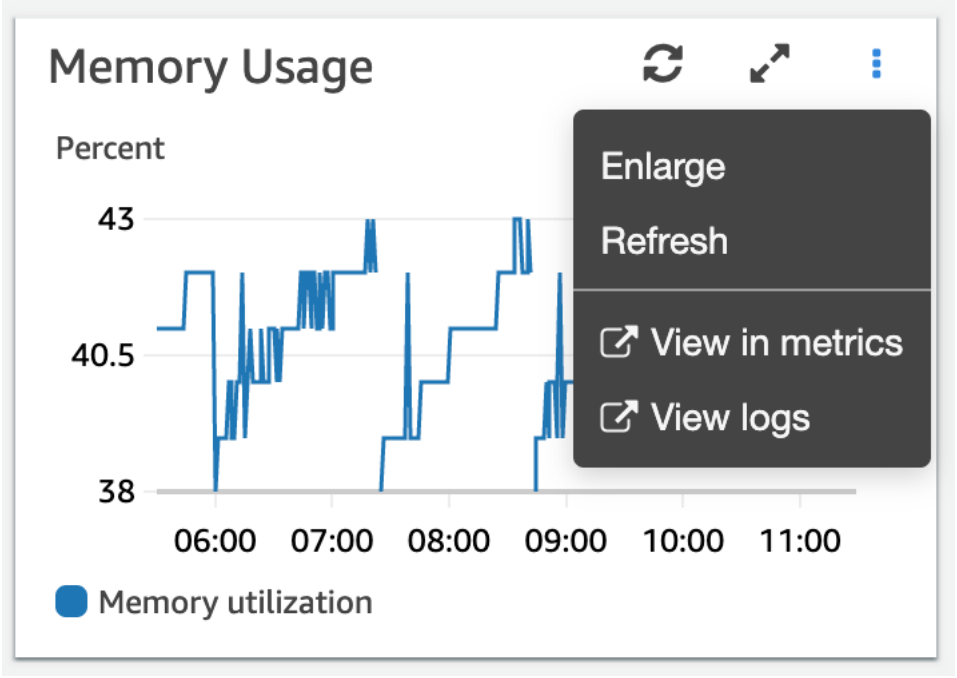
### To enable anomaly detection for a function

1. Open the Multi-function page in the CloudWatch console.
2. Under **Function summary**, choose your function's name.

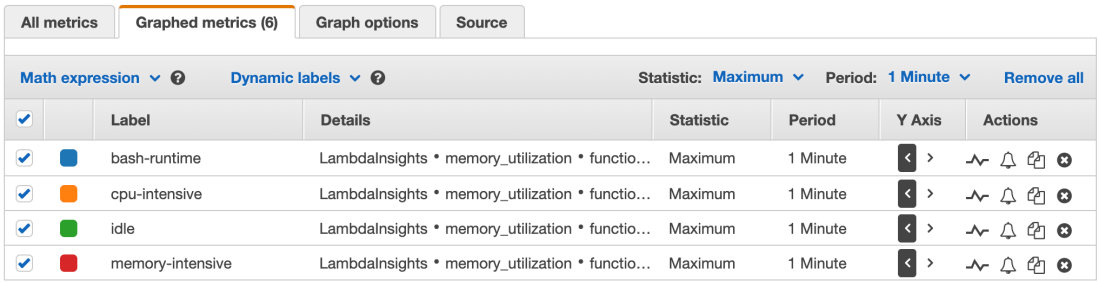
   The single-function view opens with the function runtime metrics.




3. On the **Memory Usage** pane, choose the three vertical dots, and then choose **View in metrics** to open the **Metrics** dashboard.




4. On the **Graphed metrics** tab, in the **Actions** column, choose the first icon to enable anomaly detection for the function.



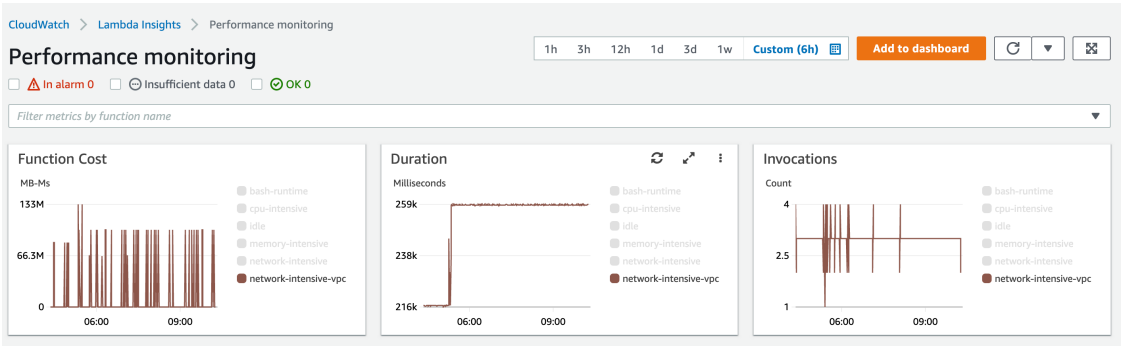

For more information, see Using CloudWatch Anomaly Detection.

# Example workflow using queries to troubleshoot a function

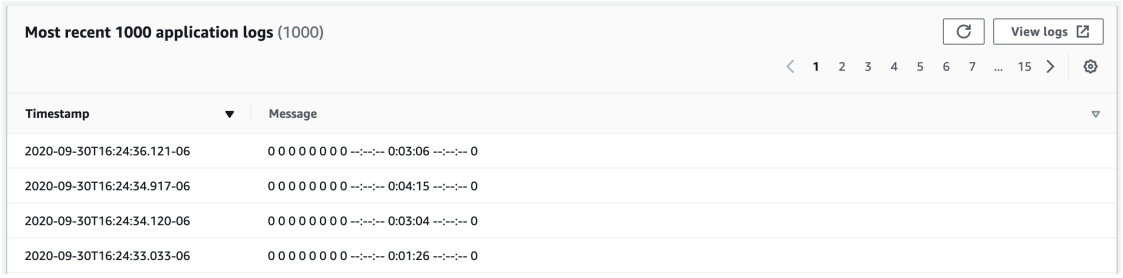
You can use the single-function view on the Lambda Insights dashboard to identify the root cause of a spike in function duration. For example, if the multi-function overview indicates a large increase in function duration, you can pause on or choose each function in the **Duration** pane to determine which function is causing the increase. You can then go to the single-function view and review the **Application logs** to determine the root cause.

### To run queries on a function

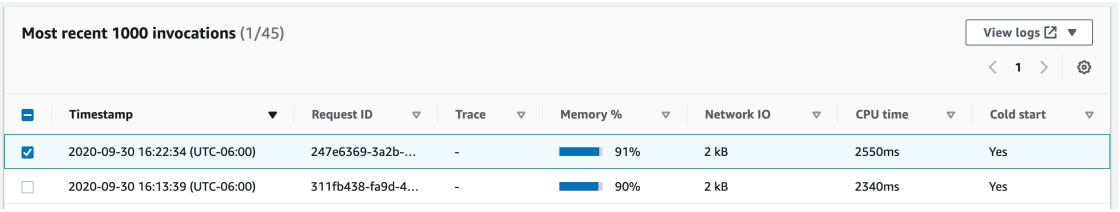
1. Open the Multi-function page in the CloudWatch console.
2. In the **Duration** pane, choose your function to filter the duration metrics.




3. Open the Single-function page.
4. Choose the **Filter metrics by function name** dropdown list, and then choose your function.
5. To view the **Most recent 1000 application logs**, choose the **Application logs** tab.
6. Review the **Timestamp** and **Message** to identify the invocation request that you want to troubleshoot.

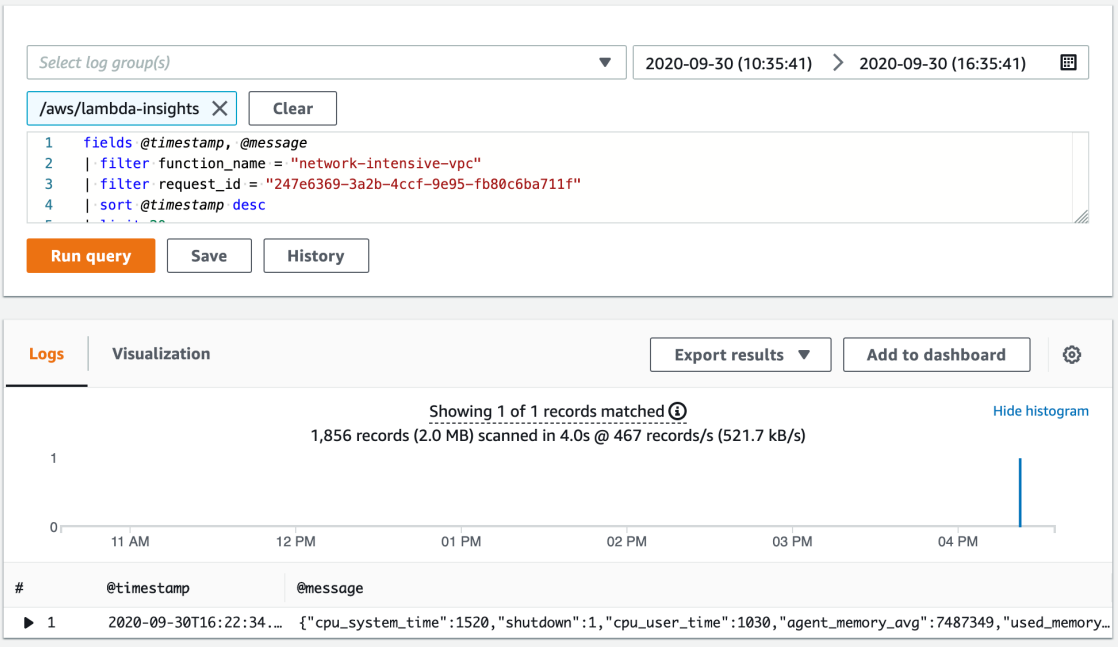


7. To show the **Most recent 1000 invocations**, choose the **Invocations** tab.
8. Select the **Timestamp** or **Message** for the invocation request that you want to troubleshoot.




9. Choose the **View logs** dropdown list, and then choose **View performance logs**.

   An autogenerated query for your function opens in the **Logs Insights** dashboard.
10. Choose **Run query** to generate a **Logs** message for the invocation request.




# What's next?

- Learn how to create a CloudWatch Logs dashboard in Create a Dashboard in the *Amazon CloudWatch User Guide*.
- Learn how to add queries to a CloudWatch Logs dashboard in Add Query to Dashboard or Export Query Results in the *Amazon CloudWatch User Guide*.

# Working with Lambda function metrics

When your AWS Lambda function finishes processing an event, Lambda sends metrics about the invocation to Amazon CloudWatch. There is no charge for these metrics.

On the CloudWatch console, you can build graphs and dashboards with these metrics. You can set alarms to respond to changes in utilization, performance, or error rates. Lambda sends metric data to CloudWatch in 1-minute intervals. If you want more immediate insight into your Lambda function, you can create high-resolution custom metrics. Charges apply for custom metrics and CloudWatch Alarms. For more information, see CloudWatch pricing..

This page describes the Lambda function invocation, performance, and concurrency metrics available on the CloudWatch console.

**Sections**

- Viewing metrics on the CloudWatch console (p. 727)
- Types of metrics (p. 727)

## Viewing metrics on the CloudWatch console

You can use the CloudWatch console to filter and sort function metrics by function name, alias, or version.

### To view metrics on the CloudWatch console

1. Open the Metrics page (`AWS/Lambda` namespace) of the CloudWatch console.
2. Choose a dimension.
   - **By Function Name** (`FunctionName`) – View aggregate metrics for all versions and aliases of a function.
   - **By Resource** (`Resource`) – View metrics for a version or alias of a function.
   - **By Executed Version** (`ExecutedVersion`) – View metrics for a combination of alias and version. Use the `ExecutedVersion` dimension to compare error rates for two versions of a function that are both targets of a weighted alias (p. 175).
   - **Across All Functions** (none) – View aggregate metrics for all functions in the current AWS Region.
3. Choose metrics to add them to the graph.

By default, graphs use the `Sum` statistic for all metrics. To choose a different statistic and customize the graph, use the options on the **Graphed metrics** tab.

> **Note**
> The timestamp on a metric reflects when the function was invoked. Depending on the duration of the invocation, this can be several minutes before the metric is emitted. For example, if your function has a 10-minute timeout, look more than 10 minutes in the past for accurate metrics.

For more information about CloudWatch, see the *Amazon CloudWatch User Guide*.

## Types of metrics

The following section describes the types of metrics available on the CloudWatch console.

## Using invocation metrics

Invocation metrics are binary indicators of the outcome of an invocation. For example, if the function returns an error, Lambda sends the `Errors` metric with a value of 1. To get a count of the number of function errors that occurred each minute, view the `Sum` of the `Errors` metric with a period of 1 minute.

View the following metrics with the `Sum` statistic.

**Invocation metrics**

- `Invocations` – The number of times that your function code is invoked, including successful invocations and invocations that result in a function error. Invocations aren't recorded if the invocation request is throttled or otherwise results in an invocation error. This equals the number of requests billed.
- `Errors` – The number of invocations that result in a function error. Function errors include exceptions that your code throws and exceptions that the Lambda runtime throws. The runtime returns errors for issues such as timeouts and configuration errors. To calculate the error rate, divide the value of `Errors` by the value of `Invocations`. Note that the timestamp on an error metric reflects when the function was invoked, not when the error occurred.
- `DeadLetterErrors` – For asynchronous invocation (p. 228), the number of times that Lambda attempts to send an event to a dead-letter queue but fails. Dead-letter errors can occur due to permissions errors, misconfigured resources, or size limits.
- `DestinationDeliveryFailures` – For asynchronous invocation, the number of times that Lambda attempts to send an event to a destination (p. 19) but fails. Delivery errors can occur due to permissions errors, misconfigured resources, or size limits.
- `Throttles` – The number of invocation requests that are throttled. When all function instances are processing requests and no concurrency is available to scale up, Lambda rejects additional requests with a `TooManyRequestsException` error. Throttled requests and other invocation errors don't count as `Invocations` or `Errors`.
- `ProvisionedConcurrencyInvocations` – The number of times that your function code is invoked on provisioned concurrency (p. 180).
- `ProvisionedConcurrencySpilloverInvocations` – The number of times that your function code is invoked on standard concurrency when all provisioned concurrency is in use.

## Using performance metrics

Performance metrics provide performance details about a single invocation. For example, the `Duration` metric indicates the amount of time in milliseconds that your function spends processing an event. To get a sense of how fast your function processes events, view these metrics with the `Average` or `Max` statistic.

**Performance metrics**

- `Duration` – The amount of time that your function code spends processing an event. The billed duration for an invocation is the value of `Duration` rounded up to the nearest millisecond.
- `PostRuntimeExtensionsDuration` – The cumulative amount of time that the runtime spends running code for extensions after the function code has completed.
- `IteratorAge` – For event source mappings (p. 236) that read from streams, the age of the last record in the event. The age is the amount of time between when a stream receives the record and when the event source mapping sends the event to the function.
- `OffsetLag` – For self-managed Apache Kafka and Amazon Managed Streaming for Apache Kafka (Amazon MSK) event sources, the difference in offset between the last record written to a topic and the last record that your Lambda function's consumer group processed. Though a Kafka topic can have multiple partitions, this metric measures the offset lag at the topic level.

`Duration` also supports percentile statistics. Use percentiles to exclude outlier values that skew average and maximum statistics. For example, the p95 statistic shows the maximum duration of 95 percent of invocations, excluding the slowest 5 percent.

## Using concurrency metrics

Lambda reports concurrency metrics as an aggregate count of the number of instances processing events across a function, version, alias, or AWS Region. To see how close you are to hitting concurrency limits, view these metrics with the `Max` statistic.

### Concurrency metrics

- `ConcurrentExecutions` – The number of function instances that are processing events. If this number reaches your concurrent executions quota (p. 796) for the Region, or the reserved concurrency limit (p. 180) that you configured on the function, Lambda throttles additional invocation requests.
- `ProvisionedConcurrentExecutions` – The number of function instances that are processing events on provisioned concurrency (p. 180). For each invocation of an alias or version with provisioned concurrency, Lambda emits the current count.
- `ProvisionedConcurrencyUtilization` – For a version or alias, the value of `ProvisionedConcurrentExecutions` divided by the total amount of provisioned concurrency allocated. For example, `.5` indicates that 50 percent of allocated provisioned concurrency is in use.
- `UnreservedConcurrentExecutions` – For a Region, the number of events that functions without reserved concurrency are processing.

# Accessing Amazon CloudWatch logs for AWS Lambda

AWS Lambda automatically monitors Lambda functions on your behalf, reporting metrics through Amazon CloudWatch. To help you troubleshoot failures in a function, after you set up permissions, Lambda logs all requests handled by your function and also automatically stores logs generated by your code through Amazon CloudWatch Logs.

You can insert logging statements into your code to help you validate that your code is working as expected. Lambda automatically integrates with CloudWatch Logs and pushes all logs from your code to a CloudWatch Logs group associated with a Lambda function, which is named /aws/lambda/*<function name>*.

You can view logs for Lambda functions using the Lambda console, the CloudWatch console, the AWS Command Line Interface (AWS CLI), or the CloudWatch API. This page describes how to view logs using the Lambda console.

> **Note**
> It may take 5 to 10 minutes for logs to show up after a function invocation.

**Section**


- Prerequisites (p. 730)
- Pricing (p. 730)
- Using the Lambda console (p. 730)
- Using the AWS CLI (p. 731)
- What's next? (p. 731)


## Prerequisites

Your execution role (p. 52) needs permission to upload logs to CloudWatch Logs. You can add CloudWatch Logs permissions using the `AWSLambdaBasicExecutionRole` AWS managed policy provided by Lambda. To add this policy to your role, run the following command:

```
aws iam attach-role-policy --role-name your-role --policy-arn arn:aws:iam::aws:policy/
service-role/AWSLambdaBasicExecutionRole
```

For more information, see AWS managed policies for Lambda features (p. 54).

## Pricing

There is no additional charge for using Lambda logs; however, standard CloudWatch Logs charges apply. For more information, see CloudWatch pricing.

## Using the Lambda console

**To view logs using the Lambda console**

1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Monitor**.
4. Choose **View logs in CloudWatch**.

## Using the AWS CLI

To debug and validate that your code is working as expected, you can output logs with the standard logging functionality for your programming language. The Lambda runtime uploads your function's log output to CloudWatch Logs. For language-specific instructions, see the following topics:

- AWS Lambda function logging in Node.js (p. 295)
- AWS Lambda function logging in Python (p. 340)
- AWS Lambda function logging in Ruby (p. 365)
- AWS Lambda function logging in Java (p. 398)
- AWS Lambda function logging in Go (p. 435)
- Lambda function logging in C# (p. 466)
- AWS Lambda function logging in PowerShell (p. 487)

## What's next?

- Learn more about log groups and accessing them through the CloudWatch console in Monitoring system, application, and custom log files in the *Amazon CloudWatch User Guide*.

# Using CodeGuru Profiler with your Lambda function

You can use Amazon CodeGuru Profiler to gain insights into runtime performance of your Lambda functions. This page describes how to activate CodeGuru Profiler from the Lambda console.

**Sections**

- Supported runtimes (p. 731)
- Activating CodeGuru Profiler from the Lambda console (p. 731)
- What happens when you activate CodeGuru Profiler from the Lambda console? (p. 732)
- What's next? (p. 732)

## Supported runtimes

You can activate CodeGuru Profiler from the Lambda console if your function's runtime is Python3.8, Python3.9, Java 8 with Amazon Linux 2, or Java 11. For additional runtime versions, you can activate CodeGuru Profiler manually.

- For Java runtimes, see Profiling your Java applications that run on AWS Lambda.
- For Python runtimes, see Profiling your Python applications that run on AWS Lambda.

## Activating CodeGuru Profiler from the Lambda console

This section describes how to activate CodeGuru Profiler from the Lambda console.

**To activate CodeGuru Profiler from the Lambda console**

1. Open the Functions page of the Lambda console.
2. Choose your function.
3. Choose the **Configuration** tab.
4. On the **Monitoring and operations tools** pane, choose **Edit**.
5. Under **Amazon CodeGuru Profiler**, turn on **Code profiling**.
6. Choose **Save**.

After activation, CodeGuru automatically creates a profiler group with the name `aws-lambda-<your-function-name>`. You can change the name from the CodeGuru console.

## What happens when you activate CodeGuru Profiler from the Lambda console?

When you activate CodeGuru Profiler from the console, Lambda automatically does the following on your behalf:

- Lambda adds a CodeGuru Profiler layer to your function. For more details, see Use AWS Lambda layers in the *Amazon CodeGuru Profiler User Guide*.
- Lambda also adds environment variables to your function. The exact value varies based on the runtime.

  **Environment variables**

  | Runtimes | Key | Value |
  |---|---|---|
  | java8.al2, java11 | `JAVA_TOOL_OPTIONS` | `-javaagent:/opt/codeguru-profiler-java-agent-standalone.jar` |
  | python3.8, python3.9 | `AWS_LAMBDA_EXEC_WRAPPER` | `/opt/codeguru_profiler_lambda_exec` |

- Lambda adds the `AmazonCodeGuruProfilerAgentAccess` policy to your function's execution role.

  **Note**
  When you deactivate CodeGuru Profiler from the console, Lambda automatically removes the CodeGuru Profiler layer and environment variables from your function. However, Lambda does not remove the `AmazonCodeGuruProfilerAgentAccess` policy from your execution role.

## What's next?

- Learn more about the data collected by your profiler group in Working with visualizations in the *Amazon CodeGuru Profiler User Guide*.

# Example workflows using other AWS services

AWS Lambda integrates with other AWS services to help you monitor, trace, debug, and troubleshoot your Lambda functions. This page shows workflows you can use with AWS X-Ray, AWS Trusted Advisor and CloudWatch ServiceLens to trace and troubleshoot your Lambda functions.

**Sections**


- Prerequisites (p. 733)
- Pricing (p. 733)
- Example AWS X-Ray workflow to view a service map (p. 734)
- Example AWS X-Ray workflow to view trace details (p. 734)
- Example AWS Trusted Advisor workflow to view recommendations (p. 735)
- What's next? (p. 735)


# Prerequisites

The following section describes the steps to using AWS X-Ray and Trusted Advisor to troubleshoot your Lambda functions.

## Using AWS X-Ray

AWS X-Ray needs to be enabled on the Lambda console to complete the AWS X-Ray workflows on this page. If your execution role does not have the required permissions, the Lambda console will attempt to add them to your execution role.

### To enable AWS X-Ray on the Lambda console

1. Open the Functions page of the Lambda console.
2. Choose your function.
3. Choose the **Configuration** tab.
4. On the **Monitoring tools** pane, choose **Edit**.
5. Under **AWS X-Ray**, turn on **Active tracing**.
6. Choose **Save**.

## Using AWS Trusted Advisor

AWS Trusted Advisor inspects your AWS environment and makes recommendations on ways you can save money, improve system availability and performance, and help close security gaps. You can use Trusted Advisor checks to evaluate the Lambda functions and applications in your AWS account. The checks provide recommended steps to take and resources for more information.

- For more information on AWS support plans for Trusted Advisor checks, see Support plans.
- For more information about the checks for Lambda, see AWS Trusted Advisor best practice checklist.
- For more information on how to use the Trusted Advisor console, see Get started with AWS Trusted Advisor.
- For instructions on how to allow and deny console access to Trusted Advisor, see IAM policy examples.

# Pricing

- With AWS X-Ray you pay only for what you use, based on the number of traces recorded, retrieved, and scanned. For more information, see AWS X-Ray Pricing.
- Trusted Advisor cost optimization checks are included with AWS Business and Enterprise support subscriptions. For more information, see AWS Trusted Advisor Pricing.

# Example AWS X-Ray workflow to view a service map

If you've enabled AWS X-Ray, you can view a ServiceLens service map on the CloudWatch console. A service map displays your service endpoints and resources as nodes and highlights the traffic, latency, and errors for each node and its connections.

You can choose a node to see detailed insights about the correlated metrics, logs, and traces associated with that part of the service. This enables you to investigate problems and their effect on an application.

**To view service map and traces using the CloudWatch console**

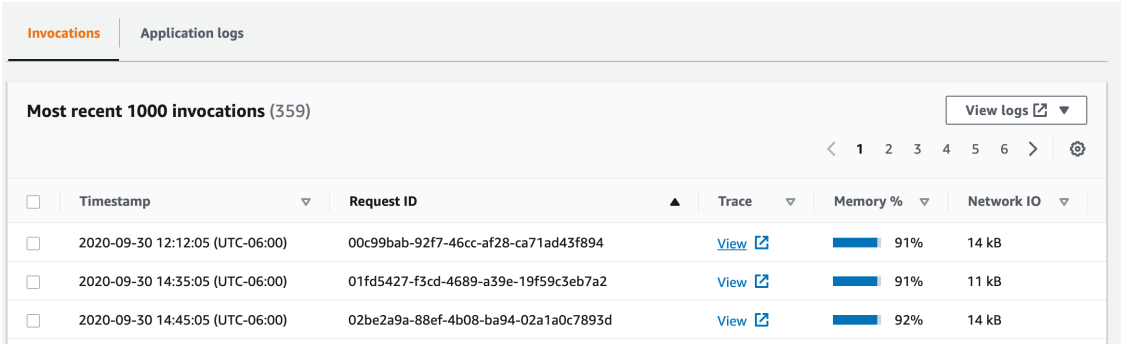
1. Open the Functions page of the Lambda console.
2. Choose a function.
3. Choose **Monitoring**.
4. Choose **View traces in X-Ray**.
5. Choose **Service map**.
6. Choose from the predefined time ranges, or choose a custom time range.
7. To troubleshoot requests, choose a filter.

# Example AWS X-Ray workflow to view trace details

If you've enabled AWS X-Ray, you can use the single-function view on the CloudWatch Lambda Insights dashboard to show the distributed trace data of a function invocation error. For example, if the application logs message shows an error, you can open the ServiceLens traces view to see the distributed trace data and the other services handling the transaction.

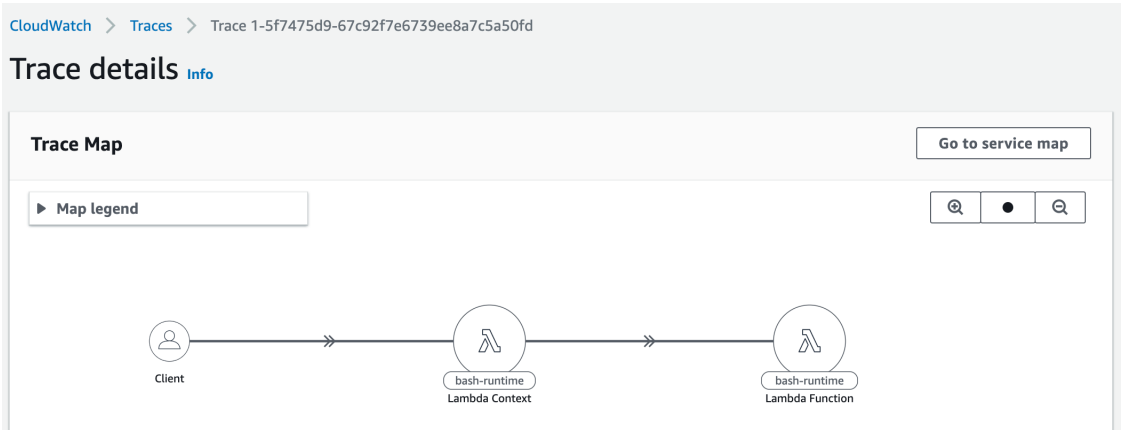
**To view trace details of a function**

1. Open the single-function view in the CloudWatch console.
2. Choose the **Application logs** tab.
3. Use the **Timestamp** or **Message** to identify the invocation request that you want to troubleshoot.
4. To show the **Most recent 1000 invocations**, choose the **Invocations** tab.




5. Choose the **Request ID** column to sort entries in ascending alphabetical order.
6. In the **Trace** column, choose **View**.

   The **Trace details** page opens in the ServiceLens traces view.




# Example AWS Trusted Advisor workflow to view recommendations

Trusted Advisor checks Lambda functions in all AWS Regions to identify functions with the highest potential cost savings, and deliver actionable recommendations for optimization. It analyzes your Lambda usage data such as function execution time, billed duration, memory used, memory configured, timeout configuration and errors.

For example, the *Lambda Functions with High Error Rate* check recommends that you use AWS X-Ray or CloudWatch to detect errors with your Lambda functions.

**To check for functions with high error rates**

1. Open the Trusted Advisor console.
2. Choose the **Cost Optimization** category.
3. Scroll down to **AWS Lambda Functions with High Error Rates**. Expand the section to see the results and the recommended actions.

# What's next?

- Learn more about how to integrate traces, metrics, logs, and alarms in Using ServiceLens to Monitor the Health of Your Applications.
- Learn more about how to get a list of Trusted Advisor checks in Using Trusted Advisor as a web service.

# Security in AWS Lambda

Cloud security at AWS is the highest priority. As an AWS customer, you benefit from a data center and network architecture that is built to meet the requirements of the most security-sensitive organizations.

Security is a shared responsibility between AWS and you. The shared responsibility model describes this as security *of* the cloud and security *in* the cloud:

- **Security of the cloud** – AWS is responsible for protecting the infrastructure that runs AWS services in the AWS Cloud. AWS also provides you with services that you can use securely. Third-party auditors regularly test and verify the effectiveness of our security as part of the AWS compliance programs. To learn about the compliance programs that apply to AWS Lambda, see AWS Services in Scope by Compliance Program.
- **Security in the cloud** – Your responsibility is determined by the AWS service that you use. You are also responsible for other factors including the sensitivity of your data, your company's requirements, and applicable laws and regulations.

This documentation helps you understand how to apply the shared responsibility model when using Lambda. The following topics show you how to configure Lambda to meet your security and compliance objectives. You also learn how to use other AWS services that help you to monitor and secure your Lambda resources.

For more information about applying security principles to Lambda applications, see Security in the *Lambda operator guide*.

**Topics**

- Data protection in AWS Lambda (p. 736)
- Identity and access management for Lambda (p. 738)
- Compliance validation for AWS Lambda (p. 746)
- Resilience in AWS Lambda (p. 747)
- Infrastructure security in AWS Lambda (p. 747)
- Configuration and vulnerability analysis in AWS Lambda (p. 748)

# Data protection in AWS Lambda

The AWS shared responsibility model applies to data protection in AWS Lambda. As described in this model, AWS is responsible for protecting the global infrastructure that runs all of the AWS Cloud. You are responsible for maintaining control over your content that is hosted on this infrastructure. This content includes the security configuration and management tasks for the AWS services that you use. For more information about data privacy, see the Data Privacy FAQ. For information about data protection in Europe, see the AWS Shared Responsibility Model and GDPR blog post on the *AWS Security Blog*.

For data protection purposes, we recommend that you protect AWS account credentials and set up individual user accounts with AWS Identity and Access Management (IAM). That way each user is given only the permissions necessary to fulfill their job duties. We also recommend that you secure your data in the following ways:

- Use multi-factor authentication (MFA) with each account.
- Use SSL/TLS to communicate with AWS resources. We recommend TLS 1.2 or later.
- Set up API and user activity logging with AWS CloudTrail.
- Use AWS encryption solutions, along with all default security controls within AWS services.
- Use advanced managed security services such as Amazon Macie, which assists in discovering and securing personal data that is stored in Amazon S3.
- If you require FIPS 140-2 validated cryptographic modules when accessing AWS through a command line interface or an API, use a FIPS endpoint. For more information about the available FIPS endpoints, see Federal Information Processing Standard (FIPS) 140-2.

We strongly recommend that you never put confidential or sensitive information, such as your customers' email addresses, into tags or free-form fields such as a **Name** field. This includes when you work with Lambda or other AWS services using the console, API, AWS CLI, or AWS SDKs. Any data that you enter into tags or free-form fields used for names may be used for billing or diagnostic logs. If you provide a URL to an external server, we strongly recommend that you do not include credentials information in the URL to validate your request to that server.

**Sections**

- Encryption in transit (p. 737)
- Encryption at rest (p. 737)

# Encryption in transit

Lambda API endpoints only support secure connections over HTTPS. When you manage Lambda resources with the AWS Management Console,AWS SDK, or the Lambda API, all communication is encrypted with Transport Layer Security (TLS). For a full list of API endpoints, see AWS Regions and endpoints in the AWS General Reference.

When you connect your function to a file system (p. 206), Lambda uses encryption in transit for all connections. For more information, see Data encryption in Amazon EFS in the *Amazon Elastic File System User Guide*.

When you use environment variables (p. 166), you can enable console encryption helpers to use client-side encryption to protect the environment variables in transit. For more information, see Securing environment variables (p. 170).

# Encryption at rest

You can use environment variables (p. 166) to store secrets securely for use with Lambda functions. Lambda always encrypts environment variables at rest. By default, Lambda uses an AWS KMS key that Lambda creates in your account to encrypt your environment variables. This AWS managed key is named `aws/lambda`.

On a per-function basis, you can optionally configure Lambda to use a customer managed key instead of the default AWS managed key to encrypt your environment variables. For more information, see Securing environment variables (p. 170).

Lambda always encrypts files that you upload to Lambda, including deployment packages (p. 143) and layer archives (p. 156).

Amazon CloudWatch Logs and AWS X-Ray also encrypt data by default, and can be configured to use a customer managed key. For details, see Encrypt log data in CloudWatch Logs and Data protection in AWS X-Ray.

# Identity and access management for Lambda

AWS Identity and Access Management (IAM) is an AWS service that helps an administrator securely control access to AWS resources. IAM administrators control who can be *authenticated* (signed in) and *authorized* (have permissions) to use Lambda resources. IAM is an AWS service that you can use with no additional charge.

**Topics**


- Audience (p. 738)
- Authenticating with identities (p. 738)
- Managing access using policies (p. 740)
- How AWS Lambda works with IAM (p. 742)
- AWS Lambda identity-based policy examples (p. 742)
- Troubleshooting AWS Lambda identity and access (p. 744)


## Audience

How you use AWS Identity and Access Management (IAM) differs, depending on the work that you do in Lambda.

**Service user** – If you use the Lambda service to do your job, then your administrator provides you with the credentials and permissions that you need. As you use more Lambda features to do your work, you might need additional permissions. Understanding how access is managed can help you request the right permissions from your administrator. If you cannot access a feature in Lambda, see Troubleshooting AWS Lambda identity and access (p. 744).

**Service administrator** – If you're in charge of Lambda resources at your company, you probably have full access to Lambda. It's your job to determine which Lambda features and resources your service users should access. You must then submit requests to your IAM administrator to change the permissions of your service users. Review the information on this page to understand the basic concepts of IAM. To learn more about how your company can use IAM with Lambda, see How AWS Lambda works with IAM (p. 742).

**IAM administrator** – If you're an IAM administrator, you might want to learn details about how you can write policies to manage access to Lambda. To view example Lambda identity-based policies that you can use in IAM, see AWS Lambda identity-based policy examples (p. 742).

## Authenticating with identities

Authentication is how you sign in to AWS using your identity credentials. For more information about signing in using the AWS Management Console, see Signing in to the AWS Management Console as an IAM user or root user in the *IAM User Guide*.

You must be *authenticated* (signed in to AWS) as the AWS account root user, an IAM user, or by assuming an IAM role. You can also use your company's single sign-on authentication or even sign in using Google or Facebook. In these cases, your administrator previously set up identity federation using IAM roles. When you access AWS using credentials from another company, you are assuming a role indirectly.

To sign in directly to the AWS Management Console, use your password with your root user email address or your IAM user name. You can access AWS programmatically using your root user or IAM users access keys. AWS provides SDK and command line tools to cryptographically sign your request using your credentials. If you don't use AWS tools, you must sign the request yourself. Do this using *Signature Version 4*, a protocol for authenticating inbound API requests. For more information about authenticating requests, see Signature Version 4 signing process in the *AWS General Reference*.

Regardless of the authentication method that you use, you might also be required to provide additional security information. For example, AWS recommends that you use multi-factor authentication (MFA) to increase the security of your account. To learn more, see Using multi-factor authentication (MFA) in AWS in the *IAM User Guide*.

## AWS account root user

When you create an AWS account, you begin with one sign-in identity that has complete access to all AWS services and resources in the account. This identity is called the AWS account *root user* and is accessed by signing in with the email address and password that you used to create the account. We strongly recommend that you do not use the root user for your everyday tasks. Safeguard your root user credentials and use them to perform the tasks that only the root user can perform. For the complete list of tasks that require you to sign in as the root user, see Tasks that require root user credentials in the *AWS General Reference*.

## IAM users and groups

An *IAM user* is an identity within your AWS account that has specific permissions for a single person or application. Where possible, we recommend relying on temporary credentials instead of creating IAM users who have long-term credentials such as passwords and access keys. However, if you have specific use cases that require long-term credentials with IAM users, we recommend that you rotate access keys. For more information, see Rotate access keys regularly for use cases that require long-term credentials in the *IAM User Guide*.

An *IAM group* is an identity that specifies a collection of IAM users. You can't sign in as a group. You can use groups to specify permissions for multiple users at a time. Groups make permissions easier to manage for large sets of users. For example, you could have a group named *IAMAdmins* and give that group permissions to administer IAM resources.

Users are different from roles. A user is uniquely associated with one person or application, but a role is intended to be assumable by anyone who needs it. Users have permanent long-term credentials, but roles provide temporary credentials. To learn more, see When to create an IAM user (instead of a role) in the *IAM User Guide*.

## IAM roles

An *IAM role* is an identity within your AWS account that has specific permissions. It is similar to an IAM user, but is not associated with a specific person. You can temporarily assume an IAM role in the AWS Management Console by switching roles. You can assume a role by calling an AWS CLI or AWS API operation or by using a custom URL. For more information about methods for using roles, see Using IAM roles in the *IAM User Guide*.

IAM roles with temporary credentials are useful in the following situations:

- **Federated user access** – To assign permissions to a federated identity, you create a role and define permissions for the role. When a federated identity authenticates, the identity is associated with the role and is granted the permissions that are defined by the role. For information about roles for federation, see Creating a role for a third-party Identity Provider in the *IAM User Guide*. If you use IAM Identity Center, you configure a permission set. To control what your identities can access after they authenticate, IAM Identity Center correlates the permission set to a role in IAM. For information about permissions sets, see Permission sets in the *AWS IAM Identity Center (successor to AWS Single Sign-On) User Guide*.
- **Temporary IAM user permissions** – An IAM user or role can assume an IAM role to temporarily take on different permissions for a specific task.
- **Cross-account access** – You can use an IAM role to allow someone (a trusted principal) in a different account to access resources in your account. Roles are the primary way to grant cross-account access. However, with some AWS services, you can attach a policy directly to a resource (instead of using a role

as a proxy). To learn the difference between roles and resource-based policies for cross-account access, see How IAM roles differ from resource-based policies in the *IAM User Guide*.

- **Cross-service access** – Some AWS services use features in other AWS services. For example, when you make a call in a service, it's common for that service to run applications in Amazon EC2 or store objects in Amazon S3. A service might do this using the calling principal's permissions, using a service role, or using a service-linked role.
  - **Principal permissions** – When you use an IAM user or role to perform actions in AWS, you are considered a principal. Policies grant permissions to a principal. When you use some services, you might perform an action that then triggers another action in a different service. In this case, you must have permissions to perform both actions. To see whether an action requires additional dependent actions in a policy, see Actions, Resources, and Condition Keys for AWS Lambda in the *Service Authorization Reference*.
  - **Service role** – A service role is an IAM role that a service assumes to perform actions on your behalf. An IAM administrator can create, modify, and delete a service role from within IAM. For more information, see Creating a role to delegate permissions to an AWS service in the *IAM User Guide*.
  - **Service-linked role** – A service-linked role is a type of service role that is linked to an AWS service. The service can assume the role to perform an action on your behalf. Service-linked roles appear in your IAM account and are owned by the service. An IAM administrator can view, but not edit the permissions for service-linked roles.
- **Applications running on Amazon EC2** – You can use an IAM role to manage temporary credentials for applications that are running on an EC2 instance and making AWS CLI or AWS API requests. This is preferable to storing access keys within the EC2 instance. To assign an AWS role to an EC2 instance and make it available to all of its applications, you create an instance profile that is attached to the instance. An instance profile contains the role and enables programs that are running on the EC2 instance to get temporary credentials. For more information, see Using an IAM role to grant permissions to applications running on Amazon EC2 instances in the *IAM User Guide*.

To learn whether to use IAM roles or IAM users, see When to create an IAM role (instead of a user) in the *IAM User Guide*.

# Managing access using policies

You control access in AWS by creating policies and attaching them to AWS identities or resources. A policy is an object in AWS that, when associated with an identity or resource, defines their permissions. AWS evaluates these policies when a principal (user, root user, or role session) makes a request. Permissions in the policies determine whether the request is allowed or denied. Most policies are stored in AWS as JSON documents. For more information about the structure and contents of JSON policy documents, see Overview of JSON policies in the *IAM User Guide*.

Administrators can use AWS JSON policies to specify who has access to what. That is, which **principal** can perform **actions** on what **resources**, and under what **conditions**.

Every IAM entity (user or role) starts with no permissions. By default, users can do nothing, not even change their own password. To give a user permission to do something, an administrator must attach a permissions policy to a user. Or the administrator can add the user to a group that has the intended permissions. When an administrator gives permissions to a group, all users in that group are granted those permissions.

IAM policies define permissions for an action regardless of the method that you use to perform the operation. For example, suppose that you have a policy that allows the `iam:GetRole` action. A user with that policy can get role information from the AWS Management Console, the AWS CLI, or the AWS API.

## Identity-based policies

Identity-based policies are JSON permissions policy documents that you can attach to an identity, such as an IAM user, group of users, or role. These policies control what actions users and roles can perform,

on which resources, and under what conditions. To learn how to create an identity-based policy, see Creating IAM policies in the *IAM User Guide*.

Identity-based policies can be further categorized as *inline policies* or *managed policies*. Inline policies are embedded directly into a single user, group, or role. Managed policies are standalone policies that you can attach to multiple users, groups, and roles in your AWS account. Managed policies include AWS managed policies and customer managed policies. To learn how to choose between a managed policy or an inline policy, see Choosing between managed policies and inline policies in the *IAM User Guide*.

## Resource-based policies

Resource-based policies are JSON policy documents that you attach to a resource. Examples of resource-based policies are IAM *role trust policies* and Amazon S3 *bucket policies*. In services that support resource-based policies, service administrators can use them to control access to a specific resource. For the resource where the policy is attached, the policy defines what actions a specified principal can perform on that resource and under what conditions. You must specify a principal in a resource-based policy. Principals can include accounts, users, roles, federated users, or AWS services.

Resource-based policies are inline policies that are located in that service. You can't use AWS managed policies from IAM in a resource-based policy.

## Access control lists (ACLs)

Access control lists (ACLs) control which principals (account members, users, or roles) have permissions to access a resource. ACLs are similar to resource-based policies, although they do not use the JSON policy document format.

Amazon S3, AWS WAF, and Amazon VPC are examples of services that support ACLs. To learn more about ACLs, see Access control list (ACL) overview in the *Amazon Simple Storage Service Developer Guide*.

## Other policy types

AWS supports additional, less-common policy types. These policy types can set the maximum permissions granted to you by the more common policy types.

- **Permissions boundaries** – A permissions boundary is an advanced feature in which you set the maximum permissions that an identity-based policy can grant to an IAM entity (IAM user or role). You can set a permissions boundary for an entity. The resulting permissions are the intersection of entity's identity-based policies and its permissions boundaries. Resource-based policies that specify the user or role in the `Principal` field are not limited by the permissions boundary. An explicit deny in any of these policies overrides the allow. For more information about permissions boundaries, see Permissions boundaries for IAM entities in the *IAM User Guide*.
- **Service control policies (SCPs)** – SCPs are JSON policies that specify the maximum permissions for an organization or organizational unit (OU) in AWS Organizations. AWS Organizations is a service for grouping and centrally managing multiple AWS accounts that your business owns. If you enable all features in an organization, then you can apply service control policies (SCPs) to any or all of your accounts. The SCP limits permissions for entities in member accounts, including each AWS account root user. For more information about Organizations and SCPs, see How SCPs work in the *AWS Organizations User Guide*.
- **Session policies** – Session policies are advanced policies that you pass as a parameter when you programmatically create a temporary session for a role or federated user. The resulting session's permissions are the intersection of the user or role's identity-based policies and the session policies. Permissions can also come from a resource-based policy. An explicit deny in any of these policies overrides the allow. For more information, see Session policies in the *IAM User Guide*.

## Multiple policy types

When multiple types of policies apply to a request, the resulting permissions are more complicated to understand. To learn how AWS determines whether to allow a request when multiple policy types are involved, see Policy evaluation logic in the *IAM User Guide*.

# How AWS Lambda works with IAM

Before you use IAM to manage access to Lambda, you should understand what IAM features are available to use with Lambda. To get a high-level view of how Lambda and other AWS services work with IAM, see AWS services that work with IAM in the *IAM User Guide*.

For an overview of permissions, policies, and roles as they are used by Lambda, see Lambda permissions (p. 51).

# AWS Lambda identity-based policy examples

By default, IAM users and roles don't have permission to create or modify Lambda resources. They also can't perform tasks using the AWS Management Console, AWS CLI, or AWS API. An IAM administrator must create IAM policies that grant users and roles permission to perform specific API operations on the specified resources they need. The administrator must then attach those policies to the IAM users or groups that require those permissions.

To learn how to create an IAM identity-based policy using these example JSON policy documents, see Creating policies on the JSON tab in the *IAM User Guide*.

**Topics**


- Policy best practices (p. 742)
- Using the Lambda console (p. 743)
- Allow users to view their own permissions (p. 743)


## Policy best practices

Identity-based policies determine whether someone can create, access, or delete Lambda resources in your account. These actions can incur costs for your AWS account. When you create or edit identity-based policies, follow these guidelines and recommendations:

- **Get started with AWS managed policies and move toward least-privilege permissions** – To get started granting permissions to your users and workloads, use the *AWS managed policies* that grant permissions for many common use cases. They are available in your AWS account. We recommend that you reduce permissions further by defining AWS customer managed policies that are specific to your use cases. For more information, see AWS managed policies or AWS managed policies for job functions in the *IAM User Guide*.
- **Apply least-privilege permissions** – When you set permissions with IAM policies, grant only the permissions required to perform a task. You do this by defining the actions that can be taken on specific resources under specific conditions, also known as *least-privilege permissions*. For more information about using IAM to apply permissions, see Policies and permissions in IAM in the *IAM User Guide*.
- **Use conditions in IAM policies to further restrict access** – You can add a condition to your policies to limit access to actions and resources. For example, you can write a policy condition to specify that all requests must be sent using SSL. You can also use conditions to grant access to service actions if they are used through a specific AWS service, such as AWS CloudFormation. For more information, see IAM JSON policy elements: Condition in the *IAM User Guide*.

- **Use IAM Access Analyzer to validate your IAM policies to ensure secure and functional permissions** – IAM Access Analyzer validates new and existing policies so that the policies adhere to the IAM policy language (JSON) and IAM best practices. IAM Access Analyzer provides more than 100 policy checks and actionable recommendations to help you author secure and functional policies. For more information, see IAM Access Analyzer policy validation in the *IAM User Guide*.
- **Require multi-factor authentication (MFA)** – If you have a scenario that requires IAM users or root users in your account, turn on MFA for additional security. To require MFA when API operations are called, add MFA conditions to your policies. For more information, see Configuring MFA-protected API access in the *IAM User Guide*.

For more information about best practices in IAM, see Security best practices in IAM in the *IAM User Guide*.

## Using the Lambda console

To access the AWS Lambda console, you must have a minimum set of permissions. These permissions must allow you to list and view details about the Lambda resources in your AWS account. If you create an identity-based policy that is more restrictive than the minimum required permissions, the console won't function as intended for entities (IAM users or roles) with that policy.

For an example policy that grants minimal access for function development, see Function development (p. 59). In addition to Lambda APIs, the Lambda console uses other services to display trigger configuration and let you add new triggers. If your users use Lambda with other services, they need access to those services as well. For details on configuring other services with Lambda, see Using AWS Lambda with other services (p. 496).

## Allow users to view their own permissions

This example shows how you might create a policy that allows IAM users to view the inline and managed policies that are attached to their user identity. This policy includes permissions to complete this action on the console or programmatically using the AWS CLI or AWS API.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "ViewOwnUserInfo",
            "Effect": "Allow",
            "Action": [
                "iam:GetUserPolicy",
                "iam:ListGroupsForUser",
                "iam:ListAttachedUserPolicies",
                "iam:ListUserPolicies",
                "iam:GetUser"
            ],
            "Resource": ["arn:aws:iam::*:user/${aws:username}"]
        },
        {
            "Sid": "NavigateInConsole",
            "Effect": "Allow",
            "Action": [
                "iam:GetGroupPolicy",
                "iam:GetPolicyVersion",
                "iam:GetPolicy",
                "iam:ListAttachedGroupPolicies",
                "iam:ListGroupPolicies",
                "iam:ListPolicyVersions",
                "iam:ListPolicies",
                "iam:ListUsers"
```

```
            ],
            "Resource": "*"
        }
    ]
}
```

# Troubleshooting AWS Lambda identity and access

Use the following information to help you diagnose and fix common issues that you might encounter when working with Lambda and IAM.

**Topics**


- I am not authorized to perform an action in Lambda (p. 744)
- I am not authorized to perform iam:PassRole (p. 744)
- I want to view my access keys (p. 745)
- I'm an administrator and want to allow others to access Lambda (p. 745)
- I'm an administrator and want to migrate from AWS managed policies for Lambda that will be deprecated (p. 745)
- I want to allow people outside of my AWS account to access my Lambda resources (p. 746)


## I am not authorized to perform an action in Lambda

If the AWS Management Console tells you that you're not authorized to perform an action, then you must contact your administrator for assistance. Your administrator is the person that provided you with your user name and password.

The following example error occurs when the `mateojackson` IAM user tries to use the console to view details about a function but does not have `lambda:GetFunction` permissions.

```
User: arn:aws:iam::123456789012:user/mateojackson is not authorized to perform:
 lambda:GetFunction on resource: my-function
```

In this case, Mateo asks his administrator to update his policies to allow him to access the `my-function` resource using the `lambda:GetFunction` action.

## I am not authorized to perform iam:PassRole

If you receive an error that you're not authorized to perform the `iam:PassRole` action, your policies must be updated to allow you to pass a role to Lambda.

Some AWS services allow you to pass an existing role to that service instead of creating a new service role or service-linked role. To do this, you must have permissions to pass the role to the service.

The following example error occurs when an IAM user named `marymajor` tries to use the console to perform an action in Lambda. However, the action requires the service to have permissions that are granted by a service role. Mary does not have permissions to pass the role to the service.

```
User: arn:aws:iam::123456789012:user/marymajor is not authorized to perform: iam:PassRole
```

In this case, Mary's policies must be updated to allow her to perform the `iam:PassRole` action.

If you need help, contact your AWS administrator. Your administrator is the person who provided you with your sign-in credentials.

## I want to view my access keys

After you create your IAM user access keys, you can view your access key ID at any time. However, you can't view your secret access key again. If you lose your secret key, you must create a new access key pair.

Access keys consist of two parts: an access key ID (for example, `AKIAIOSFODNN7EXAMPLE`) and a secret access key (for example, `wJalrXUtnFEMI/K7MDENG/bPxRfiCYEXAMPLEKEY`). Like a user name and password, you must use both the access key ID and secret access key together to authenticate your requests. Manage your access keys as securely as you do your user name and password.

> **Important**
> Do not provide your access keys to a third party, even to help find your canonical user ID. By doing this, you might give someone permanent access to your account.

When you create an access key pair, you are prompted to save the access key ID and secret access key in a secure location. The secret access key is available only at the time you create it. If you lose your secret access key, you must add new access keys to your IAM user. You can have a maximum of two access keys. If you already have two, you must delete one key pair before creating a new one. To view instructions, see Managing access keys in the *IAM User Guide*.

## I'm an administrator and want to allow others to access Lambda

To allow others to access Lambda, you must create an IAM entity (user or role) for the person or application that needs access. They will use the credentials for that entity to access AWS. You must then attach a policy to the entity that grants them the correct permissions in Lambda.

To get started right away, see Creating your first IAM delegated user and group in the *IAM User Guide*.

## I'm an administrator and want to migrate from AWS managed policies for Lambda that will be deprecated

After March 1, 2021, the AWS managed policies **AWSLambdaReadOnlyAccess** and **AWSLambdaFullAccess** will be deprecated and can no longer be attached to new IAM users. For more information about policy deprecations, see Deprecated AWS managed policies in the *IAM User Guide*.

Lambda has introduced two new AWS managed policies:

- The **AWSLambda_ReadOnlyAccess** policy grants read-only access to Lambda, Lambda console features, and other related AWS services. This policy was created by scoping down the previous policy **AWSLambdaReadOnlyAccess**.
- The **AWSLambda_FullAccess** policy grants full access to Lambda, Lambda console features, and other related AWS services. This policy was created by scoping down the previous policy **AWSLambdaFullAccess**.

### Using the AWS managed policies

We recommend using the newly launched managed policies to grant users, groups, and roles access to Lambda; however, review the permissions granted in the policies to ensure they meet your requirements.

- To review the permissions of the **AWSLambda_ReadOnlyAccess** policy, see the AWSLambda_ReadOnlyAccess policy page in the IAM console.
- To review the permissions of the **AWSLambda_FullAccess** policy, see the AWSLambda_FullAccess policy page in the IAM console.

After reviewing the permissions, you can attach the policies to an IAM identity (groups, users, or roles). For instructions about attaching an AWS managed policy, see Adding and removing IAM identity permissions in the *IAM User Guide*.

### Using customer managed policies

If you need more fine-grained access control or would like to add permissions, you can create your own customer managed policies. For more information, see Creating policies on the JSON tab in the *IAM User Guide*.

## I want to allow people outside of my AWS account to access my Lambda resources

You can create a role that users in other accounts or people outside of your organization can use to access your resources. You can specify who is trusted to assume the role. For services that support resource-based policies or access control lists (ACLs), you can use those policies to grant people access to your resources.

To learn more, consult the following:

- To learn whether Lambda supports these features, see How AWS Lambda works with IAM (p. 742).
- To learn how to provide access to your resources across AWS accounts that you own, see Providing access to an IAM user in another AWS account that you own in the *IAM User Guide*.
- To learn how to provide access to your resources to third-party AWS accounts, see Providing access to AWS accounts owned by third parties in the *IAM User Guide*.
- To learn how to provide access through identity federation, see Providing access to externally authenticated users (identity federation) in the *IAM User Guide*.
- To learn the difference between using roles and resource-based policies for cross-account access, see How IAM roles differ from resource-based policies in the *IAM User Guide*.

# Compliance validation for AWS Lambda

Third-party auditors assess the security and compliance of AWS Lambda as part of multiple AWS compliance programs. These include SOC, PCI, FedRAMP, HIPAA, and others.

For a list of AWS services in scope of specific compliance programs, see AWS services in scope by compliance program. For general information, see AWS compliance programs.

You can download third-party audit reports using AWS Artifact. For more information, see Downloading reports in AWS artifact.

Your compliance responsibility when using Lambda is determined by the sensitivity of your data, your company's compliance objectives, and applicable laws and regulations. AWS provides the following resources to help with compliance:

- Security and compliance quick start guides – These deployment guides discuss architectural considerations and provide steps for deploying security- and compliance-focused baseline environments on AWS.
- Architecting for HIPAA security and compliance whitepaper – This whitepaper describes how companies can use AWS to create HIPAA-compliant applications.
- AWS compliance resources – This collection of workbooks and guides might apply to your industry and location.

- AWS Config – This AWS service assesses how well your resource configurations comply with internal practices, industry guidelines, and regulations.
- AWS Security Hub – This AWS service provides a comprehensive view of your security state within AWS that helps you check your compliance with security industry standards and best practices.

# Resilience in AWS Lambda

The AWS global infrastructure is built around AWS Regions and Availability Zones. AWS Regions provide multiple physically separated and isolated Availability Zones, which are connected with low-latency, high-throughput, and highly redundant networking. With Availability Zones, you can design and operate applications and databases that automatically fail over between Availability Zones without interruption. Availability Zones are more highly available, fault tolerant, and scalable than traditional single or multiple data center infrastructures.

For more information about AWS Regions and Availability Zones, see AWS global infrastructure.

In addition to the AWS global infrastructure, Lambda offers several features to help support your data resiliency and backup needs.

- **Versioning** – You can use versioning in Lambda to save your function's code and configuration as you develop it. Together with aliases, you can use versioning to perform blue/green and rolling deployments. For details, see Lambda function versions (p. 173).
- **Scaling** – When your function receives a request while it's processing a previous request, Lambda launches another instance of your function to handle the increased load. Lambda automatically scales to handle 1,000 concurrent executions per Region, a quota (p. 796) that can be increased if needed. For details, see Lambda function scaling (p. 30).
- **High availability** – Lambda runs your function in multiple Availability Zones to ensure that it is available to process events in case of a service interruption in a single zone. If you configure your function to connect to a virtual private cloud (VPC) in your account, specify subnets in multiple Availability Zones to ensure high availability. For details, see Configuring a Lambda function to access resources in a VPC (p. 191).
- **Reserved concurrency** – To make sure that your function can always scale to handle additional requests, you can reserve concurrency for it. Setting reserved concurrency for a function ensures that it can scale to, but not exceed, a specified number of concurrent invocations. This ensures that you don't lose requests due to other functions consuming all of the available concurrency. For details, see Managing Lambda reserved concurrency (p. 180).
- **Retries** – For asynchronous invocations and a subset of invocations triggered by other services, Lambda automatically retries on error with delays between retries. Other clients and AWS services that invoke functions synchronously are responsible for performing retries. For details, see Error handling and automatic retries in AWS Lambda (p. 250).
- **Dead-letter queue** – For asynchronous invocations, you can configure Lambda to send requests to a dead-letter queue if all retries fail. A dead-letter queue is an Amazon SNS topic or Amazon SQS queue that receives events for troubleshooting or reprocessing. For details, see Dead-letter queues (p. 234).

# Infrastructure security in AWS Lambda

As a managed service, AWS Lambda is protected by the AWS global network security procedures that are described in the Best Practices for Security, Identity, and Compliance.

You use AWS published API calls to access Lambda through the network. Clients must support Transport Layer Security (TLS) 1.0 or later. We recommend TLS 1.2 or later. Clients must also support cipher suites with perfect forward secrecy (PFS) such as Ephemeral Diffie-Hellman (DHE) or Elliptic Curve Ephemeral Diffie-Hellman (ECDHE). Most modern systems such as Java 7 and later support these modes.

Additionally, requests must be signed by using an access key ID and a secret access key that is associated with an IAM principal. Or you can use the AWS Security Token Service (AWS STS) to generate temporary security credentials to sign requests.

# Configuration and vulnerability analysis in AWS Lambda

AWS Lambda provides runtimes (p. 82) that run your function code in an Amazon Linux–based execution environment. Lambda is responsible for keeping software in the runtime and execution environment up to date, releasing new runtimes for new languages and frameworks, and deprecating runtimes when the underlying software is no longer supported.

If you use additional libraries with your function, you're responsible for updating the libraries. You can include additional libraries in the deployment package (p. 143), or in layers (p. 156) that you attach to your function. You can also build custom runtimes (p. 90) and use layers to share them with other accounts.

Lambda deprecates runtimes when the software on the runtime or its execution environment reaches end of life. When Lambda deprecates a runtime, you're responsible for migrating your functions to a supported runtime for the same language or framework. For details, see Runtime deprecation policy (p. 83).

# Troubleshooting issues in Lambda

The following topics provide troubleshooting advice for errors and issues that you might encounter when using the Lambda API, console, or tools. If you find an issue that is not listed here, you can use the **Feedback** button on this page to report it.

For more troubleshooting advice and answers to common support questions, visit the AWS Knowledge Center.

For more information about debugging and troubleshooting Lambda applications, see Debugging in the *Lambda operator guide*.

**Topics**


- Troubleshoot deployment issues in Lambda (p. 749)
- Troubleshoot invocation issues in Lambda (p. 752)
- Troubleshoot execution issues in Lambda (p. 755)
- Troubleshoot networking issues in Lambda (p. 757)
- Troubleshoot container image issues in Lambda (p. 758)


## Troubleshoot deployment issues in Lambda

When you update your function, Lambda deploys the change by launching new instances of the function with the updated code or settings. Deployment errors prevent the new version from being used and can arise from issues with your deployment package, code, permissions, or tools.

When you deploy updates to your function directly with the Lambda API or with a client such as the AWS CLI, you can see errors from Lambda directly in the output. If you use services like AWS CloudFormation, AWS CodeDeploy, or AWS CodePipeline, look for the response from Lambda in the logs or event stream for that service.

### General: Permission is denied / Cannot load such file

**Error:** *EACCES: permission denied, open '/var/task/index.js'*

**Error:** *cannot load such file -- function*

**Error:** *[Errno 13] Permission denied: '/var/task/function.py'*

The Lambda runtime needs permission to read the files in your deployment package. You can use the `chmod` command to change the file mode. The following example commands make all files and folders in the current directory readable by any user.

```
chmod -R o+rX .
```

### General: Error occurs when calling the UpdateFunctionCode

**Error:** *An error occurred (RequestEntityTooLargeException) when calling the UpdateFunctionCode operation*

When you upload a deployment package or layer archive directly to Lambda, the size of the ZIP file is limited to 50 MB. To upload a larger file, store it in Amazon S3 and use the S3Bucket and S3Key parameters.

> **Note**
> When you upload a file directly with the AWS CLI, AWS SDK, or otherwise, the binary ZIP file is converted to base64, which increases its size by about 30%. To allow for this, and the size of other parameters in the request, the actual request size limit that Lambda applies is larger. Due to this, the 50 MB limit is approximate.

# Amazon S3: Error Code PermanentRedirect.

**Error:** *Error occurred while GetObject. S3 Error Code: PermanentRedirect. S3 Error Message: The bucket is in this region: us-east-2. Please use this region to retry the request*

When you upload a function's deployment package from an Amazon S3 bucket, the bucket must be in the same Region as the function. This issue can occur when you specify an Amazon S3 object in a call to UpdateFunctionCode (p. 1088), or use the package and deploy commands in the AWS CLI or AWS SAM CLI. Create a deployment artifact bucket for each Region where you develop applications.

# General: Cannot find, cannot load, unable to import, class not found, no such file or directory

**Error:** *Cannot find module 'function'*

**Error:** *cannot load such file -- function*

**Error:** *Unable to import module 'function'*

**Error:** *Class not found: function.Handler*

**Error:** *fork/exec /var/task/function: no such file or directory*

**Error:** *Unable to load type 'Function.Handler' from assembly 'Function'.*

The name of the file or class in your function's handler configuration doesn't match your code. See the following entry for more information.

# General: Undefined method handler

**Error:** *index.handler is undefined or not exported*

**Error:** *Handler 'handler' missing on module 'function'*

**Error:** *undefined method `handler' for #<LambdaHandler:0x000055b76ccebf98>*

**Error:** *No public method named handleRequest with appropriate method signature found on class function.Handler*

**Error:** *Unable to find method 'handleRequest' in type 'Function.Handler' from assembly 'Function'*

The name of the handler method in your function's handler configuration doesn't match your code. Each runtime defines a naming convention for handlers, such as `filename.methodname`. The handler is the method in your function's code that the runtime runs when your function is invoked.

For some languages, Lambda provides a library with an interface that expects a handler method to have a specific name. For details about handler naming for each language, see the following topics.

- Building Lambda functions with Node.js (p. 282)
- Building Lambda functions with Python (p. 324)
- Building Lambda functions with Ruby (p. 354)
- Building Lambda functions with Java (p. 379)
- Building Lambda functions with Go (p. 420)
- Building Lambda functions with C# (p. 449)
- Building Lambda functions with PowerShell (p. 481)

# Lambda: InvalidParameterValueException or RequestEntityTooLargeException

**Error:** *InvalidParameterValueException: Lambda was unable to configure your environment variables because the environment variables you have provided exceeded the 4KB limit. String measured: {"A1":"uSFeY5cyPiPn7AtnX5BsM...*

**Error:** *RequestEntityTooLargeException: Request must be smaller than 5120 bytes for the UpdateFunctionConfiguration operation*

The maximum size of the variables object that is stored in the function's configuration must not exceed 4096 bytes. This includes key names, values, quotes, commas, and brackets. The total size of the HTTP request body is also limited.

```
{
    "FunctionName": "my-function",
    "FunctionArn": "arn:aws:lambda:us-east-2:123456789012:function:my-function",
    "Runtime": "nodejs16.x",
    "Role": "arn:aws:iam::123456789012:role/lambda-role",
    "Environment": {
        "Variables": {
            "BUCKET": "my-bucket",
            "KEY": "file.txt"
        }
    },
    ...
}
```

In this example, the object is 39 characters and takes up 39 bytes when it's stored (without white space) as the string `{"BUCKET":"my-bucket","KEY":"file.txt"}`. Standard ASCII characters in environment variable values use one byte each. Extended ASCII and Unicode characters can use between 2 bytes and 4 bytes per character.

# Lambda: InvalidParameterValueException

**Error:** *InvalidParameterValueException: Lambda was unable to configure your environment variables because the environment variables you have provided contains reserved keys that are currently not supported for modification.*

Lambda reserves some environment variable keys for internal use. For example, `AWS_REGION` is used by the runtime to determine the current Region and cannot be overridden. Other variables, like `PATH`, are used by the runtime but can be extended in your function configuration. For a full list, see Defined runtime environment variables (p. 169).

## Lambda: Concurrency and memory quotas

**Error:** *Specified ConcurrentExecutions for function decreases account's UnreservedConcurrentExecution below its minimum value*

**Error:** *'MemorySize' value failed to satisfy constraint: Member must have value less than or equal to 3008*

These errors occur when you exceed the concurrency or memory quotas (p. 796) for your account. New AWS accounts have reduced concurrency and memory quotas. AWS raises these quotas automatically based on your usage. To resolve these errors, you can request a quota increase.

- **Concurrency:** You might get an error if you try to create a function using reserved or provisioned concurrency, or if your per-function concurrency request (PutFunctionConcurrency (p. 1053)) exceeds your account's concurrency quota.
- **Memory:** Errors occur if the amount of memory allocated to the function exceeds your account's memory quota.

# Troubleshoot invocation issues in Lambda

When you invoke a Lambda function, Lambda validates the request and checks for scaling capacity before sending the event to your function or, for asynchronous invocation, to the event queue. Invocation errors can be caused by issues with request parameters, event structure, function settings, user permissions, resource permissions, or limits.

If you invoke your function directly, you see any invocation errors in the response from Lambda. If you invoke your function asynchronously with an event source mapping or through another service, you might find errors in logs, a dead-letter queue, or a failed-event destination. Error handling options and retry behavior vary depending on how you invoke your function and on the type of error.

For a list of error types that the `Invoke` operation can return, see Invoke (p. 993).

## IAM: lambda:InvokeFunction not authorized

**Error:** *User: arn:aws:iam::123456789012:user/developer is not authorized to perform: lambda:InvokeFunction on resource: my-function*

Your AWS Identity and Access Management (IAM) user, or the role that you assume, must have permission to invoke a function. This requirement also applies to Lambda functions and other compute resources that invoke functions. Add the AWS managed policy **AWSLambdaRole** to your IAM user, or add a custom policy that allows the `lambda:InvokeFunction` action on the target function.

> **Note**
> Unlike other Lambda API operations, the name of the IAM action (`lambda:InvokeFunction`) doesn't match the name of the API operation (`Invoke`) for invoking a function.

For more information, see Lambda permissions (p. 51).

## Lambda: Operation cannot be performed ResourceConflictException

**Error:** *ResourceConflictException: The operation cannot be performed at this time. The function is currently in the following state: Pending*

When you connect a function to a virtual private cloud (VPC) at the time of creation, the function enters a `Pending` state while Lambda creates elastic network interfaces. During this time, you can't invoke or

modify your function. If you connect your function to a VPC after creation, you can invoke it while the update is pending, but you can't modify its code or configuration.

For more information, see Lambda function states (p. 248).

# Lambda: Function is stuck in Pending

**Error:** *A function is stuck in the* `Pending` *state for several minutes.*

If a function is stuck in the `Pending` state for more than six minutes, call one of the following API operations to unblock it:

- UpdateFunctionCode (p. 1088)
- UpdateFunctionConfiguration (p. 1098)
- PublishVersion (p. 1042)

Lambda cancels the pending operation and puts the function into the `Failed` state. You can then delete the function and recreate it, or attempt another update.

# Lambda: One function is using all concurrency

**Issue:** *One function is using all of the available concurrency, causing other functions to be throttled.*

To divide your AWS account's available concurrency in an AWS Region into pools, use reserved concurrency (p. 180). Reserved concurrency ensures that a function can always scale to its assigned concurrency, and that it doesn't scale beyond its assigned concurrency.

# General: Cannot invoke function with other accounts or services

**Issue:** *You can invoke your function directly, but it doesn't run when another service or account invokes it.*

You grant other services (p. 496) and accounts permission to invoke a function in the function's resource-based policy (p. 68). If the invoker is in another account, that user must also have permission to invoke functions (p. 59).

# General: Function invocation is looping

**Issue:** *Function is invoked continuously in a loop.*

This typically occurs when your function manages resources in the same AWS service that triggers it. For example, it's possible to create a function that stores an object in an Amazon Simple Storage Service (Amazon S3) bucket that's configured with a notification that invokes the function again (p. 663). To stop the function from running, on the function configuration page (p. 162), choose **Throttle**. Then, identify the code path or configuration error that caused the recursive invocation.

# Lambda: Alias routing with provisioned concurrency

**Issue:** *Provisioned concurrency spillover invocations during alias routing.*

Lambda uses a simple probabilistic model to distribute the traffic between the two function versions. At low traffic levels, you might see a high variance between the configured and actual percentage of traffic on each version. If your function uses provisioned concurrency, you can avoid spillover

invocations (p. 728) by configuring a higher number of provisioned concurrency instances during the time that alias routing is active.

# Lambda: Cold starts with provisioned concurrency

**Issue:** *You see cold starts after enabling provisioned concurrency.*

When the number of concurrent executions on a function is less than or equal to the configured level of provisioned concurrency (p. 183), there shouldn't be any cold starts. To help you confirm if provisioned concurrency is operating normally, do the following:

- Check that provisioned concurrency is enabled (p. 183) on the function version or alias.

  **Note**
  Provisioned concurrency is not configurable on the $LATEST version (p. 141).
- Ensure that your triggers invoke the correct function version or alias. For example, if you're using Amazon API Gateway, check that API Gateway invokes the function version or alias with provisioned concurrency, not $LATEST. To confirm that provisioned concurrency is being used, you can check the ProvisionedConcurrencyInvocations Amazon CloudWatch metric (p. 728). A non-zero value indicates that the function is processing invocations on initialized execution environments.
- Determine whether your function concurrency exceeds the configured level of provisioned concurrency by checking the ProvisionedConcurrencySpilloverInvocations CloudWatch metric (p. 728). A non-zero value indicates that all provisioned concurrency is in use and some invocation occurred with a cold start.
- Check your invocation frequency (p. 796) (requests per second). Functions with provisioned concurrency have a maximum rate of 10 requests per second per provisioned concurrency. For example, a function configured with 100 provisioned concurrency can handle 1,000 requests per second. If the invocation rate exceeds 1,000 requests per second, some cold starts can occur.

  **Note**
  There is a known issue in which the first invocation on an initialized execution environment reports a non-zero **Init Duration** metric in CloudWatch Logs, even though no cold start has occurred. We're developing a fix to correct the reporting to CloudWatch Logs.

# Lambda: Latency variability with provisioned concurrency

**Issue:** *You see latency variability on the first invocation after enabling provisioned concurrency.*

Depending on your function's runtime and memory configuration, it's possible to see some latency variability on the first invocation on an initialized execution environment. For example, .NET and other JIT runtimes can lazily load resources on the first invocation, leading to some latency variability (typically tens of milliseconds). This variability is more apparent on 128-MiB functions. You mitigate this by increasing the function's configured memory.

# Lambda: Cold starts with new versions

**Issue:** *You see cold starts while deploying new versions of your function.*

When you update a function alias, Lambda automatically shifts provisioned concurrency to the new version based on the weights configured on the alias.

**Error:** *KMSDisabledException: Lambda was unable to decrypt the environment variables because the KMS key used is disabled. Please check the function's KMS key settings.*

This error can occur if your AWS Key Management Service (AWS KMS) key is disabled, or if the grant that allows Lambda to use the key is revoked. If the grant is missing, configure the function to use a different key. Then, reassign the custom key to recreate the grant.

## EFS: Function could not mount the EFS file system

**Error:** *EFSMountFailureException: The function could not mount the EFS file system with access point arn:aws:elasticfilesystem:us-east-2:123456789012:access-point/fsap-015cxmplb72b405fd.*

The mount request to the function's file system (p. 206) was rejected. Check the function's permissions, and confirm that its file system and access point exist and are ready for use.

## EFS: Function could not connect to the EFS file system

**Error:** *EFSMountConnectivityException: The function couldn't connect to the Amazon EFS file system with access point arn:aws:elasticfilesystem:us-east-2:123456789012:access-point/fsap-015cxmplb72b405fd. Check your network configuration and try again.*

The function couldn't establish a connection to the function's file system (p. 206) with the NFS protocol (TCP port 2049). Check the security group and routing configuration for the VPC's subnets.

## EFS: Function could not mount the EFS file system due to timeout

**Error:** *EFSMountTimeoutException: The function could not mount the EFS file system with access point {arn:aws:elasticfilesystem:us-east-2:123456789012:access-point/fsap-015cxmplb72b405fd} due to mount time out.*

The function could connect to the function's file system (p. 206), but the mount operation timed out. Try again after a short time and consider limiting the function's concurrency (p. 180) to reduce load on the file system.

## Lambda: Lambda detected an IO process that was taking too long

*EFSIOException: This function instance was stopped because Lambda detected an IO process that was taking too long.*

A previous invocation timed out and Lambda couldn't terminate the function handler. This issue can occur when an attached file system runs out of burst credits and the baseline throughput is insufficient. To increase throughput, you can increase the size of the file system or use provisioned throughput. For more information, see Throughput (p. 596).

# Troubleshoot execution issues in Lambda

When the Lambda runtime runs your function code, the event might be processed on an instance of the function that's been processing events for some time, or it might require a new instance to be initialized. Errors can occur during function initialization, when your handler code processes the event, or when your function returns (or fails to return) a response.

Function execution errors can be caused by issues with your code, function configuration, downstream resources, or permissions. If you invoke your function directly, you see function errors in the response from Lambda. If you invoke your function asynchronously, with an event source mapping, or through another service, you might find errors in logs, a dead-letter queue, or an on-failure destination. Error handling options and retry behavior vary depending on how you invoke your function and on the type of error.

When your function code or the Lambda runtime return an error, the status code in the response from Lambda is 200 OK. The presence of an error in the response is indicated by a header named `X-Amz-Function-Error`. 400 and 500-series status codes are reserved for invocation errors (p. 752).

# Lambda: Execution takes too long

**Issue:** *Function execution takes too long.*

If your code takes much longer to run in Lambda than on your local machine, it may be constrained by the memory or processing power available to the function. Configure the function with additional memory (p. 162) to increase both memory and CPU.

# Lambda: Logs or traces don't appear

**Issue:** *Logs don't appear in CloudWatch Logs.*

**Issue:** *Traces don't appear in AWS X-Ray.*

Your function needs permission to call CloudWatch Logs and X-Ray. Update its execution role (p. 52) to grant it permission. Add the following managed policies to enable logs and tracing.

- **AWSLambdaBasicExecutionRole**
- **AWSXRayDaemonWriteAccess**

When you add permissions to your function, update its code or configuration as well. This forces running instances of your function, which have outdated credentials, to stop and be replaced.

> **Note**
> It may take 5 to 10 minutes for logs to show up after a function invocation.

# Lambda: The function returns before execution finishes

**Issue: (Node.js)** *Function returns before code finishes executing*

Many libraries, including the AWS SDK, operate asynchronously. When you make a network call or perform another operation that requires waiting for a response, libraries return an object called a promise that tracks the progress of the operation in the background.

To wait for the promise to resolve into a response, use the `await` keyword. This blocks your handler code from executing until the promise is resolved into an object that contains the response. If you don't need to use the data from the response in your code, you can return the promise directly to the runtime.

Some libraries don't return promises but can be wrapped in code that does. For more information, see AWS Lambda function handler in Node.js (p. 285).

# AWS SDK: Versions and updates

**Issue:** *The AWS SDK included on the runtime is not the latest version*

**Issue:** *The AWS SDK included on the runtime updates automatically*

Runtimes for scripting languages include the AWS SDK and are periodically updated to the latest version. The current version for each runtime is listed on runtimes page (p. 82). To use a newer version of the AWS SDK, or to lock your functions to a specific version, you can bundle the library with your function code, or create a Lambda layer (p. 156). For details on creating a deployment package with dependencies, see the following topics:

Node.js

- Deploy Node.js Lambda functions with .zip file archives (p. 288)

Python

- Deploy Python Lambda functions with .zip file archives (p. 330)

Ruby

- Deploy Ruby Lambda functions with .zip file archives (p. 358)

Java

- Deploy Java Lambda functions with .zip or JAR file archives (p. 386)

Go

- Deploy Go Lambda functions with .zip file archives (p. 427)

C#

- Deploy C# Lambda functions with .zip file archives (p. 458)

PowerShell

- Deploy PowerShell Lambda functions with .zip file archives (p. 483)

## Python: Libraries load incorrectly

**Issue:** (Python) *Some libraries don't load correctly from the deployment package*

Libraries with extension modules written in C or C++ must be compiled in an environment with the same processor architecture as Lambda (Amazon Linux). For more information, see Deploy Python Lambda functions with .zip file archives (p. 330).

# Troubleshoot networking issues in Lambda

By default, Lambda runs your functions in an internal virtual private cloud (VPC) with connectivity to AWS services and the internet. To access local network resources, you can configure your function to connect to a VPC in your account (p. 191). When you use this feature, you manage the function's internet access and network connectivity with Amazon Virtual Private Cloud (Amazon VPC) resources.

Network connectivity errors can result from issues with your VPC's routing configuration, security group rules, AWS Identity and Access Management (IAM) role permissions, or network address translation (NAT), or from the availability of resources such as IP addresses or network interfaces. Depending on the issue, you might see a specific error or timeout if a request can't reach its destination.

## VPC: Function loses internet access or times out

**Issue:** *Your Lambda function loses internet access after connecting to a VPC.*

**Error:** *Error: connect ETIMEDOUT 176.32.98.189:443*

**Error:** *Error: Task timed out after 10.00 seconds*

**Error:** *ReadTimeoutError: Read timed out. (read timeout=15)*

When you connect a function to a VPC, all outbound requests go through the VPC. To connect to the internet, configure your VPC to send outbound traffic from the function's subnet to a NAT gateway in a public subnet. For more information and sample VPC configurations, see Internet and service access for VPC-connected functions (p. 197).

If some of your TCP connections are timing out, this may be due to packet fragmentation. Lambda functions cannot handle incoming fragmented TCP requests, since Lambda does not support IP fragmentation for TCP or ICMP.

### VPC: Function needs access to AWS services without using the internet

**Issue:** *Your Lambda function needs access to AWS services without using the internet.*

To connect a function to AWS services from a private subnet with no internet access, use VPC endpoints. For a sample AWS CloudFormation template with VPC endpoints for Amazon Simple Storage Service (Amazon S3) and Amazon DynamoDB (DynamoDB), see Sample VPC configurations (p. 197).

### VPC: Elastic network interface limit reached

**Error:** *ENILimitReachedException: The elastic network interface limit was reached for the function's VPC.*

When you connect a Lambda function to a VPC, Lambda creates an elastic network interface for each combination of subnet and security group attached to the function. The default service quota is 250 network interfaces per VPC. To request a quota increase, use the Service Quotas console.

## Troubleshoot container image issues in Lambda

### Container: CodeArtifactUserException errors related to the code artifact.

**Issue:** *CodeArtifactUserPendingException error message*

The CodeArtifact is pending optimization. The function transitions to active state when Lambda completes the optimization. HTTP response code 409.

**Issue:** *CodeArtifactUserDeletedException error message*

The CodeArtifact is scheduled to be deleted. HTTP response code 409.

**Issue:** *CodeArtifactUserFailedException error message*

Lambda failed to optimize the code. You need to correct the code and upload it again. HTTP response code 409.

### Container: ManifestKeyCustomerException errors related to the code manifest key.

**Issue:** *KMSAccessDeniedException error message*

You do not have permissions to access the key to decrypt the manifest. HTTP response code 502.

**Issue:** *TooManyRequestsException error message*

The client is being throttled. The current request rate exceeds the KMS subscription rate. HTTP response code 429.

**Issue:** *KMSNotFoundException error message*

Lambda cannot find the key to decrypt the manifest. HTTP response code 502.

**Issue:** *KMSDisabledException error message*

The key to decrypt the manifest is disabled. HTTP response code 502.

**Issue:** *KMSInvalidStateException error message*

The key is in a state (such as pending deletion or unavailable) such that Lambda cannot use the key to decrypt the manifest. HTTP response code 502.

# Container: Error occurs on runtime InvalidEntrypoint

**Issue:** *You receive a Runtime.ExitError error message, or an error message with `"errorType": "Runtime.InvalidEntrypoint"`.*

Verify that the ENTRYPOINT to your container image includes the absolute path as the location. Also verify that the image does not contain a symlink as the ENTRYPOINT.

# Lambda: System provisioning additional capacity

**Error:** *"Error: We currently do not have sufficient capacity in the region you requested. Our system will be working on provisioning additional capacity.*

Retry the function invocation. If the retry fails, validate that the files required to run the function code can be read by any user. Lambda defines a default Linux user with least-privileged permissions. You need to verify that your application code does not rely on files that are restricted by other Linux users for execution.

# CloudFormation: ENTRYPOINT is being overridden with a null or empty value

**Error:** *You are using an AWS CloudFormation template, and your container ENTRYPOINT is being overridden with a null or empty value.*

Review the `ImageConfig` resource in the AWS CloudFormation template. If you declare an `ImageConfig` resource in your template, you must provide non-empty values for all three of the properties.

# AWS Lambda applications

An AWS Lambda application is a combination of Lambda functions, event sources, and other resources that work together to perform tasks. You can use AWS CloudFormation and other tools to collect your application's components into a single package that can be deployed and managed as one resource. Applications make your Lambda projects portable and enable you to integrate with additional developer tools, such as AWS CodePipeline, AWS CodeBuild, and the AWS Serverless Application Model command line interface (SAM CLI).

The AWS Serverless Application Repository provides a collection of Lambda applications that you can deploy in your account with a few clicks. The repository includes both ready-to-use applications and samples that you can use as a starting point for your own projects. You can also submit your own projects for inclusion.

AWS CloudFormation enables you to create a template that defines your application's resources and lets you manage the application as a *stack*. You can more safely add or modify resources in your application stack. If any part of an update fails, AWS CloudFormation automatically rolls back to the previous configuration. With AWS CloudFormation parameters, you can create multiple environments for your application from the same template. AWS SAM (p. 5) extends AWS CloudFormation with a simplified syntax focused on Lambda application development.

The AWS CLI (p. 5) and SAM CLI (p. 6) are command line tools for managing Lambda application stacks. In addition to commands for managing application stacks with the AWS CloudFormation API, the AWS CLI supports higher-level commands that simplify tasks like uploading deployment packages and updating templates. The AWS SAM CLI provides additional functionality, including validating templates, testing locally, and integrating with CI/CD systems.

When creating an application, you can create its Git repository using either CodeCommit or an AWS CodeStar connection to GitHub. CodeCommit enables you to use the IAM console to manage SSH keys and HTTP credentials for your users. AWS CodeStar connections enables you to connect to your GitHub account. For more information about connections, see What are connections? in the *Developer Tools console User Guide*.

For more information about designing Lambda applications, see Application design in the *Lambda operator guide*.

**Topics**

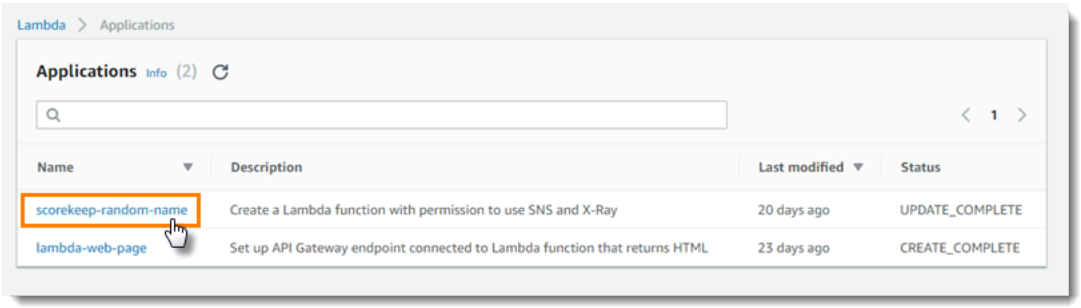

- Managing applications in the AWS Lambda console (p. 761)
- Creating an application with continuous delivery in the Lambda console (p. 764)
- Rolling deployments for Lambda functions (p. 773)
- Invoking Lambda functions with the AWS Mobile SDK for Android (p. 775)

# Managing applications in the AWS Lambda console

The AWS Lambda console helps you monitor and manage your Lambda applications (p. 760). The **Applications** menu lists AWS CloudFormation stacks with Lambda functions. The menu includes stacks that you launch in AWS CloudFormation by using the AWS CloudFormation console, the AWS Serverless Application Repository, the AWS CLI, or the AWS SAM CLI.

### To view a Lambda application

1. Open the Lambda console Applications page.
2. Choose an application.




The overview shows the following information about your application.

- **AWS CloudFormation template** or **SAM template** – The template that defines your application.
- **Resources** – The AWS resources that are defined in your application's template. To manage your application's Lambda functions, choose a function name from the list.

## Monitoring applications

The **Monitoring** tab shows an Amazon CloudWatch dashboard with aggregate metrics for the resources in your application.

### To monitor a Lambda application

1. Open the Lambda console Applications page.
2. Choose **Monitoring**.

By default, the Lambda console shows a basic dashboard. You can customize this page by defining custom dashboards in your application template. When your template includes one or more dashboards, the page shows your dashboards instead of the default dashboard. You can switch between dashboards with the drop-down menu on the top right of the page.

## Custom monitoring dashboards

Customize your application monitoring page by adding one or more Amazon CloudWatch dashboards to your application template with the AWS::CloudWatch::Dashboard resource type. The following example creates a dashboard with a single widget that graphs the number of invocations of a function named `my-function`.

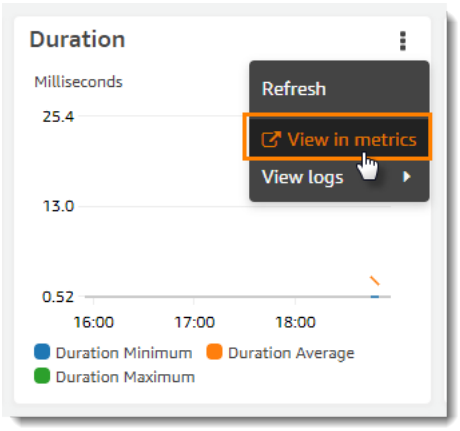
### Example function dashboard template

```
Resources:
  MyDashboard:
    Type: AWS::CloudWatch::Dashboard
    Properties:
      DashboardName: my-dashboard
      DashboardBody: |
        {
            "widgets": [
                {
                    "type": "metric",
                    "width": 12,
                    "height": 6,
                    "properties": {
                        "metrics": [
                            [
                                "AWS/Lambda",
                                "Invocations",
                                "FunctionName",
                                "my-function",
                                {
                                    "stat": "Sum",
                                    "label": "MyFunction"
                                }
                            ],
                            [
                                {
                                    "expression": "SUM(METRICS())",
                                    "label": "Total Invocations"
                                }
                            ]
                        ],
                        "region": "us-east-1",
                        "title": "Invocations",
                        "view": "timeSeries",
                        "stacked": false
                    }
                }
            ]
        }
```

You can get the definition for any of the widgets in the default monitoring dashboard from the CloudWatch console.

### To view a widget definition

1. Open the Lambda console Applications page.
2. Choose an application that has the standard dashboard.
3. Choose **Monitoring**.
4. On any widget, choose **View in metrics** from the drop-down menu.




5. Choose **Source**.

For more information about authoring CloudWatch dashboards and widgets, see Dashboard body structure and syntax in the *Amazon CloudWatch API Reference*.

# Creating an application with continuous delivery in the Lambda console

You can use the Lambda console to create an application with an integrated continuous delivery pipeline. With continuous delivery, every change that you push to your source control repository triggers a pipeline that builds and deploys your application automatically. The Lambda console provides starter projects for common application types with Node.js sample code and templates that create supporting resources.

In this tutorial, you create the following resources.

- **Application** – A Node.js Lambda function, build specification, and AWS Serverless Application Model (AWS SAM) template.
- **Pipeline** – An AWS CodePipeline pipeline that connects the other resources to enable continuous delivery.
- **Repository** – A Git repository in AWS CodeCommit. When you push a change, the pipeline copies the source code into an Amazon S3 bucket and passes it to the build project.
- **Trigger** – An Amazon EventBridge (CloudWatch Events) rule that watches the main branch of the repository and triggers the pipeline.
- **Build project** – An AWS CodeBuild build that gets the source code from the pipeline and packages the application. The source includes a build specification with commands that install dependencies and prepare the application template for deployment.
- **Deployment configuration** – The pipeline's deployment stage defines a set of actions that take the processed AWS SAM template from the build output, and deploy the new version with AWS CloudFormation.
- **Bucket** – An Amazon Simple Storage Service (Amazon S3) bucket for deployment artifact storage.
- **Roles** – The pipeline's source, build, and deploy stages have IAM roles that allow them to manage AWS resources. The application's function has an execution role (p. 52) that allows it to upload logs and can be extended to access other services.

Your application and pipeline resources are defined in AWS CloudFormation templates that you can customize and extend. Your application repository includes a template that you can modify to add Amazon DynamoDB tables, an Amazon API Gateway API, and other application resources. The continuous delivery pipeline is defined in a separate template outside of source control and has its own stack.

The pipeline maps a single branch in a repository to a single application stack. You can create additional pipelines to add environments for other branches in the same repository. You can also add stages to your pipeline for testing, staging, and manual approvals. For more information about AWS CodePipeline, see What is AWS CodePipeline.

**Sections**

- Prerequisites (p. 765)
- Create an application (p. 765)
- Invoke the function (p. 766)
- Add an AWS resource (p. 767)
- Update the permissions boundary (p. 769)
- Update the function code (p. 769)
- Next steps (p. 770)
- Troubleshooting (p. 771)
- Clean up (p. 772)

# Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

This tutorial uses CodeCommit for source control. To set up your local machine to access and update application code, see Setting up in the *AWS CodeCommit User Guide*.

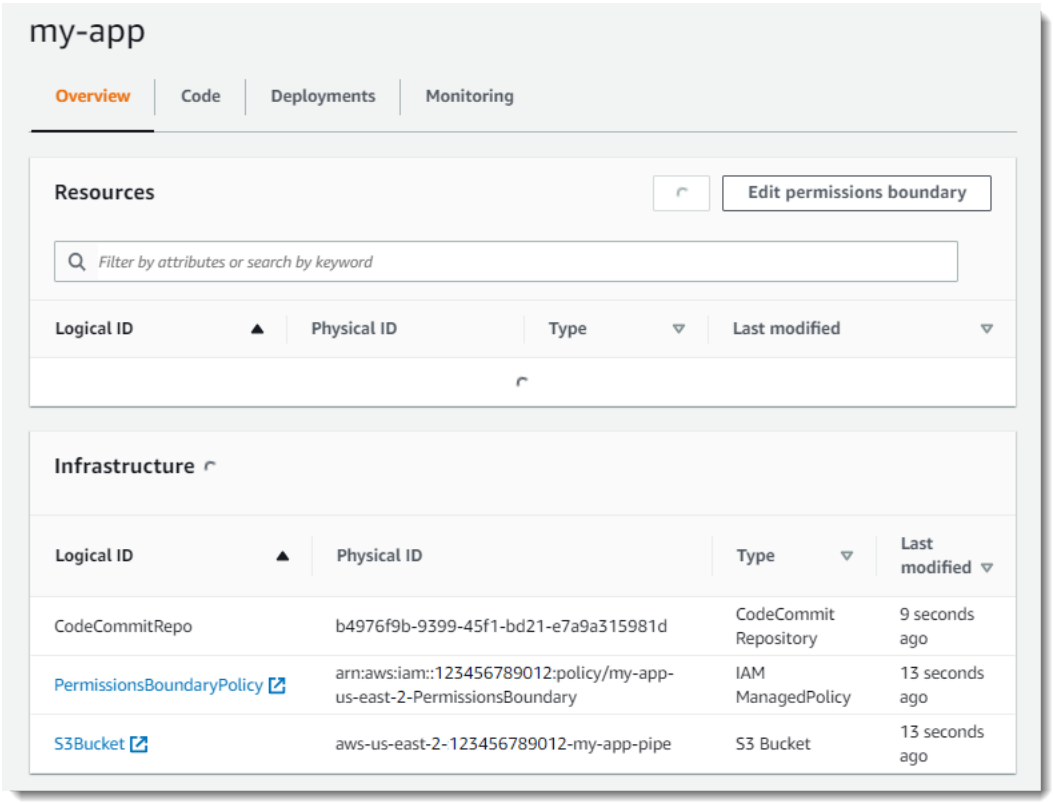
# Create an application

Create an application in the Lambda console. In Lambda, an application is an AWS CloudFormation stack with a Lambda function and any number of supporting resources. In this tutorial, you create an application that has a function and its execution role.

### To create an application

1. Open the Lambda console Applications page.
2. Choose **Create application**.
3. Choose **Author from scratch**.
4. Configure application settings.
   - **Application name** – `my-app`.
   - **Runtime** – **Node.js 14.x**.
   - **Source control service** – **CodeCommit**.
   - **Repository name** – `my-app-repo`.
   - **Permissions** – **Create roles and permissions boundary**.
5. Choose **Create**.

Lambda creates the pipeline and related resources and commits the sample application code to the Git repository. As resources are created, they appear on the overview page.




The **Infrastructure** stack contains the repository, build project, and other resources that combine to form a continuous delivery pipeline. When this stack finishes deploying, it in turn deploys the application stack that contains the function and execution role. These are the application resources that appear under **Resources**.

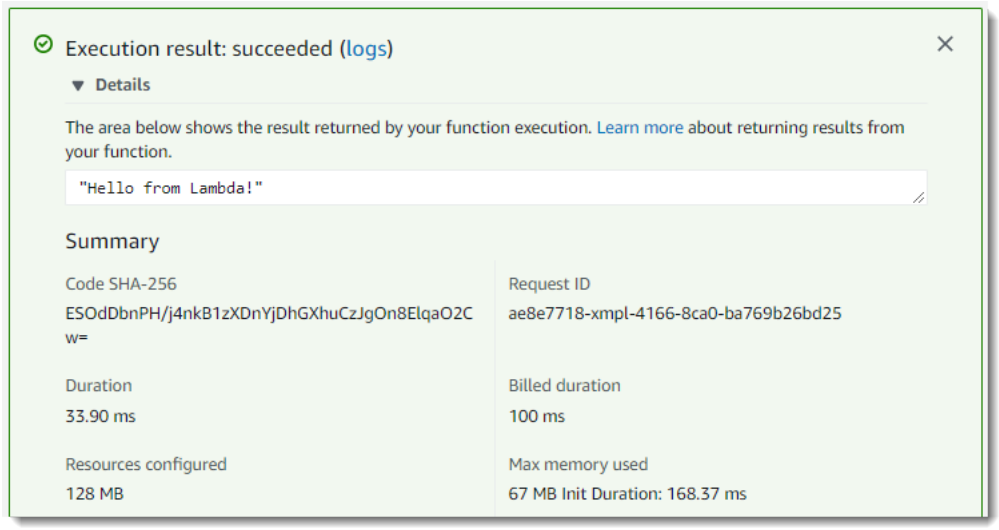
# Invoke the function

When the deployment process completes, invoke the function from the Lambda console.

### To invoke the application's function

1. Open the Lambda console Applications page.
2. Choose **my-app**.
3. Under **Resources**, choose **helloFromLambdaFunction**.
4. Choose **Test**.
5. Configure a test event.
   - **Event name** – `event`
   - **Body** – `{}`
6. Choose **Create**.
7. Choose **Test**.

The Lambda console runs your function and displays the result. Expand the **Details** section under the result to see the output and execution details.




# Add an AWS resource

In the previous step, Lambda console created a Git repository that contains function code, a template, and a build specification. You can add resources to your application by modifying the template and pushing changes to the repository. To get a copy of the application on your local machine, clone the repository.

### To clone the project repository

1. Open the Lambda console Applications page.
2. Choose **my-app**.
3. Choose **Code**.
4. Under **Repository details**, copy the HTTP or SSH repository URI, depending on the authentication mode that you configured during setup (p. 765).
5. To clone the repository, use the `git clone` command.

```
git clone ssh://git-codecommit.us-east-2.amazonaws.com/v1/repos/my-app-repo
```

To add a DynamoDB table to the application, define an `AWS::Serverless::SimpleTable` resource in the template.

### To add a DynamoDB table

1. Open `template.yml` in a text editor.
2. Add a table resource, an environment variable that passes the table name to the function, and a permissions policy that allows the function to manage it.

**Example template.yml - resources**

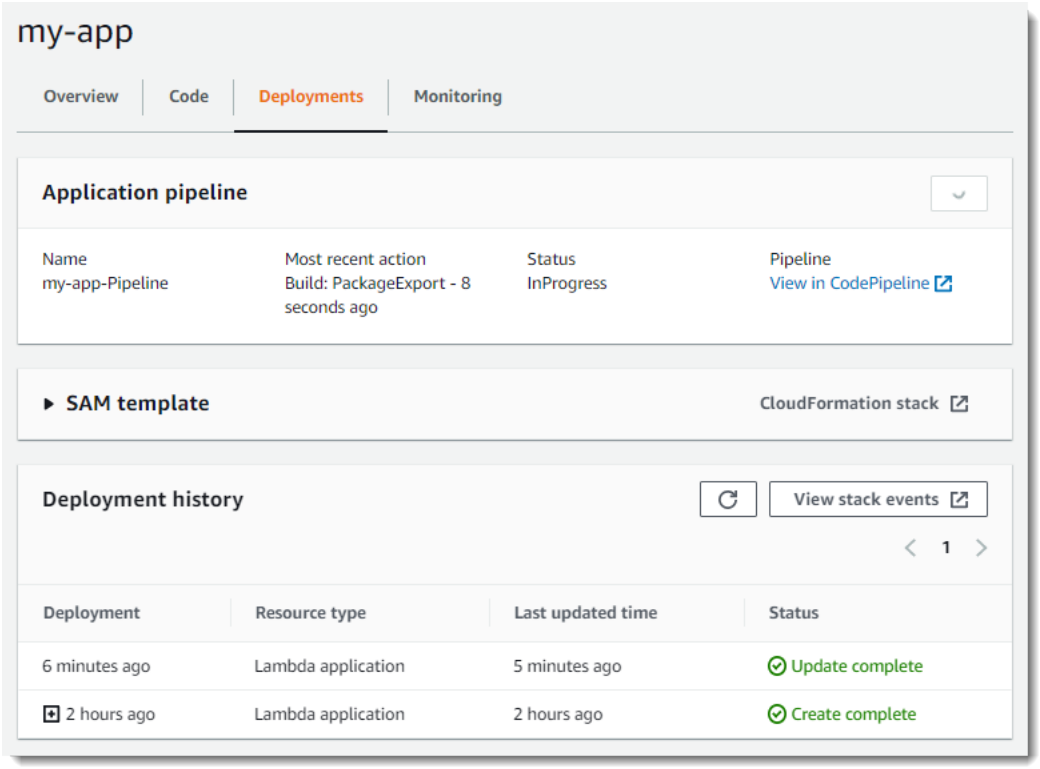
```
...
Resources:
  ddbTable:
    Type: AWS::Serverless::SimpleTable
    Properties:
```

```
      PrimaryKey:
        Name: id
        Type: String
      ProvisionedThroughput:
        ReadCapacityUnits: 1
        WriteCapacityUnits: 1
  helloFromLambdaFunction:
    Type: AWS::Serverless::Function
    Properties:
      CodeUri: ./
      Handler: src/handlers/hello-from-lambda.helloFromLambdaHandler
      Runtime: nodejs14.x
      MemorySize: 128
      Timeout: 60
      Description: A Lambda function that returns a static string.
      Environment:
        Variables:
          DDB_TABLE: !Ref ddbTable
      Policies:
        - DynamoDBCrudPolicy:
            TableName: !Ref ddbTable
        - AWSLambdaBasicExecutionRole
```

3. Commit and push the change.

```
git commit -am "Add DynamoDB table"
git push
```

When you push a change, it triggers the application's pipeline. Use the **Deployments** tab of the application screen to track the change as it flows through the pipeline. When the deployment is complete, proceed to the next step.



# Update the permissions boundary

The sample application applies a *permissions boundary* to its function's execution role. The permissions boundary limits the permissions that you can add to the function's role. Without the boundary, users with write access to the project repository could modify the project template to give the function permission to access resources and services outside of the scope of the sample application.

In order for the function to use the DynamoDB permission that you added to its execution role in the previous step, you must extend the permissions boundary to allow the additional permissions. The Lambda console detects resources that aren't in the permissions boundary and provides an updated policy that you can use to update it.

**To update the application's permissions boundary**

1. Open the Lambda console Applications page.
2. Choose your application.
3. Under **Resources**, choose **Edit permissions boundary**.
4. Follow the instructions shown to update the boundary to allow access to the new table.

For more information about permissions boundaries, see Using permissions boundaries for AWS Lambda applications (p. 80).

# Update the function code

Next, update the function code to use the table. The following code uses the DynamoDB table to track the number of invocations processed by each instance of the function. It uses the log stream ID as a unique identifier for the function instance.

**To update the function code**

1. Add a new handler named `index.js` to the `src/handlers` folder with the following content.

   **Example src/handlers/index.js**

```
const dynamodb = require('aws-sdk/clients/dynamodb');
const docClient = new dynamodb.DocumentClient();

exports.handler = async (event, context) => {
    const message = 'Hello from Lambda!';
    const tableName = process.env.DDB_TABLE;
    const logStreamName = context.logStreamName;
    var params = {
        TableName : tableName,
        Key: { id : logStreamName },
        UpdateExpression: 'set invocations = if_not_exists(invocations, :start)
 + :inc',
        ExpressionAttributeValues: {
            ':start': 0,
            ':inc': 1
        },
        ReturnValues: 'ALL_NEW'
    };
    await docClient.update(params).promise();

    const response = {
        body: JSON.stringify(message)
    };
    console.log(`body: ${response.body}`);
    return response;
```

```
}
```

2. Open the application template and change the handler value to `src/handlers/index.handler`.

**Example template.yml**

```
...
  helloFromLambdaFunction:
    Type: AWS::Serverless::Function
    Properties:
      CodeUri: ./
      Handler: src/handlers/index.handler
      Runtime: nodejs14.x
```

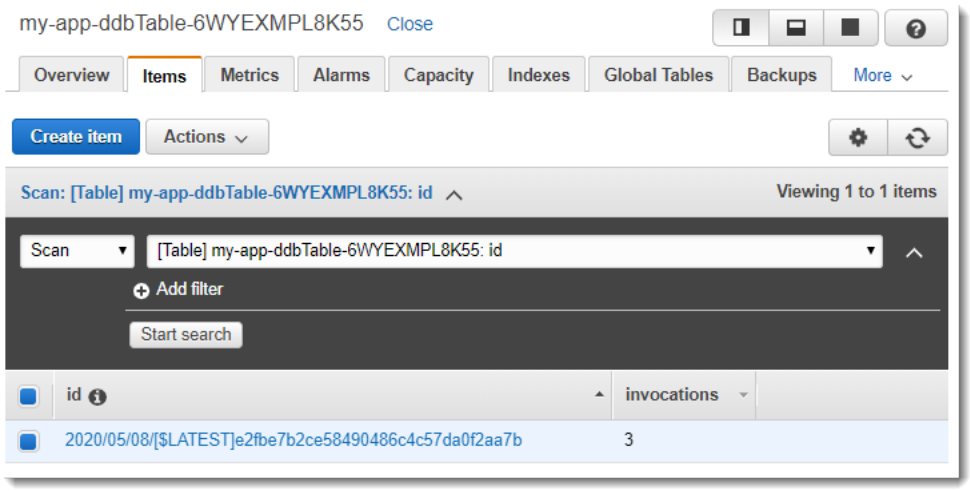
3. Commit and push the change.

```
git add . && git commit -m "Use DynamoDB table"
git push
```

After the code change is deployed, invoke the function a few times to update the DynamoDB table.

**To view the DynamoDB table**

1. Open the Tables page of the DynamoDB console.
2. Choose the table that starts with **my-app**.
3. Choose **Items**.
4. Choose **Start search**.




Lambda creates additional instances of your function to handle multiple concurrent invocations. Each log stream in the CloudWatch Logs log group corresponds to a function instance. A new function instance is also created when you change your function's code or configuration. For more information on scaling, see Lambda function scaling (p. 30).

# Next steps

The AWS CloudFormation template that defines your application resources uses the AWS Serverless Application Model transform to simplify the syntax for resource definitions, and automate uploading

the deployment package and other artifacts. AWS SAM also provides a command line interface (the AWS SAM CLI), which has the same packaging and deployment functionality as the AWS CLI, with additional features specific to Lambda applications. Use the AWS SAM CLI to test your application locally in a Docker container that emulates the Lambda execution environment.

- Installing the AWS SAM CLI
- Testing and debugging serverless applications with AWS SAM
- Deploying serverless applications using CI/CD systems with AWS SAM

AWS Cloud9 provides an online development environment that includes Node.js, the AWS SAM CLI, and Docker. With AWS Cloud9, you can start developing quickly and access your development environment from any computer. For instructions, see Getting started in the *AWS Cloud9 User Guide*.

For local development, AWS toolkits for integrated development environments (IDEs) let you test and debug functions before pushing them to your repository.

- AWS Toolkit for JetBrains – Plugin for PyCharm (Python) and IntelliJ (Java) IDEs.
- AWS Toolkit for Eclipse – Plugin for Eclipse IDE (multiple languages).
- AWS Toolkit for Visual Studio Code – Plugin for Visual Studio Code IDE (multiple languages).
- AWS Toolkit for Visual Studio – Plugin for Visual Studio IDE (multiple languages).

# Troubleshooting

As you develop your application, you will likely encounter the following types of errors.

- **Build errors** – Issues that occur during the build phase, including compilation, test, and packaging errors.
- **Deployment errors** – Issues that occur when AWS CloudFormation isn't able to update the application stack. These include permissions errors, account quotas, service issues, or template errors.
- **Invocation errors** – Errors that are returned by a function's code or runtime.

For build and deployment errors, you can identify the cause of an error in the Lambda console.

### To troubleshoot application errors

1. Open the Lambda console Applications page.
2. Choose an application.
3. Choose **Deployments**.
4. To view the application's pipeline, choose **Deployment pipeline**.
5. Identify the action that encountered an error.
6. To view the error in context, choose **Details**.

For deployment errors that occur during the **ExecuteChangeSet** action, the pipeline links to a list of stack events in the AWS CloudFormation console. Search for an event with the status **UPDATE_FAILED**. Because AWS CloudFormation rolls back after an error, the relevant event is under several other events in the list. If AWS CloudFormation could not create a change set, the error appears under **Change sets** instead of under **Events**.

A common cause of deployment and invocation errors is a lack of permissions in one or more roles. The pipeline has a role for deployments (`CloudFormationRole`) that's equivalent to the user permissions (p. 59) that you would use to update an AWS CloudFormation stack directly. If you add

resources to your application or enable Lambda features that require user permissions, the deployment role is used. You can find a link to the deployment role under **Infrastructure** in the application overview.

If your function accesses other AWS services or resources, or if you enable features that require the function to have additional permissions, the function's execution role (p. 52) is used. All execution roles that are created in your application template are also subject to the application's permissions boundary. This boundary requires you to explicitly grant access to additional services and resources in IAM after adding permissions to the execution role in the template.

For example, to connect a function to a virtual private cloud (p. 191) (VPC), you need user permissions to describe VPC resources. The execution role needs permission to manage network interfaces. This requires the following steps.

1. Add the required user permissions to the deployment role in IAM.
2. Add the execution role permissions to the permissions boundary in IAM.
3. Add the execution role permissions to the execution role in the application template.
4. Commit and push to deploy the updated execution role.

After you address permissions errors, choose **Release change** in the pipeline overview to rerun the build and deployment.

# Clean up

You can continue to modify and use the sample to develop your own application. If you are done using the sample, delete the application to avoid paying for the pipeline, repository, and storage.

### To delete the application

1. Open the AWS CloudFormation console.
2. Delete the application stack – **my-app**.
3. Open the Amazon S3 console.
4. Delete the artifact bucket – ***us-east-2*-*123456789012*-my-app-pipe**.
5. Return to the AWS CloudFormation console and delete the infrastructure stack – **serverlessrepo-my-app-toolchain**.

Function logs are not associated with the application or infrastructure stack in AWS CloudFormation. Delete the log group separately in the CloudWatch Logs console.

### To delete the log group

1. Open the Log groups page of the Amazon CloudWatch console.
2. Choose the function's log group (`/aws/lambda/my-app-helloFromLambdaFunction-`*`YV1VXMPLK7QK`*).
3. Choose **Actions**, and then choose **Delete log group**.
4. Choose **Yes, Delete**.

# Rolling deployments for Lambda functions

Use rolling deployments to control the risks associated with introducing new versions of your Lambda function. In a rolling deployment, the system automatically deploys the new version of the function and gradually sends an increasing amount of traffic to the new version. The amount of traffic and rate of increase are parameters that you can configure.

You configure a rolling deployment by using AWS CodeDeploy and AWS SAM. CodeDeploy is a service that automates application deployments to Amazon computing platforms such as Amazon EC2 and AWS Lambda. For more information, see What is CodeDeploy?. By using CodeDeploy to deploy your Lambda function, you can easily monitor the status of the deployment and initiate a rollback if you detect any issues.

AWS SAM is an open-source framework for building serverless applications. You create an AWS SAM template (in YAML format) to specify the configuration of the components required for the rolling deployment. AWS SAM uses the template to create and configure the components. For more information, see What is the AWS SAM?.

In a rolling deployment, AWS SAM performs these tasks:

- It configures your Lambda function and creates an alias.

  The alias routing configuration is the underlying capability that implements the rolling deployment.
- It creates a CodeDeploy application and deployment group.

  The deployment group manages the rolling deployment and the rollback (if needed).
- It detects when you create a new version of your Lambda function.
- It triggers CodeDeploy to start the deployment of the new version.

## Example AWS SAM Lambda template

The following example shows an AWS SAM template for a simple rolling deployment.

```
AWSTemplateFormatVersion : '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Description: A sample SAM template for deploying Lambda functions.

Resources:
# Details about the myDateTimeFunction Lambda function
  myDateTimeFunction:
    Type: AWS::Serverless::Function
    Properties:
      Handler: myDateTimeFunction.handler
      Runtime: nodejs12.x
# Creates an alias named "live" for the function, and automatically publishes when you
 update the function.
      AutoPublishAlias: live
      DeploymentPreference:
# Specifies the deployment configuration
          Type: Linear10PercentEvery2Minutes
```

This template defines a Lambda function named `myDateTimeFunction` with the following properties.

**AutoPublishAlias**

The `AutoPublishAlias` property creates an alias named `live`. In addition, the AWS SAM framework automatically detects when you save new code for the function. The framework then publishes a new function version and updates the `live` alias to point to the new version.

**DeploymentPreference**

The `DeploymentPreference` property determines the rate at which the CodeDeploy application shifts traffic from the original version of the Lambda function to the new version. The value `Linear10PercentEvery2Minutes` shifts an additional ten percent of the traffic to the new version every two minutes.

For a list of the predefined deployment configurations, see Deployment configurations.

For a detailed tutorial on how to use CodeDeploy with Lambda functions, see Deploy an updated Lambda function with CodeDeploy.

# Invoking Lambda functions with the AWS Mobile SDK for Android

You can call a Lambda function from a mobile application. Put business logic in functions to separate its development lifecycle from that of front-end clients, making mobile applications less complex to develop and maintain. With the Mobile SDK for Android, you use Amazon Cognito to authenticate users and authorize requests (p. 775).

When you invoke a function from a mobile application, you choose the event structure, invocation type (p. 224), and permission model. You can use aliases (p. 175) to enable seamless updates to your function code, but otherwise the function and application are tightly coupled. As you add more functions, you can create an API layer to decouple your function code from your front-end clients and improve performance.

To create a fully-featured web API for your mobile and web applications, use Amazon API Gateway. With API Gateway, you can add custom authorizers, throttle requests, and cache results for all of your functions. For more information, see Using AWS Lambda with Amazon API Gateway (p. 502).

**Topics**


- Tutorial: Using AWS Lambda with the Mobile SDK for Android (p. 775)
- Sample function code (p. 781)


## Tutorial: Using AWS Lambda with the Mobile SDK for Android

In this tutorial, you create a simple Android mobile application that uses Amazon Cognito to get credentials and invokes a Lambda function.

The mobile application retrieves AWS credentials from an Amazon Cognito identity pool and uses them to invoke a Lambda function with an event that contains request data. The function processes the request and returns a response to the front-end.

### Prerequisites

This tutorial assumes that you have some knowledge of basic Lambda operations and the Lambda console. If you haven't already, follow the instructions in Create a Lambda function with the console (p. 8) to create your first Lambda function.

To complete the following steps, you need a command line terminal or shell to run commands. Commands and the expected output are listed in separate blocks:

```
aws --version
```

You should see the following output:

```
aws-cli/2.0.57 Python/3.7.4 Darwin/19.6.0 exe/x86_64
```

For long commands, an escape character (\) is used to split a command over multiple lines.

On Linux and macOS, use your preferred shell and package manager. On Windows 10, you can install the Windows Subsystem for Linux to get a Windows-integrated version of Ubuntu and Bash.

## Create the execution role

Create the execution role (p. 52) that gives your function permission to access AWS resources.

### To create an execution role

1. Open the roles page in the IAM console.
2. Choose **Create role**.
3. Create a role with the following properties.
   - **Trusted entity** – **AWS Lambda**.
   - **Permissions** – **AWSLambdaBasicExecutionRole**.
   - **Role name** – **`lambda-android-role`**.

The **AWSLambdaBasicExecutionRole** policy has the permissions that the function needs to write logs to CloudWatch Logs.

## Create the function

The following example uses data to generate a string response.

> **Note**
> For sample code in other languages, see Sample function code (p. 781).

### Example index.js

```
exports.handler = function(event, context, callback) {
   console.log("Received event: ", event);
   var data = {
       "greetings": "Hello, " + event.firstName + " " + event.lastName + "."
   };
   callback(null, data);
}
```

### To create the function

1. Copy the sample code into a file named `index.js`.
2. Create a deployment package.

   ```
   zip function.zip index.js
   ```
3. Create a Lambda function with the `create-function` command.

   ```
   aws lambda create-function --function-name AndroidBackendLambdaFunction \
   --zip-file fileb://function.zip --handler index.handler --runtime nodejs12.x \
   --role arn:aws:iam::123456789012:role/lambda-android-role
   ```

## Test the Lambda function

Invoke the function manually using the sample event data.

### To test the Lambda function (AWS CLI)

1. Save the following sample event JSON in a file, `input.txt`.

```
{   "firstName": "first-name",   "lastName": "last-name" }
```

2. Run the following `invoke` command:

```
aws lambda  invoke --function-name AndroidBackendLambdaFunction \
--payload file://file-path/input.txt outputfile.txt
```

The **cli-binary-format** option is required if you're using AWS CLI version 2. To make this the default setting, run `aws configure set cli-binary-format raw-in-base64-out`. For more information, see AWS CLI supported global command line options.

## Create an Amazon Cognito identity pool

In this section, you create an Amazon Cognito identity pool. The identity pool has two IAM roles. You update the IAM role for unauthenticated users and grant permissions to run the `AndroidBackendLambdaFunction` Lambda function.

For more information about IAM roles, see IAM roles in the *IAM User Guide*. For more information about Amazon Cognito services, see the Amazon Cognito product detail page.

### To create an identity pool

1. Open the Amazon Cognito console.
2. Create a new identity pool called `JavaFunctionAndroidEventHandlerPool`. Before you follow the procedure to create an identity pool, note the following:

   - The identity pool you are creating must allow access to unauthenticated identities because our example mobile application does not require a user log in. Therefore, make sure to select the **Enable access to unauthenticated identities** option.
   - Add the following statement to the permission policy associated with the unauthenticated identities.

```
{
        "Effect": "Allow",
        "Action": [
            "lambda:InvokeFunction"
        ],
        "Resource": [
           "arn:aws:lambda:us-
east-1:123456789012:function:AndroidBackendLambdaFunction"
        ]
}
```

   The resulting policy will be as follows:

```
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action":[
            "mobileanalytics:PutEvents",
            "cognito-sync:*"
         ],
         "Resource":[
            "*"
         ]
```

```
      },
      {
         "Effect":"Allow",
         "Action":[
            "lambda:invokefunction"
         ],
         "Resource":[
            "arn:aws:lambda:us-east-1:account-
id:function:AndroidBackendLambdaFunction"
         ]
      }
   ]
}
```

For instructions about how to create an identity pool, log in to the Amazon Cognito console and follow the **New Identity Pool** wizard.

3. Note the identity pool ID. You specify this ID in your mobile application you create in the next section. The app uses this ID when it sends request to Amazon Cognito to request for temporary security credentials.

## Create an Android application

Create a simple Android mobile application that generates events and invokes Lambda functions by passing the event data as parameters.

The following instructions have been verified using Android studio.

1. Create a new Android project called `AndroidEventGenerator` using the following configuration:
   - Select the **Phone and Tablet** platform.
   - Choose **Blank Activity**.
2. In the build.gradle (`Module:app`) file, add the following in the `dependencies` section:

```
compile 'com.amazonaws:aws-android-sdk-core:2.2.+'
compile 'com.amazonaws:aws-android-sdk-lambda:2.2.+'
```

3. Build the project so that the required dependencies are downloaded, as needed.
4. In the Android application manifest (`AndroidManifest.xml`), add the following permissions so that your application can connect to the Internet. You can add them just before the `</manifest>` end tag.

```
<uses-permission android:name="android.permission.INTERNET" />
<uses-permission android:name="android.permission.ACCESS_NETWORK_STATE" />
```

5. In `MainActivity`, add the following imports:

```
import com.amazonaws.mobileconnectors.lambdainvoker.*;
import com.amazonaws.auth.CognitoCachingCredentialsProvider;
import com.amazonaws.regions.Regions;
```

6. In the `package` section, add the following two classes (`RequestClass` and `ResponseClass`). Note that the POJO is same as the POJO you created in your Lambda function in the preceding section.
   - `RequestClass`. The instances of this class act as the POJO (Plain Old Java Object) for event data which consists of first and last name. If you are using Java example for your Lambda function you created in the preceding section, this POJO is same as the POJO you created in your Lambda function code.

```
package com.example....lambdaeventgenerator;
public class RequestClass {
    String firstName;
    String lastName;

    public String getFirstName() {
        return firstName;
    }

    public void setFirstName(String firstName) {
        this.firstName = firstName;
    }

    public String getLastName() {
        return lastName;
    }

    public void setLastName(String lastName) {
        this.lastName = lastName;
    }

    public RequestClass(String firstName, String lastName) {
        this.firstName = firstName;
        this.lastName = lastName;
    }

    public RequestClass() {
    }
}
```

- `ResponseClass`

```
package com.example....lambdaeventgenerator;
public class ResponseClass {
    String greetings;

    public String getGreetings() {
        return greetings;
    }

    public void setGreetings(String greetings) {
        this.greetings = greetings;
    }

    public ResponseClass(String greetings) {
        this.greetings = greetings;
    }

    public ResponseClass() {
    }
}
```

7. In the same package, create interface called `MyInterface` for invoking the `AndroidBackendLambdaFunction` Lambda function.

```
package com.example.....lambdaeventgenerator;
import com.amazonaws.mobileconnectors.lambdainvoker.LambdaFunction;
public interface MyInterface {

    /**
     * Invoke the Lambda function "AndroidBackendLambdaFunction".
     * The function name is the method name.
     */
```

```
    @LambdaFunction
     ResponseClass AndroidBackendLambdaFunction(RequestClass request);

}
```

The `@LambdaFunction` annotation in the code maps the specific client method to the same-name Lambda function.

8. To keep the application simple, we are going to add code to invoke the Lambda function in the `onCreate()` event handler. In `MainActivity`, add the following code toward the end of the `onCreate()` code.

```
// Create an instance of CognitoCachingCredentialsProvider
CognitoCachingCredentialsProvider cognitoProvider = new
 CognitoCachingCredentialsProvider(
        this.getApplicationContext(), "identity-pool-id", Regions.US_WEST_2);

// Create LambdaInvokerFactory, to be used to instantiate the Lambda proxy.
LambdaInvokerFactory factory = new LambdaInvokerFactory(this.getApplicationContext(),
        Regions.US_WEST_2, cognitoProvider);

// Create the Lambda proxy object with a default Json data binder.
// You can provide your own data binder by implementing
// LambdaDataBinder.
final MyInterface myInterface = factory.build(MyInterface.class);

RequestClass request = new RequestClass("John", "Doe");
// The Lambda function invocation results in a network call.
// Make sure it is not called from the main thread.
new AsyncTask<RequestClass, Void, ResponseClass>() {
    @Override
    protected ResponseClass doInBackground(RequestClass... params) {
        // invoke "echo" method. In case it fails, it will throw a
        // LambdaFunctionException.
        try {
            return myInterface.AndroidBackendLambdaFunction(params[0]);
        } catch (LambdaFunctionException lfe) {
            Log.e("Tag", "Failed to invoke echo", lfe);
            return null;
        }
    }

    @Override
    protected void onPostExecute(ResponseClass result) {
        if (result == null) {
            return;
        }

        // Do a toast
        Toast.makeText(MainActivity.this, result.getGreetings(),
 Toast.LENGTH_LONG).show();
    }
}.execute(request);
```

9. Run the code and verify it as follows:

   - The `Toast.makeText()` displays the response returned.
   - Verify that CloudWatch Logs shows the log created by the Lambda function. It should show the event data (first name and last name). You can also verify this in the AWS Lambda console.

# Sample function code

Sample code is available for the following languages.

**Topics**


- Node.js (p. 781)
- Java (p. 781)


## Node.js

The following example uses data to generate a string response.

**Example index.js**

```
exports.handler = function(event, context, callback) {
   console.log("Received event: ", event);
   var data = {
       "greetings": "Hello, " + event.firstName + " " + event.lastName + "."
   };
   callback(null, data);
}
```

Zip up the sample code to create a deployment package. For instructions, see Deploy Node.js Lambda functions with .zip file archives (p. 288).

## Java

The following example uses data to generate a string response.

In the code, the `handler` (`myHandler`) uses the `RequestClass` and `ResponseClass` types for the input and output. The code provides implementation for these types.

**Example HelloPojo.java**

```
package example;

import com.amazonaws.services.lambda.runtime.Context;

public class HelloPojo {

    // Define two classes/POJOs for use with Lambda function.
    public static class RequestClass {
        String firstName;
        String lastName;

        public String getFirstName() {
            return firstName;
        }

        public void setFirstName(String firstName) {
            this.firstName = firstName;
        }

        public String getLastName() {
            return lastName;
        }

        public void setLastName(String lastName) {
```

```
            this.lastName = lastName;
        }

        public RequestClass(String firstName, String lastName) {
            this.firstName = firstName;
            this.lastName = lastName;
        }

        public RequestClass() {
        }
    }

    public static class ResponseClass {
        String greetings;

        public String getGreetings() {
            return greetings;
        }

        public void setGreetings(String greetings) {
            this.greetings = greetings;
        }

        public ResponseClass(String greetings) {
            this.greetings = greetings;
        }

        public ResponseClass() {
        }

    }

    public static ResponseClass myHandler(RequestClass request, Context context){
        String greetingString = String.format("Hello %s, %s.", request.firstName,
 request.lastName);
        context.getLogger().log(greetingString);
        return new ResponseClass(greetingString);
    }
}
```

### Dependencies

- `aws-lambda-java-core`

Build the code with the Lambda library dependencies to create a deployment package. For instructions, see Deploy Java Lambda functions with .zip or JAR file archives (p. 386).

# Orchestrating functions with Step Functions

AWS Step Functions is an orchestration service that lets you connect Lambda functions together into serverless workflows, called state machines. Use Step Functions to orchestrate serverless applications workflows (for example, a store checkout process), build long-running workflows for IT automation and human-approval use cases, or create high-volume short-duration workflows for streaming data processing and ingestion.

**Topics**


- State machine application patterns (p. 783)
- Managing state machines in the Lambda console (p. 786)
- Orchestration examples with Step Functions (p. 788)


## State machine application patterns

In Step Functions, you orchestrate your resources using state machines, which are defined using a JSON-based, structured language called Amazon States Language.

**Sections**


- State machine components (p. 783)
- State machine application patterns (p. 783)
- Applying patterns to state machines (p. 784)
- Example branching application pattern (p. 784)


### State machine components

State machines contain elements called states that make up your workflow. The logic of each state determines which state comes next, what data to pass along, and when to terminate the workflow. A state is referred to by its name, which can be any string, but which must be unique within the scope of the entire state machine.

To create a state machine that uses Lambda, you need the following components:

1. An AWS Identity and Access Management (IAM) role for Lambda with one or more permissions policies (such as AWSLambdaRole service permissions).
2. One or more Lambda functions (with the IAM role attached) for your specific runtime.
3. A state machine authored in Amazon States Language.

### State machine application patterns

You can create complex orchestrations for state machines using application patterns such as:

- **Catch and retry** – Handle errors using sophisticated catch-and-retry functionality.

- **Branching** – Design your workflow to choose different branches based on Lambda function output.
- **Chaining** – Connect functions into a series of steps, with the output of one step providing the input to the next step.
- **Parallelism** – Run functions in parallel, or use dynamic parallelism to invoke a function for every member of any array.

# Applying patterns to state machines

The following shows how you can apply these application patterns to a state machine within an Amazon States Language definition.

**Catch and Retry**

A `Catch` field and a `Retry` field add catch-and-retry logic to a state machine. Catch (`"Type": "Catch"`) is an array of objects that define a fallback state. Retry (`"Type": "Retry"`) is an array of objects that define a retry policy if the state encounters runtime errors.

**Branching**

A `Choice` state adds branching logic to a state machine. Choice (`"Type": "Choice"`) is an array of rules that determine which state the state machine transitions to next.

**Chaining**

A "Chaining" pattern describes multiple Lambda functions connected together in a state machine. You can use chaining to create reusable workflow invocations from a Task (`"Type": "Task"`) state of a state machine.

**Parallelism**

A `Parallel` state adds parallelism logic to a state machine. You can use a Parallel state (`"Type": "Parallel"`) to create parallel branches of invocation in your state machine.

**Dynamic parallelism**

A `Map` state adds dynamic "for-each" loop logic to a state machine. You can use a Map state (`"Type": "Map"`) to run a set of steps for each element of an input array in a state machine. While the `Parallel` state invokes multiple branches of steps using the same input, a `Map` state invokes the same steps for multiple entries of the array.

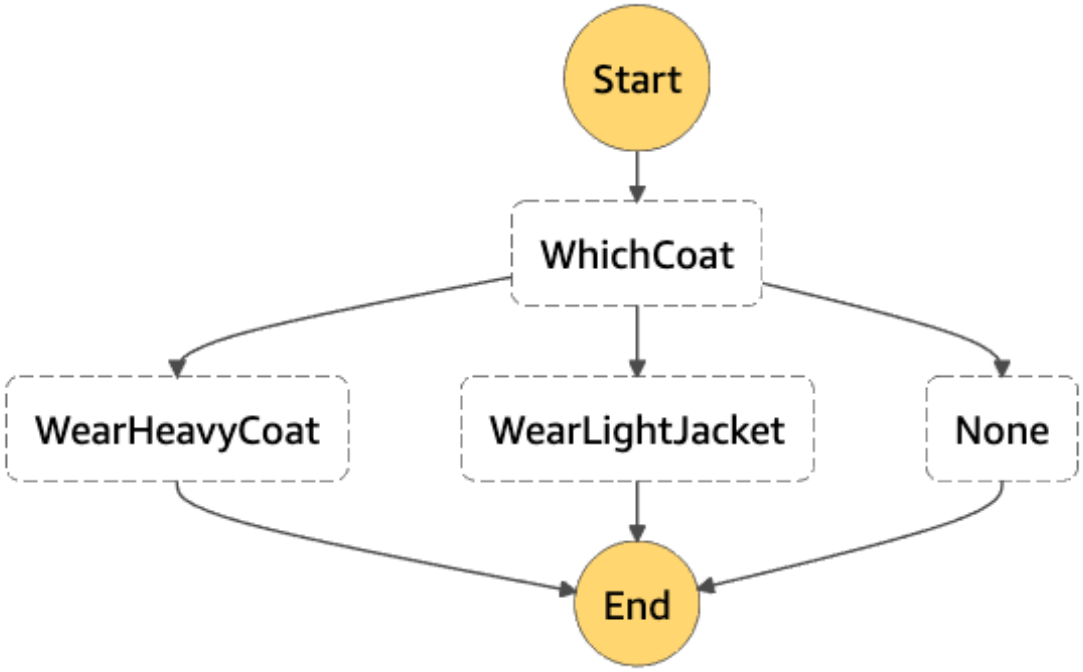
In addition to application patterns, Step Functions supports various service integration patterns, including the ability to pause a workflow for human approval, or to call a legacy system or other third party.

# Example branching application pattern

In the following example, the `WhichCoat` state machine defined in the Amazon States Language (ASL) definition shows a branching application pattern with a Choice state (`"Type": "Choice"`). If the condition of one of the three `Choice` states is met, the Lambda function is invoked as a Task:

1. The `WearHeavyCoat` state invokes the `wear_heavy_coat` Lambda function and returns a message.
2. The `WearLightJacket` state invokes the `wear_light_jacket` Lambda function and returns a message.
3. The `None` state invokes the `no_jacket` Lambda function and returns a message.

The `WhichCoat` state machine has the following structure:




### Example Example Amazon States Language definition

The following Amazon States Language definition of the `WhichCoat` state machine uses a `Variable` context object called `Weather`. If one of the three conditions in `StringEquals` is met, the Lambda function defined in the `Resource` field's Amazon Resource Name (ARN) is invoked.

```
{
        "Comment":"Coat Indicator State Machine",
        "StartAt":"WhichCoat",
        "States":{
            "WhichCoat":{
                "Type":"Choice",
                "Choices":[
                {
                    "Variable":"$.Weather",
                    "StringEquals":"FREEZING",
                    "Next":"WearHeavyCoat"
                },
                {
                    "Variable":"$.Weather",
                    "StringEquals":"COOL",
                    "Next":"WearLightJacket"
                },
                {
                    "Variable":"$.Weather",
                    "StringEquals":"WARM",
                    "Next":"None"
                }
                ]
            },
            "WearHeavyCoat":{
                "Type":"Task",
                "Resource":"arn:aws:lambda:us-west-2:01234567890:function:wear_heavy_coat",

                "End":true
            },
```

```
            "WearLightJacket":{
                "Type":"Task",
                "Resource":"arn:aws:lambda:us-
west-2:01234567890:function:wear_light_jacket",
                "End":true
            },
            "None":{
                "Type":"Task",
                "Resource":"arn:aws:lambda:us-west-2:01234567890:function:no_coat",

                "End":true
            }
        }
    }
```

### Example Example Python function

The following Lambda function in Python (`wear_heavy_coat`) can be invoked for the state machine defined in the previous example. If the `WhichCoat` state machine equals a string value of `FREEZING`, the `wear_heavy_coat` function is invoked from Lambda, and the user receives the message that corresponds with the function: "You should wear a heavy coat today."

```
from __future__ import print_function

import datetime


def wear_heavy_coat(message, context):
    print(message)

    response = {}
    response['Weather'] = message['Weather']
    response['Timestamp'] = datetime.datetime.now().strftime("%Y-%m-%d %H-%M-%S")
    response['Message'] = 'You should wear a heavy coat today.'

    return response
```

### Example Example invocation data

The following input data runs the `WearHeavyCoat` state that invokes the `wear_heavy_coat` Lambda function, when the `Weather` variable is equal to a string value of `FREEZING`.

```
{
    "Weather":"FREEZING"
}
```

For more information, see Creating a Step Functions State Machine That Uses Lambda in the *AWS Step Functions Developer Guide*.

# Managing state machines in the Lambda console

You can use the Lambda console to view details about your Step Functions state machines and the Lambda functions that they use.

**Sections**

- Viewing state machine details (p. 787)

- Editing a state machine (p. 787)
- Running a state machine (p. 787)

# Viewing state machine details

The Lambda console displays a list of your state machines in the current AWS Region that contain at least one workflow step that invokes a Lambda function.

Choose a state machine to view a graphical representation of the workflow. Steps highlighted in blue represent Lambda functions. Use the graph controls to zoom in, zoom out, and center the graph.

> **Note**
> When a Lambda function is dynamically referenced with JsonPath in the state machine definition, the function details cannot be shown in the Lambda console. Instead, the function name is listed as a **Dynamic reference**, and the corresponding steps in the graph are grayed out.

**To view state machine details**

1. Open the Lambda console Step Functions state machines page.
2. Choose a state machine.
<result>

The Lambda console opens the **Details** page.
</result>

For more information, see Step Functions in the *AWS Step Functions Developer Guide*.

# Editing a state machine

When you want to edit a state machine, Lambda opens the **Edit definition** page of the Step Functions console.

**To edit a state machine**

1. Open the Lambda console Step Functions state machine page.
2. Choose a state machine.
3. Choose **Edit**.

   The Step Functions console opens the **Edit definition** page.
4. Edit the state machine and choose **Save**.

For more information about editing state machines, see Step Functions state machine language in the *AWS Step Functions Developer Guide*.

# Running a state machine

When you want to run a state machine, Lambda opens the **New execution** page of the Step Functions console.

**To run a state machine**

1. Open the Lambda console Step Functions state machines page.
2. Choose a state machine.

3. Choose **Execute**.

   The Step Functions console opens the **New execution** page.
4. (Optional) Edit the state machine and choose **Start execution**.

For more information about running state machines, see Step Functions state machine execution concepts in the *AWS Step Functions Developer Guide*.

# Orchestration examples with Step Functions

All work in your Step Functions state machine is done by `Tasks`. A `Task` performs work by using an activity, a Lambda function, or by passing parameters to the API actions of other Supported AWS Service Integrations for Step Functions.

**Sections**


- Configuring a Lambda function as a task (p. 788)
- Configuring a state machine as an event source (p. 788)
- Handling function and service errors (p. 789)
- AWS CloudFormation and AWS SAM (p. 790)


## Configuring a Lambda function as a task

Step Functions can invoke Lambda functions directly from a `Task` state in an Amazon States Language definition.

```
...
        "MyStateName":{
          "Type":"Task",
          "Resource":"arn:aws:lambda:us-west-2:01234567890:function:my_lambda_function",

          "End":true
      ...
```

You can create a `Task` state that invokes your Lambda function with the input to the state machine or any JSON document.

**Example event.json – Input to random-error function (p. 807)**

```
{
  "max-depth": 10,
  "current-depth": 0,
  "error-rate": 0.05
}
```

## Configuring a state machine as an event source

You can create a Step Functions state machine that invokes a Lambda function. The following example shows a `Task` state that invokes version `1` of a function named `my-function` with an event payload that has three keys. When the function returns a successful response, the state machine continues to the next task.

**Example Example state machine**

```
...
"Invoke": {
  "Type": "Task",
  "Resource": "arn:aws:states:::lambda:invoke",
  "Parameters": {
    "FunctionName": "arn:aws:lambda:us-east-2:123456789012:function:my-function:1",
    "Payload": {
      "max-depth": 10,
      "current-depth": 0,
      "error-rate": 0.05
    }
  },
  "Next": "NEXT_STATE",
  "TimeoutSeconds": 25
}
```

**Permissions**
Your state machine needs permission to call the Lambda API to invoke a function. To grant it permission, add the AWS managed policy AWSLambdaRole or a function-scoped inline policy to its role. For more information, see How AWS Step Functions Works with IAM in the *AWS Step Functions Developer Guide*.

The `FunctionName` and `Payload` parameters map to parameters in the Invoke (p. 993) API operation. In addition to these, you can also specify the `InvocationType` and `ClientContext` parameters. For example, to invoke the function asynchronously and continue to the next state without waiting for a result, you can set `InvocationType` to `Event`:

```
"InvocationType": "Event"
```

Instead of hard-coding the event payload in the state machine definition, you can use the input from the state machine execution. The following example uses the input specified when you run the state machine as the event payload:

```
"Payload.$": "$"
```

You can also invoke a function asynchronously and wait for it to make a callback with the AWS SDK. To do this, set the state's resource to `arn:aws:states:::lambda:invoke.waitForTaskToken`.

For more information, see Invoke Lambda with Step Functions in the *AWS Step Functions Developer Guide*.

# Handling function and service errors

When your function or the Lambda service returns an error, you can retry the invocation or continue to a different state based on the error type.

The following example shows an invoke task that retries on `5XX` series Lambda API exceptions (`ServiceException`), throttles (`TooManyRequestsException`), runtime errors (`Lambda.Unknown`), and a function-defined error named `function.MaxDepthError`. It also catches an error named `function.DoublesRolledError` and continues to a state named `CaughtException` when it occurs.

**Example Example catch and retry pattern**

```
...
"Invoke": {
    "Type": "Task",
    "Resource": "arn:aws:states:::lambda:invoke",
```

```
    "Retry": [
      {
        "ErrorEquals": [
            "function.MaxDepthError",
            "Lambda.TooManyRequestsException",
            "Lambda.ServiceException",
            "Lambda.Unknown"
          ],
        "MaxAttempts": 5
      }
    ],
    "Catch": [
      {
        "ErrorEquals": [ "function.DoublesRolledError" ],
        "Next": "CaughtException"
      }
    ],
    "Parameters": {
      "FunctionName": "arn:aws:lambda:us-east-2:123456789012:function:my-function:1",
      ...
```

To catch or retry function errors, create a custom error type. The name of the error type must match the `errorType` in the formatted error response that Lambda returns when you throw an error.

For more information on error handling in Step Functions, see Handling Error Conditions Using a Step Functions State Machine in the *AWS Step Functions Developer Guide*.

# AWS CloudFormation and AWS SAM

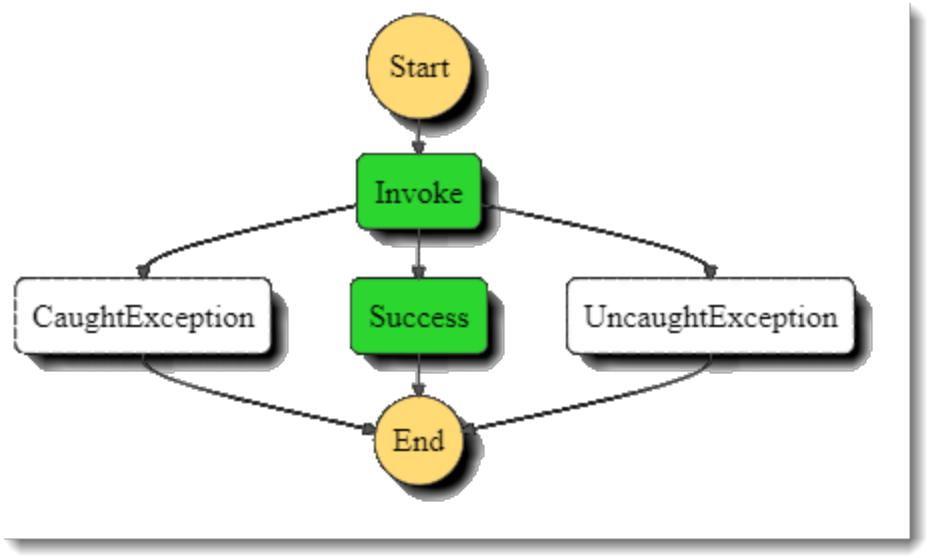
You can define state machines using a AWS CloudFormation template with AWS Serverless Application Model (AWS SAM). Using AWS SAM, you can define the state machine inline in the template or in a separate file. The following example shows a state machine that invokes a Lambda function that handles errors. It refers to a function resource defined in the same template (not shown).

**Example Example branching pattern in template.yml**

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: 'AWS::Serverless-2016-10-31'
Description: An AWS Lambda application that uses AWS Step Functions.
Resources:
  statemachine:
    Type: AWS::Serverless::StateMachine
    Properties:
      DefinitionSubstitutions:
        FunctionArn: !GetAtt function.Arn
        Payload: |
          {
            "max-depth": 5,
            "current-depth": 0,
            "error-rate": 0.2
          }
      Definition:
        StartAt: Invoke
        States:
          Invoke:
            Type: Task
            Resource: arn:aws:states:::lambda:invoke
            Parameters:
              FunctionName: "${FunctionArn}"
              Payload: "${Payload}"
              InvocationType: Event
            Retry:
            - ErrorEquals:
```

```
            - function.MaxDepthError
            - function.MaxDepthError
            - Lambda.TooManyRequestsException
            - Lambda.ServiceException
            - Lambda.Unknown
            IntervalSeconds: 1
            MaxAttempts: 5
          Catch:
          - ErrorEquals:
            - function.DoublesRolledError
            Next: CaughtException
          - ErrorEquals:
            - States.ALL
            Next: UncaughtException
          Next: Success
        CaughtException:
          Type: Pass
          Result: The function returned an error.
          End: true
        UncaughtException:
          Type: Pass
          Result: Invocation failed.
          End: true
        Success:
          Type: Pass
          Result: Invocation succeeded!
          End: true
    Events:
      scheduled:
        Type: Schedule
        Properties:
          Description: Run every minute
          Schedule: rate(1 minute)
    Type: STANDARD
    Policies:
      - AWSLambdaRole
    ...
```

This creates a state machine with the following structure:




For more information, see AWS::Serverless::StateMachine in the *AWS Serverless Application Model Developer Guide*.

# Best practices for working with AWS Lambda functions

The following are recommended best practices for using AWS Lambda:

**Topics**


- Function code (p. 792)
- Function configuration (p. 793)
- Metrics and alarms (p. 794)
- Working with streams (p. 794)


For more information about best practices for Lambda applications, see Application design in the *Lambda operator guide*.

## Function code

- **Separate the Lambda handler from your core logic.** This allows you to make a more unit-testable function. In Node.js this may look like:

```
exports.myHandler = function(event, context, callback) {
 var foo = event.foo;
 var bar = event.bar;
 var result = MyLambdaFunction (foo, bar);

 callback(null, result);
}

function MyLambdaFunction (foo, bar) {
 // MyLambdaFunction logic here
}
```

- **Take advantage of execution environment reuse to improve the performance of your function.** Initialize SDK clients and database connections outside of the function handler, and cache static assets locally in the `/tmp` directory. Subsequent invocations processed by the same instance of your function can reuse these resources. This saves cost by reducing function run time.

  To avoid potential data leaks across invocations, don't use the execution environment to store user data, events, or other information with security implications. If your function relies on a mutable state that can't be stored in memory within the handler, consider creating a separate function or separate versions of a function for each user.
- **Use a keep-alive directive to maintain persistent connections.** Lambda purges idle connections over time. Attempting to reuse an idle connection when invoking a function will result in a connection error. To maintain your persistent connection, use the keep-alive directive associated with your runtime. For an example, see Reusing Connections with Keep-Alive in Node.js.
- **Use environment variables (p. 166) to pass operational parameters to your function.** For example, if you are writing to an Amazon S3 bucket, instead of hard-coding the bucket name you are writing to, configure the bucket name as an environment variable.

- **Control the dependencies in your function's deployment package.** The AWS Lambda execution environment contains a number of libraries such as the AWS SDK for the Node.js and Python runtimes (a full list can be found here: Lambda runtimes (p. 82)). To enable the latest set of features and security updates, Lambda will periodically update these libraries. These updates may introduce subtle changes to the behavior of your Lambda function. To have full control of the dependencies your function uses, package all of your dependencies with your deployment package.
- **Minimize your deployment package size to its runtime necessities.** This will reduce the amount of time that it takes for your deployment package to be downloaded and unpacked ahead of invocation. For functions authored in Java or .NET Core, avoid uploading the entire AWS SDK library as part of your deployment package. Instead, selectively depend on the modules which pick up components of the SDK you need (e.g. DynamoDB, Amazon S3 SDK modules and Lambda core libraries).
- **Reduce the time it takes Lambda to unpack deployment packages** authored in Java by putting your dependency `.jar` files in a separate /lib directory. This is faster than putting all your function's code in a single jar with a large number of `.class` files. See Deploy Java Lambda functions with .zip or JAR file archives (p. 386) for instructions.
- **Minimize the complexity of your dependencies.** Prefer simpler frameworks that load quickly on execution environment (p. 100) startup. For example, prefer simpler Java dependency injection (IoC) frameworks like Dagger or Guice, over more complex ones like Spring Framework.
- **Avoid using recursive code** in your Lambda function, wherein the function automatically calls itself until some arbitrary criteria is met. This could lead to unintended volume of function invocations and escalated costs. If you do accidentally do so, set the function reserved concurrency to `0` immediately to throttle all invocations to the function, while you update the code.
- **Do not use non-documented, non-public APIs** in your Lambda function code. For AWS Lambda managed runtimes, Lambda periodically applies security and functional updates to Lambda's internal APIs. These internal API updates may be backwards-incompatible, leading to unintended consequences such as invocation failures if your function has a dependency on these non-public APIs. See the API reference (p. 875) for a list of publicly available APIs.
- **Write idempotent code.** Writing idempotent code for your functions ensures that duplicate events are handled the same way. Your code should properly validate events and gracefully handle duplicate events. For more information, see How do I make my Lambda function idempotent?.

# Function configuration

- **Performance testing your Lambda function** is a crucial part in ensuring you pick the optimum memory size configuration. Any increase in memory size triggers an equivalent increase in CPU available to your function. The memory usage for your function is determined per-invoke and can be viewed in Amazon CloudWatch. On each invoke a `REPORT:` entry will be made, as shown below:

```
REPORT RequestId: 3604209a-e9a3-11e6-939a-754dd98c7be3 Duration: 12.34 ms Billed
 Duration: 100 ms Memory Size: 128 MB Max Memory Used: 18 MB
```

  By analyzing the `Max Memory Used:` field, you can determine if your function needs more memory or if you over-provisioned your function's memory size.

  **To find the right memory configuration** for your functions, we recommend using the open source AWS Lambda Power Tuning project. For more information, see AWS Lambda Power Tuning on GitHub.

  To optimize function performance, we also recommend deploying libraries that can leverage Advanced Vector Extensions 2 (AVX2). This allows you to process demanding workloads, including machine learning inferencing, media processing, high performance computing (HPC), scientific simulations, and financial modeling. For more information, see Creating faster AWS Lambda functions with AVX2.
- **Load test your Lambda function** to determine an optimum timeout value. It is important to analyze how long your function runs so that you can better determine any problems with a dependency

service that may increase the concurrency of the function beyond what you expect. This is especially important when your Lambda function makes network calls to resources that may not handle Lambda's scaling.

- **Use most-restrictive permissions when setting IAM policies.** Understand the resources and operations your Lambda function needs, and limit the execution role to these permissions. For more information, see Lambda permissions (p. 51).
- **Be familiar with Lambda quotas (p. 796).** Payload size, file descriptors and /tmp space are often overlooked when determining runtime resource limits.
- **Delete Lambda functions that you are no longer using.** By doing so, the unused functions won't needlessly count against your deployment package size limit.
- **If you are using Amazon Simple Queue Service** as an event source, make sure the value of the function's expected invocation time does not exceed the Visibility Timeout value on the queue. This applies both to CreateFunction (p. 904) and UpdateFunctionConfiguration (p. 1098).
  - In the case of **CreateFunction**, AWS Lambda will fail the function creation process.
  - In the case of **UpdateFunctionConfiguration**, it could result in duplicate invocations of the function.

# Metrics and alarms

- **Use Working with Lambda function metrics (p. 727) and CloudWatch Alarms** instead of creating or updating a metric from within your Lambda function code. It's a much more efficient way to track the health of your Lambda functions, allowing you to catch issues early in the development process. For instance, you can configure an alarm based on the expected duration of your Lambda function invocation in order to address any bottlenecks or latencies attributable to your function code.
- **Leverage your logging library and AWS Lambda Metrics and Dimensions** to catch app errors (e.g. ERR, ERROR, WARNING, etc.)
- **Use AWS Cost Anomaly Detection** to detect unusual activity on your account. Cost Anomaly Detection uses machine learning to continuously monitor your cost and usage while minimizing false positive alerts. Cost Anomaly Detection uses data from AWS Cost Explorer, which has a delay of up to 24 hours. As a result, it can take up to 24 hours to detect an anomaly after usage occurs. To get started with Cost Anomaly Detection, you must first sign up for Cost Explorer. Then, access Cost Anomaly Detection.

# Working with streams

- **Test with different batch and record sizes** so that the polling frequency of each event source is tuned to how quickly your function is able to complete its task. The CreateEventSourceMapping (p. 893) BatchSize parameter controls the maximum number of records that can be sent to your function with each invoke. A larger batch size can often more efficiently absorb the invoke overhead across a larger set of records, increasing your throughput.

  By default, Lambda invokes your function as soon as records are available. If the batch that Lambda reads from the event source has only one record in it, Lambda sends only one record to the function. To avoid invoking the function with a small number of records, you can tell the event source to buffer records for up to 5 minutes by configuring a *batching window*. Before invoking the function, Lambda continues to read records from the event source until it has gathered a full batch, the batching window expires, or the batch reaches the payload limit of 6 MB. For more information, see Batching behavior (p. 237).
- **Increase Kinesis stream processing throughput by adding shards.** A Kinesis stream is composed of one or more shards. Lambda will poll each shard with at most one concurrent invocation. For example, if your stream has 100 active shards, there will be at most 100 Lambda function invocations running concurrently. Increasing the number of shards will directly increase the number of maximum concurrent Lambda function invocations and can increase your Kinesis stream processing throughput.

If you are increasing the number of shards in a Kinesis stream, make sure you have picked a good partition key (see Partition Keys) for your data, so that related records end up on the same shards and your data is well distributed.

- **Use Amazon CloudWatch** on IteratorAge to determine if your Kinesis stream is being processed. For example, configure a CloudWatch alarm with a maximum setting to 30000 (30 seconds).

# Lambda quotas

**Important**
New AWS accounts have reduced concurrency and memory quotas. AWS raises these quotas automatically based on your usage. You can also request a quota increase.

## Compute and storage

Lambda sets quotas for the amount of compute and storage resources that you can use to run and store functions. The following quotas apply per AWS Region and can be increased. For more information, see Requesting a quota increase in the *Service Quotas User Guide*.

| Resource | Default quota | Can be increased up to |
|---|---|---|
| Concurrent executions | 1,000 | Tens of thousands |
| Storage for uploaded functions (.zip file archives) and layers. Each function version and layer version consumes storage.<br><br>For best practices on managing your code storage, see Monitoring Lambda code storage in the *Lambda Operator Guide*. | 75 GB | Terabytes |
| Storage for functions defined as container images. These images are stored in Amazon ECR. | See Amazon ECR service quotas. | |
| Elastic network interfaces per virtual private cloud (VPC) (p. 191)<br><br>**Note**<br>This quota is shared with other services, such as Amazon Elastic File System (Amazon EFS). See Amazon VPC quotas. | 250 | Hundreds |

For details on concurrency and how Lambda scales your function concurrency in response to traffic, see Lambda function scaling (p. 30).

## Function configuration, deployment, and execution

The following quotas apply to function configuration, deployment, and execution. They cannot be changed.

**Note**
The Lambda documentation, log messages, and console use the abbreviation MB (rather than MiB) to refer to 1024 KB.

| Resource | Quota |
| --- | --- |
| Function memory allocation (p. 162) | 128 MB to 10,240 MB, in 1-MB increments.<br><br>**Note:** Lambda allocates CPU power in proportion to the amount of memory configured. You can increase or decrease the memory and CPU power allocated to your function using the **Memory (MB)** setting. At 1,769 MB, a function has the equivalent of one vCPU. |
| Function timeout | 900 seconds (15 minutes) |
| Function environment variables (p. 166) | 4 KB, for all environment variables associated with the function, in aggregate |
| Function resource-based policy (p. 68) | 20 KB |
| Function layers (p. 156) | five layers |
| Function burst concurrency (p. 30) | 500 - 3000 (varies per Region) |
| Invocation payload (p. 224) (request and response) | 6 MB (synchronous)<br><br>256 KB (asynchronous) |
| Deployment package (.zip file archive) (p. 35) size | 50 MB (zipped, for direct upload)<br><br>250 MB (unzipped)<br><br>This quota applies to all the files you upload, including layers and custom runtimes.<br><br>3 MB (console editor) |
| Container image (p. 143) code package size | 10 GB |
| Test events (console editor) | 10 |
| `/tmp` directory storage | Between 512 MB and 10,240 MB, in 1-MB increments |
| File descriptors | 1,024 |
| Execution processes/threads | 1,024 |

# Lambda API requests

The following quotas are associated with Lambda API requests.

| Resource | Quota |
| --- | --- |
| Invocation requests per Region (requests per second) | 10 x concurrent executions quota (synchronous (p. 225), all sources)<br><br>10 x concurrent executions quota (asynchronous (p. 228), non-AWS sources) |
| Invocation requests per Region (requests per second) for asynchronous AWS service sources (p. 496) | Unlimited requests accepted. Execution rate is based on concurrency available to the function. See Asynchronous invocation (p. 228). |
| Invocation requests per function version or alias (requests per second) | 10 x allocated provisioned concurrency (p. 180)<br><br>**Note**<br>This quota applies only to functions that use provisioned concurrency. |
| GetFunction (p. 958) API requests | 100 requests per second |
| GetPolicy (p. 988) API requests | 15 requests per second |
| Remainder of the control plane API requests (excludes invocation, GetFunction, and GetPolicy requests) | 15 requests per second |

# Other services

Quotas for other services, such as AWS Identity and Access Management (IAM), Amazon CloudFront (Lambda@Edge), and Amazon Virtual Private Cloud (Amazon VPC), can impact your Lambda functions. For more information, see AWS service quotas in the *Amazon Web Services General Reference*, and Using AWS Lambda with other services (p. 496).

# Using Lambda with an AWS SDK

AWS software development kits (SDKs) are available for many popular programming languages. Each SDK provides an API, code examples, and documentation that make it easier for developers to build applications in their preferred language.

| SDK documentation | Code examples |
| --- | --- |
| AWS SDK for C++ | AWS SDK for C++ code examples |
| AWS SDK for Go | AWS SDK for Go code examples |
| AWS SDK for Java | AWS SDK for Java code examples |
| AWS SDK for JavaScript | AWS SDK for JavaScript code examples |
| AWS SDK for Kotlin | AWS SDK for Kotlin code examples |
| AWS SDK for .NET | AWS SDK for .NET code examples |
| AWS SDK for PHP | AWS SDK for PHP code examples |
| AWS SDK for Python (Boto3) | AWS SDK for Python (Boto3) code examples |
| AWS SDK for Ruby | AWS SDK for Ruby code examples |
| AWS SDK for Rust | AWS SDK for Rust code examples |
| AWS SDK for Swift | AWS SDK for Swift code examples |

For examples specific to Lambda, see Code examples for Lambda using AWS SDKs (p. 813).

**Example availability**
Can't find what you need? Request a code example by using the **Provide feedback** link at the bottom of this page.

# Lambda sample applications

The GitHub repository for this guide includes sample applications that demonstrate the use of various languages and AWS services. Each sample application includes scripts for easy deployment and cleanup, an AWS SAM template, and supporting resources.

Node.js

### Sample Lambda applications in Node.js

- blank-nodejs – A Node.js function that shows the use of logging, environment variables, AWS X-Ray tracing, layers, unit tests and the AWS SDK.
- nodejs-apig – A function with a public API endpoint that processes an event from API Gateway and returns an HTTP response.
- rds-mysql – A function that relays queries to a MySQL for RDS Database. This sample includes a private VPC and database instance configured with a password in AWS Secrets Manager.
- efs-nodejs – A function that uses an Amazon EFS file system in a Amazon VPC. This sample includes a VPC, file system, mount targets, and access point configured for use with Lambda.
- list-manager – A function processes events from an Amazon Kinesis data stream and update aggregate lists in Amazon DynamoDB. The function stores a record of each event in a MySQL for RDS Database in a private VPC. This sample includes a private VPC with a VPC endpoint for DynamoDB and a database instance.
- error-processor – A Node.js function generates errors for a specified percentage of requests. A CloudWatch Logs subscription invokes a second function when an error is recorded. The processor function uses the AWS SDK to gather details about the request and stores them in an Amazon S3 bucket.

Python

### Sample Lambda applications in Python

- blank-python – A Python function that shows the use of logging, environment variables, AWS X-Ray tracing, layers, unit tests and the AWS SDK.

Ruby

### Sample Lambda applications in Ruby

- blank-ruby – A Ruby function that shows the use of logging, environment variables, AWS X-Ray tracing, layers, unit tests and the AWS SDK.
- Ruby Code Samples for AWS Lambda – Code samples written in Ruby that demonstrate how to interact with AWS Lambda.

Java

### Sample Lambda applications in Java

- java-basic – A collection of minimal Java functions with unit tests and variable logging configuration.
- java-events – A collection of Java functions that contain skeleton code for how to handle events from various services such as Amazon API Gateway, Amazon SQS, and Amazon Kinesis. These

functions use the latest version of the aws-lambda-java-events (p. 386) library (3.0.0 and newer). These examples do not require the AWS SDK as a dependency.
- s3-java – A Java function that processes notification events from Amazon S3 and uses the Java Class Library (JCL) to create thumbnails from uploaded image files.
- Use API Gateway to invoke a Lambda function – A Java function that scans a Amazon DynamoDB table that contains employee information. It then uses Amazon Simple Notification Service to send a text message to employees celebrating their work anniversaries. This example uses API Gateway to invoke the function.

Go

Lambda provides the following sample applications for the Go runtime:

**Sample Lambda applications in Go**

- blank-go – A Go function that shows the use of Lambda's Go libraries, logging, environment variables, and the AWS SDK.

C#

**Sample Lambda applications in C#**

- blank-csharp – A C# function that shows the use of Lambda's .NET libraries, logging, environment variables, AWS X-Ray tracing, unit tests, and the AWS SDK.
- ec2-spot – A function that manages spot instance requests in Amazon EC2.

PowerShell

Lambda provides the following sample applications for the PowerShell runtime:

- blank-powershell – A PowerShell function that shows the use of logging, environment variables, and the AWS SDK.

To deploy a sample application, follow the instructions in its README file. To learn more about the architecture and use cases of an application, read the topics in this chapter.

**Topics**
- Blank function sample application for AWS Lambda (p. 802)
- Error processor sample application for AWS Lambda (p. 807)
- List manager sample application for AWS Lambda (p. 810)

# Blank function sample application for AWS Lambda

The blank function sample application is a starter application that demonstrates common operations in Lambda with a function that calls the Lambda API. It shows the use of logging, environment variables, AWS X-Ray tracing, layers, unit tests and the AWS SDK. Explore this application to learn about building Lambda functions in your programming language, or use it as a starting point for your own projects.

Variants of this sample application are available for the following languages:

**Variants**

- Node.js – blank-nodejs.
- Python – blank-python.
- Ruby – blank-ruby.
- Java – blank-java.
- Go – blank-go.
- C# – blank-csharp.
- PowerShell – blank-powershell.

The examples in this topic highlight code from the Node.js version, but the details are generally applicable to all variants.

You can deploy the sample in a few minutes with the AWS CLI and AWS CloudFormation. Follow the instructions in the README to download, configure, and deploy it in your account.

**Sections**

- Architecture and handler code (p. 802)
- Deployment automation with AWS CloudFormation and the AWS CLI (p. 803)
- Instrumentation with the AWS X-Ray (p. 805)
- Dependency management with layers (p. 805)

## Architecture and handler code

The sample application consists of function code, an AWS CloudFormation template, and supporting resources. When you deploy the sample, you use the following AWS services:

- AWS Lambda – Runs function code, sends logs to CloudWatch Logs, and sends trace data to X-Ray. The function also calls the Lambda API to get details about the account's quotas and usage in the current Region.
- AWS X-Ray – Collects trace data, indexes traces for search, and generates a service map.
- Amazon CloudWatch – Stores logs and metrics.
- AWS Identity and Access Management (IAM) – Grants permission.
- Amazon Simple Storage Service (Amazon S3) – Stores the function's deployment package during deployment.
- AWS CloudFormation – Creates application resources and deploys function code.

Standard charges apply for each service. For more information, see AWS Pricing.

The function code shows a basic workflow for processing an event. The handler takes an Amazon Simple Queue Service (Amazon SQS) event as input and iterates through the records that it contains, logging the contents of each message. It logs the contents of the event, the context object, and environment variables. Then it makes a call with the AWS SDK and passes the response back to the Lambda runtime.

**Example blank-nodejs/function/index.js – Handler code**

```
// Handler
exports.handler = async function(event, context) {
  event.Records.forEach(record => {
    console.log(record.body)
  })
  console.log('## ENVIRONMENT VARIABLES: ' + serialize(process.env))
  console.log('## CONTEXT: ' + serialize(context))
  console.log('## EVENT: ' + serialize(event))

  return getAccountSettings()
}

// Use SDK client
var getAccountSettings = function(){
  return lambda.getAccountSettings().promise()
}

var serialize = function(object) {
  return JSON.stringify(object, null, 2)
}
```

The input/output types for the handler and support for asynchronous programming vary per runtime. In this example, the handler method is `async`, so in Node.js this means that it must return a promise back to the runtime. The Lambda runtime waits for the promise to be resolved and returns the response to the invoker. If the function code or AWS SDK client return an error, the runtime formats the error into a JSON document and returns that.

The sample application doesn't include an Amazon SQS queue to send events, but uses an event from Amazon SQS (event.json) to illustrate how events are processed. To add an Amazon SQS queue to your application, see Using Lambda with Amazon SQS (p. 697).

# Deployment automation with AWS CloudFormation and the AWS CLI

The sample application's resources are defined in an AWS CloudFormation template and deployed with the AWS CLI. The project includes simple shell scripts that automate the process of setting up, deploying, invoking, and tearing down the application.

The application template uses an AWS Serverless Application Model (AWS SAM) resource type to define the model. AWS SAM simplifies template authoring for serverless applications by automating the definition of execution roles, APIs, and other resources.

The template defines the resources in the application *stack*. This includes the function, its execution role, and a Lambda layer that provides the function's library dependencies. The stack does not include the bucket that the AWS CLI uses during deployment or the CloudWatch Logs log group.

**Example blank-nodejs/template.yml – Serverless resources**

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: 'AWS::Serverless-2016-10-31'
Description: An AWS Lambda application that calls the Lambda API.
Resources:
```

```
  function:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs12.x
      CodeUri: function/.
      Description: Call the AWS Lambda API
      Timeout: 10
      # Function's execution role
      Policies:
        - AWSLambdaBasicExecutionRole
        - AWSLambda_ReadOnlyAccess
        - AWSXrayWriteOnlyAccess
      Tracing: Active
      Layers:
        - !Ref libs
  libs:
    Type: AWS::Serverless::LayerVersion
    Properties:
      LayerName: blank-nodejs-lib
      Description: Dependencies for the blank sample app.
      ContentUri: lib/.
      CompatibleRuntimes:
        - nodejs12.x
```

When you deploy the application, AWS CloudFormation applies the AWS SAM transform to the template to generate an AWS CloudFormation template with standard types such as `AWS::Lambda::Function` and `AWS::IAM::Role`.

### Example processed template

```
{
  "AWSTemplateFormatVersion": "2010-09-09",
  "Description": "An AWS Lambda application that calls the Lambda API.",
  "Resources": {
    "function": {
      "Type": "AWS::Lambda::Function",
      "Properties": {
        "Layers": [
          {
            "Ref": "libs32xmpl61b2"
          }
        ],
        "TracingConfig": {
          "Mode": "Active"
        },
        "Code": {
          "S3Bucket": "lambda-artifacts-6b000xmpl1e9bf2a",
          "S3Key": "3d3axmpl473d249d039d2d7a37512db3"
        },
        "Description": "Call the AWS Lambda API",
        "Tags": [
          {
            "Value": "SAM",
            "Key": "lambda:createdBy"
          }
        ],
```

In this example, the `Code` property specifies an object in an Amazon S3 bucket. This corresponds to the local path in the `CodeUri` property in the project template:

```
      CodeUri: function/.
```

To upload the project files to Amazon S3, the deployment script uses commands in the AWS CLI. The `cloudformation package` command preprocesses the template, uploads artifacts, and replaces local paths with Amazon S3 object locations. The `cloudformation deploy` command deploys the processed template with a AWS CloudFormation change set.

**Example blank-nodejs/3-deploy.sh – Package and deploy**

```
#!/bin/bash
set -eo pipefail
ARTIFACT_BUCKET=$(cat bucket-name.txt)
aws cloudformation package --template-file template.yml --s3-bucket $ARTIFACT_BUCKET --
output-template-file out.yml
aws cloudformation deploy --template-file out.yml --stack-name blank-nodejs --capabilities
 CAPABILITY_NAMED_IAM
```

The first time you run this script, it creates a AWS CloudFormation stack named `blank-nodejs`. If you make changes to the function code or template, you can run it again to update the stack.

The cleanup script (blank-nodejs/5-cleanup.sh) deletes the stack and optionally deletes the deployment bucket and function logs.

# Instrumentation with the AWS X-Ray

The sample function is configured for tracing with AWS X-Ray. With the tracing mode set to active, Lambda records timing information for a subset of invocations and sends it to X-Ray. X-Ray processes the data to generate a *service map* that shows a client node and two service nodes.

The first service node (`AWS::Lambda`) represents the Lambda service, which validates the invocation request and sends it to the function. The second node, `AWS::Lambda::Function`, represents the function itself.

To record additional detail, the sample function uses the X-Ray SDK. With minimal changes to the function code, the X-Ray SDK records details about calls made with the AWS SDK to AWS services.

**Example blank-nodejs/function/index.js – Instrumentation**

```
const AWSXRay = require('aws-xray-sdk-core')
const AWS = AWSXRay.captureAWS(require('aws-sdk'))

// Create client outside of handler to reuse
const lambda = new AWS.Lambda()
```

Instrumenting the AWS SDK client adds an additional node to the service map and more detail in traces. In this example, the service map shows the sample function calling the Lambda API to get details about storage and concurrency usage in the current Region.

The trace shows timing details for the invocation, with subsegments for function initialization, invocation, and overhead. The invocation subsegment has a subsegment for the AWS SDK call to the `GetAccountSettings` API operation.

You can include the X-Ray SDK and other libraries in your function's deployment package, or deploy them separately in a Lambda layer. For Node.js, Ruby, and Python, the Lambda runtime includes the AWS SDK in the execution environment.

# Dependency management with layers

You can install libraries locally and include them in the deployment package that you upload to Lambda, but this has its drawbacks. Larger file sizes cause increased deployment times and can prevent you from

testing changes to your function code in the Lambda console. To keep the deployment package small and avoid uploading dependencies that haven't changed, the sample app creates a Lambda layer (p. 156) and associates it with the function.

**Example blank-nodejs/template.yml – Dependency layer**

```
Resources:
  function:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs12.x
      CodeUri: function/.
      Description: Call the AWS Lambda API
      Timeout: 10
      # Function's execution role
      Policies:
        - AWSLambdaBasicExecutionRole
        - AWSLambda_ReadOnlyAccess
        - AWSXrayWriteOnlyAccess
      Tracing: Active
      Layers:
        - !Ref libs
  libs:
    Type: AWS::Serverless::LayerVersion
    Properties:
      LayerName: blank-nodejs-lib
      Description: Dependencies for the blank sample app.
      ContentUri: lib/.
      CompatibleRuntimes:
        - nodejs12.x
```

The `2-build-layer.sh` script installs the function's dependencies with npm and places them in a folder with the structure required by the Lambda runtime (p. 157).

**Example 2-build-layer.sh – Preparing the layer**

```
#!/bin/bash
set -eo pipefail
mkdir -p lib/nodejs
rm -rf node_modules lib/nodejs/node_modules
npm install --production
mv node_modules lib/nodejs/
```

The first time that you deploy the sample application, the AWS CLI packages the layer separately from the function code and deploys both. For subsequent deployments, the layer archive is only uploaded if the contents of the `lib` folder have changed.

# Error processor sample application for AWS Lambda

The Error Processor sample application demonstrates the use of AWS Lambda to handle events from an Amazon CloudWatch Logs subscription (p. 541). CloudWatch Logs lets you invoke a Lambda function when a log entry matches a pattern. The subscription in this application monitors the log group of a function for entries that contain the word `ERROR`. It invokes a processor Lambda function in response. The processor function retrieves the full log stream and trace data for the request that caused the error, and stores them for later use.

Function code is available in the following files:

- Random error – random-error/index.js
- Processor – processor/index.js

You can deploy the sample in a few minutes with the AWS CLI and AWS CloudFormation. To download, configure, and deploy it in your account, follow the instructions in the README.

**Sections**

- Architecture and event structure (p. 807)
- Instrumentation with AWS X-Ray (p. 808)
- AWS CloudFormation template and additional resources (p. 808)

## Architecture and event structure

The sample application uses the following AWS services.

- AWS Lambda – Runs function code, sends logs to CloudWatch Logs, and sends trace data to X-Ray.
- Amazon CloudWatch Logs – Collects logs, and invokes a function when a log entry matches a filter pattern.
- AWS X-Ray – Collects trace data, indexes traces for search, and generates a service map.
- Amazon Simple Storage Service (Amazon S3) – Stores deployment artifacts and application output.

Standard charges apply for each service.

A Lambda function in the application generates errors randomly. When CloudWatch Logs detects the word `ERROR` in the function's logs, it sends an event to the processor function for processing.

**Example CloudWatch Logs message event**

```
{
    "awslogs": {
        "data": "H4sIAAAAAAAAAHWQT0/DMAzFv0vEkbLYcdJkt4qVXmCDteIAm1DbZKjS
+kdpB0Jo350MhsQFyVLsZ+unl/fJWjeO5asrPgbH5..."
    }
}
```

When it's decoded, the data contains details about the log event. The function uses these details to identify the log stream, and parses the log message to get the ID of the request that caused the error.

**Example decoded CloudWatch Logs event data**

```
{
    "messageType": "DATA_MESSAGE",
    "owner": "123456789012",
    "logGroup": "/aws/lambda/lambda-error-processor-randomerror-1GD4SSDNACNP4",
    "logStream": "2019/04/04/[$LATEST]63311769a9d742f19cedf8d2e38995b9",
    "subscriptionFilters": [
        "lambda-error-processor-subscription-15OPDVQ59CG07"
    ],
    "logEvents": [
        {
            "id": "34664632210239891980253245280462376874059932423703429141",
            "timestamp": 1554415868243,
            "message": "2019-04-04T22:11:08.243Z\t1d2c1444-efd1-43ec-
b16e-8fb2d37508b8\tERROR\n"
        }
    ]
}
```

The processor function uses information from the CloudWatch Logs event to download the full log stream and X-Ray trace for a request that caused an error. It stores both in an Amazon S3 bucket. To allow the log stream and trace time to finalize, the function waits for a short period of time before accessing the data.

# Instrumentation with AWS X-Ray

The application uses AWS X-Ray (p. 715) to trace function invocations and the calls that functions make to AWS services. X-Ray uses the trace data that it receives from functions to create a service map that helps you identify errors.

The two Node.js functions are configured for active tracing in the template, and are instrumented with the AWS X-Ray SDK for Node.js in code. With active tracing, Lambda tags adds a tracing header to incoming requests and sends a trace with timing details to X-Ray. Additionally, the random error function uses the X-Ray SDK to record the request ID and user information in annotations. The annotations are attached to the trace, and you can use them to locate the trace for a specific request.

The processor function gets the request ID from the CloudWatch Logs event, and uses the AWS SDK for JavaScript to search X-Ray for that request. It uses AWS SDK clients, which are instrumented with the X-Ray SDK, to download the trace and log stream. Then it stores them in the output bucket. The X-Ray SDK records these calls, and they appear as subsegments in the trace.

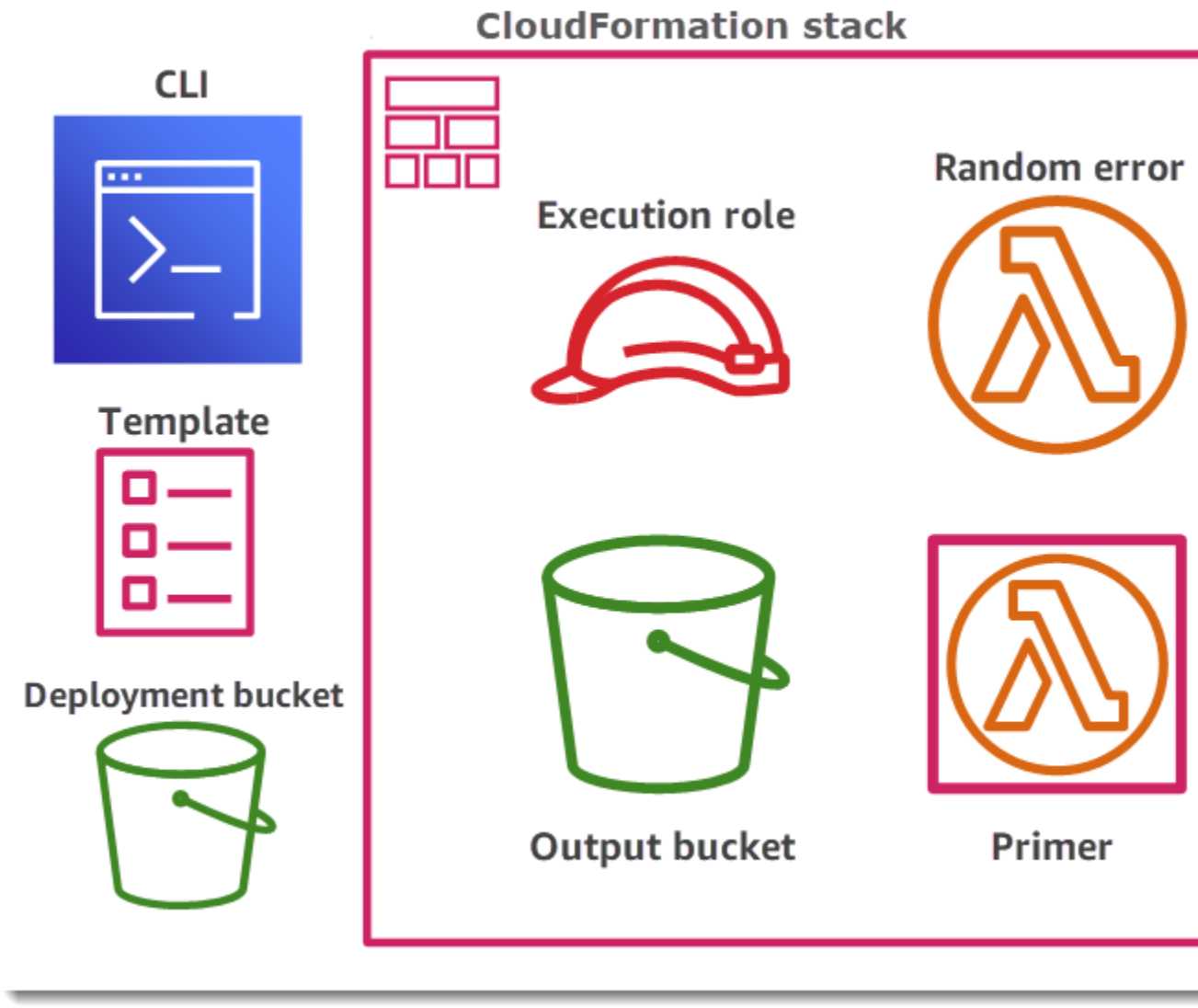
# AWS CloudFormation template and additional resources

The application is implemented in two Node.js modules and deployed with an AWS CloudFormation template and shell scripts. The template creates the processor function, the random error function, and the following supporting resources.

- Execution role – An IAM role that grants the functions permission to access other AWS services.
- Primer function – An additional function that invokes the random error function to create a log group.
- Custom resource – An AWS CloudFormation custom resource that invokes the primer function during deployment to ensure that the log group exists.
- CloudWatch Logs subscription – A subscription for the log stream that triggers the processor function when the word ERROR is logged.
- Resource-based policy – A permission statement on the processor function that allows CloudWatch Logs to invoke it.

- Amazon S3 bucket – A storage location for output from the processor function.

View the application template on GitHub.




To work around a limitation of Lambda's integration with AWS CloudFormation, the template creates an additional function that runs during deployments. All Lambda functions come with a CloudWatch Logs log group that stores output from function executions. However, the log group isn't created until the function is invoked for the first time.

To create the subscription, which depends on the existence of the log group, the application uses a third Lambda function to invoke the random error function. The template includes the code for the primer function inline. An AWS CloudFormation custom resource invokes it during deployment. `DependsOn` properties ensure that the log stream and resource-based policy are created prior to the subscription.

# List manager sample application for AWS Lambda

The list manager sample application demonstrates the use of AWS Lambda to process records in an Amazon Kinesis data stream. A Lambda event source mapping reads records from the stream in batches and invokes a Lambda function. The function uses information from the records to update documents in Amazon DynamoDB and stores the records it processes in Amazon Relational Database Service (Amazon RDS).

Clients send records to a Kinesis stream, which stores them and makes them available for processing. The Kinesis stream is used like a queue to buffer records until they can be processed. Unlike an Amazon SQS queue, records in a Kinesis stream are not deleted after they are processed, so multiple consumers can process the same data. Records in Kinesis are also processed in order, where queue items can be delivered out of order. Records are deleted from the stream after 7 days.

In addition to the function that processes events, the application includes a second function for performing administrative tasks on the database. Function code is available in the following files:

- Processor – processor/index.js
- Database admin – dbadmin/index.js

You can deploy the sample in a few minutes with the AWS CLI and AWS CloudFormation. To download, configure, and deploy it in your account, follow the instructions in the README.

**Sections**

- Architecture and event structure (p. 810)
- Instrumentation with AWS X-Ray (p. 812)
- AWS CloudFormation templates and additional resources (p. 812)

## Architecture and event structure

The sample application uses the following AWS services:

- Kinesis – Receives events from clients and stores them temporarily for processing.
- AWS Lambda – Reads from the Kinesis stream and sends events to the function's handler code.
- DynamoDB – Stores lists generated by the application.
- Amazon RDS – Stores a copy of processed records in a relational database.
- AWS Secrets Manager – Stores the database password.
- Amazon VPC – Provides a private local network for communication between the function and database.

> **Pricing**
> Standard charges apply for each service.

The application processes JSON documents from clients that contain information necessary to update a list. It supports two types of list: tally and ranking. A *tally* contains values that are added to the current value for key if it exists. Each entry processed for a user increases the value of a key in the specified table.

The following example shows a document that increases the `xp` (experience points) value for a user's `stats` list.

**Example record – Tally type**

```
{
```

```
  "title": "stats",
  "user": "bill",
  "type": "tally",
  "entries": {
    "xp": 83
  }
}
```

A *ranking* contains a list of entries where the value is the order in which they are ranked. A ranking can be updated with different values that overwrite the current value, instead of incrementing it. The following example shows a ranking of favorite movies:

**Example record – Ranking type**

```
{
  "title": "favorite movies",
  "user": "mike",
  "type": "rank",
  "entries": {
    "blade runner": 1,
    "the empire strikes back": 2,
    "alien": 3
  }
}
```

A Lambda event source mapping (p. 236) read records from the stream in batches and invokes the processor function. The event that the function handler received contains an array of objects that each contain details about a record, such as when it was received, details about the stream, and an encoded representation of the original record document.

**Example events/kinesis.json – Record**

```
{
  "Records": [
    {
      "kinesis": {
        "kinesisSchemaVersion": "1.0",
        "partitionKey": "0",
        "sequenceNumber": "49598630142999655949899443842509554952738656579378741250",
        "data":
 "eyJ0aXRsZSI6ICJmYXZvcml0ZSBtb3ZpZXMiLCAidXNlciI6ICJyZGx5c2N0IiwgInR5cGUiOiAicmFuayIsICJlbnRyaWVzIjoge
        "approximateArrivalTimestamp": 1570667770.615
      },
      "eventSource": "aws:kinesis",
      "eventVersion": "1.0",
      "eventID":
 "shardId-000000000000:49598630142999655949899443842509554952738656579378741250",
      "eventName": "aws:kinesis:record",
      "invokeIdentityArn": "arn:aws:iam::123456789012:role/list-manager-
processorRole-7FYXMPLH7IUS",
      "awsRegion": "us-east-2",
      "eventSourceARN": "arn:aws:kinesis:us-east-2:123456789012:stream/list-manager-
stream-87B3XMPLF1AZ"
    },
    ...
```

When it's decoded, the data contains a record. The function uses the record to update the user's list and an aggregate list that stores accumulated values across all users. It also stores a copy of the event in the application's database.

# Instrumentation with AWS X-Ray

The application uses AWS X-Ray (p. 715) to trace function invocations and the calls that functions make to AWS services. X-Ray uses the trace data that it receives from functions to create a service map that helps you identify errors.

The Node.js function is configured for active tracing in the template, and is instrumented with the AWS X-Ray SDK for Node.js in code. The X-Ray SDK records a subsegment for each call made with an AWS SDK or MySQL client.

The function uses the AWS SDK for JavaScript in Node.js to read and write to two tables for each record. The primary table stores the current state of each combination of list name and user. The aggregate table stores lists that combine data from multiple users.

# AWS CloudFormation templates and additional resources

The application is implemented in Node.js modules and deployed with an AWS CloudFormation template and shell scripts. The application template creates two functions, a Kinesis stream, DynamoDB tables and the following supporting resources.

### Application resources

- Execution role – An IAM role that grants the functions permission to access other AWS services.
- Lambda event source mapping – Reads records from the data stream and invokes the function.

View the application template on GitHub.

A second template, template-vpcrds.yml, creates the Amazon VPC and database resources. While it is possible to create all of the resources in one template, separating them makes it easier to clean up the application and allows the database to be reused with multiple applications.

### Infrastructure resources

- VPC – A virtual private cloud network with private subnets, a route table, and a VPC endpoint that allows the function to communicate with DynamoDB without an internet connection.
- Database – An Amazon RDS database instance and a subnet group that connects it to the VPC.

# Code examples for Lambda using AWS SDKs

The following code examples show how to use Lambda with an AWS software development kit (SDK).

The examples are divided into the following categories:

**Actions**

Code excerpts that show you how to call individual service functions.

**Scenarios**

Code examples that show you how to accomplish a specific task by calling multiple functions within the same service.

**Cross-service examples**

Sample applications that work across multiple AWS services.

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

**Code examples**


- Actions for Lambda using AWS SDKs (p. 814)
    - Create a Lambda function using an AWS SDK (p. 814)
    - Delete a Lambda function using an AWS SDK (p. 817)
    - Get a Lambda function using an AWS SDK (p. 819)
    - Invoke a Lambda function using an AWS SDK (p. 821)
    - List Lambda functions using an AWS SDK (p. 824)
    - Update Lambda function code using an AWS SDK (p. 827)
    - Update Lambda function configuration using an AWS SDK (p. 829)
- Scenarios for Lambda using AWS SDKs (p. 830)
    - Get started creating and invoking Lambda functions using an AWS SDK (p. 830)
- Cross-service examples for Lambda using AWS SDKs (p. 851)
    - Create an API Gateway REST API to track COVID-19 data (p. 851)
    - Create a lending library REST API (p. 852)
    - Create a messenger application with Step Functions (p. 853)
    - Create a websocket chat application with API Gateway (p. 853)
    - Invoke a Lambda function from a browser (p. 854)
    - Use API Gateway to invoke a Lambda function (p. 854)
    - Use Step Functions to invoke Lambda functions (p. 856)
    - Use scheduled events to invoke a Lambda function (p. 857)

# Actions for Lambda using AWS SDKs

The following code examples demonstrate how to perform individual Lambda actions with AWS SDKs. These excerpts call the Lambda API and are not intended to be run in isolation. Each example includes a link to GitHub, where you can find instructions on how to set up and run the code in context.

The following examples include only the most commonly used actions. For a complete list, see the AWS Lambda API Reference.

**Examples**


- Create a Lambda function using an AWS SDK (p. 814)
- Delete a Lambda function using an AWS SDK (p. 817)
- Get a Lambda function using an AWS SDK (p. 819)
- Invoke a Lambda function using an AWS SDK (p. 821)
- List Lambda functions using an AWS SDK (p. 824)
- Update Lambda function code using an AWS SDK (p. 827)
- Update Lambda function configuration using an AWS SDK (p. 829)


## Create a Lambda function using an AWS SDK

The following code examples show how to create a Lambda function.

Java

**SDK for Java 2.x**

**Tip**
To learn how to set up and run this example, see GitHub.

```
    public static void createLambdaFunction(LambdaClient awsLambda,
                                             String functionName,
                                             String filePath,
                                             String role,
                                             String handler) {

        try {
            LambdaWaiter waiter = awsLambda.waiter();
            InputStream is = new FileInputStream(filePath);
            SdkBytes fileToUpload = SdkBytes.fromInputStream(is);

            FunctionCode code = FunctionCode.builder()
                .zipFile(fileToUpload)
                .build();

            CreateFunctionRequest functionRequest = CreateFunctionRequest.builder()
                .functionName(functionName)
                .description("Created by the Lambda Java API")
                .code(code)
                .handler(handler)
                .runtime(Runtime.JAVA8)
                .role(role)
                .build();

            // Create a Lambda function using a waiter.
            CreateFunctionResponse functionResponse =
awsLambda.createFunction(functionRequest);
            GetFunctionRequest getFunctionRequest = GetFunctionRequest.builder()
```

```
                .functionName(functionName)
                .build();
            WaiterResponse<GetFunctionResponse> waiterResponse =
 waiter.waitUntilFunctionExists(getFunctionRequest);
            waiterResponse.matched().response().ifPresent(System.out::println);
            System.out.println("The function ARN is " +
 functionResponse.functionArn());

        } catch(LambdaException | FileNotFoundException e) {
            System.err.println(e.getMessage());
            System.exit(1);
        }
    }
```

- For API details, see CreateFunction in *AWS SDK for Java 2.x API Reference*.

JavaScript

**SDK for JavaScript V3**

**Tip**
To learn how to set up and run this example, see GitHub.

```
const createFunction = async (funcName, roleArn) => {
  const client = createClientForDefaultRegion(LambdaClient);
  const code = await zip(`${dirname}../functions/${funcName}`);

  const command = new CreateFunctionCommand({
    Code: { ZipFile: code },
    FunctionName: funcName,
    Role: roleArn,
    Architectures: [Architecture.arm64],
    Handler: "index.handler", // Required when sending a .zip file
    PackageType: PackageType.Zip, // Required when sending a .zip file
    Runtime: Runtime.nodejs16x, // Required when sending a .zip file
  });

  return client.send(command);
};
```

- For API details, see CreateFunction in *AWS SDK for JavaScript API Reference*.

Kotlin

**SDK for Kotlin**

**Note**
This is prerelease documentation for a feature in preview release. It is subject to change.

**Tip**
To learn how to set up and run this example, see GitHub.

```
suspend fun createNewFunction(
    myFunctionName: String,
    s3BucketName: String,
    myS3Key: String,
    myHandler: String,
    myRole: String
```

```
): String? {

    val functionCode = FunctionCode {
        s3Bucket = s3BucketName
        s3Key = myS3Key
    }

    val request = CreateFunctionRequest {
        functionName = myFunctionName
        code = functionCode
        description = "Created by the Lambda Kotlin API"
        handler = myHandler
        role = myRole
        runtime = Runtime.Java8
    }

    LambdaClient { region = "us-west-2" }.use { awsLambda ->
        val functionResponse = awsLambda.createFunction(request)
        awsLambda.waitUntilFunctionActive {
            functionName = myFunctionName
        }
        return functionResponse.functionArn
    }
}
```

- For API details, see CreateFunction in *AWS SDK for Kotlin API reference*.

PHP

**SDK for PHP**

**Tip**
To learn how to set up and run this example, see GitHub.

```
    public function createFunction($functionName, $role, $bucketName, $handler)
    {
        //This assumes the Lambda function is in an S3 bucket.
        return $this->customWaiter(function () use ($functionName, $role,
$bucketName, $handler) {
            return $this->lambdaClient->createFunction([
                'Code' => [
                    'S3Bucket' => $bucketName,
                    'S3Key' => $functionName,
                ],
                'FunctionName' => $functionName,
                'Role' => $role['Arn'],
                'Runtime' => 'python3.9',
                'Handler' => "$handler.lambda_handler",
            ]);
        });
    }
```

- For API details, see CreateFunction in *AWS SDK for PHP API Reference*.

Python

**SDK for Python (Boto3)**

**Tip**
To learn how to set up and run this example, see GitHub.

```
class LambdaWrapper:
    def __init__(self, lambda_client, iam_resource):
        self.lambda_client = lambda_client
        self.iam_resource = iam_resource

    def create_function(self, function_name, handler_name, iam_role,
 deployment_package):
        """
        Deploys a Lambda function.

        :param function_name: The name of the Lambda function.
        :param handler_name: The fully qualified name of the handler function. This
                             must include the file name and the function name.
        :param iam_role: The IAM role to use for the function.
        :param deployment_package: The deployment package that contains the
 function
                                   code in .zip format.
        :return: The Amazon Resource Name (ARN) of the newly created function.
        """
        try:
            response = self.lambda_client.create_function(
                FunctionName=function_name,
                Description="AWS Lambda doc example",
                Runtime='python3.8',
                Role=iam_role.arn,
                Handler=handler_name,
                Code={'ZipFile': deployment_package},
                Publish=True)
            function_arn = response['FunctionArn']
            waiter = self.lambda_client.get_waiter('function_active_v2')
            waiter.wait(FunctionName=function_name)
            logger.info("Created function '%s' with ARN: '%s'.",
                        function_name, response['FunctionArn'])
        except ClientError:
            logger.error("Couldn't create function %s.", function_name)
            raise
        else:
            return function_arn
```

- For API details, see CreateFunction in *AWS SDK for Python (Boto3) API Reference*.

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Delete a Lambda function using an AWS SDK

The following code examples show how to delete a Lambda function.

Java

**SDK for Java 2.x**

**Tip**
To learn how to set up and run this example, see GitHub.

```
    public static void deleteLambdaFunction(LambdaClient awsLambda, String
 functionName) {
```

```
        try {
            DeleteFunctionRequest request = DeleteFunctionRequest.builder()
                .functionName(functionName)
                .build();

            awsLambda.deleteFunction(request);
            System.out.println("The "+functionName +" function was deleted");

        } catch(LambdaException e) {
            System.err.println(e.getMessage());
            System.exit(1);
        }
    }
```

- For API details, see DeleteFunction in *AWS SDK for Java 2.x API Reference*.

JavaScript

**SDK for JavaScript V3**

**Tip**
To learn how to set up and run this example, see GitHub.

```
const deleteFunction = (funcName) => {
  const client = createClientForDefaultRegion(LambdaClient);
  const command = new DeleteFunctionCommand({ FunctionName: funcName });
  return client.send(command);
};
```

- For API details, see DeleteFunction in *AWS SDK for JavaScript API Reference*.

Kotlin

**SDK for Kotlin**

**Note**
This is prerelease documentation for a feature in preview release. It is subject to change.

**Tip**
To learn how to set up and run this example, see GitHub.

```
suspend fun delLambdaFunction(myFunctionName: String) {

    val request = DeleteFunctionRequest {
        functionName = myFunctionName
    }

    LambdaClient { region = "us-west-2" }.use { awsLambda ->
        awsLambda.deleteFunction(request)
        println("$myFunctionName was deleted")
    }
}
```

- For API details, see DeleteFunction in *AWS SDK for Kotlin API reference*.

PHP

**SDK for PHP**

**Tip**
To learn how to set up and run this example, see GitHub.

```
    public function deleteFunction($functionName)
    {
        return $this->lambdaClient->deleteFunction([
            'FunctionName' => $functionName,
        ]);
    }
```

- For API details, see DeleteFunction in *AWS SDK for PHP API Reference*.

Python

**SDK for Python (Boto3)**

**Tip**
To learn how to set up and run this example, see GitHub.

```
class LambdaWrapper:
    def __init__(self, lambda_client, iam_resource):
        self.lambda_client = lambda_client
        self.iam_resource = iam_resource

    def delete_function(self, function_name):
        """
        Deletes a Lambda function.

        :param function_name: The name of the function to delete.
        """
        try:
            self.lambda_client.delete_function(FunctionName=function_name)
        except ClientError:
            logger.exception("Couldn't delete function %s.", function_name)
            raise
```

- For API details, see DeleteFunction in *AWS SDK for Python (Boto3) API Reference*.

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Get a Lambda function using an AWS SDK

The following code examples show how to get a Lambda function.

JavaScript

**SDK for JavaScript V3**

**Tip**
To learn how to set up and run this example, see GitHub.

```
const getFunction = (funcName) => {
  const client = createClientForDefaultRegion(LambdaClient);
  const command = new GetFunctionCommand({ FunctionName: funcName });
  return client.send(command);
};
```

- For API details, see GetFunction in *AWS SDK for JavaScript API Reference*.

PHP

**SDK for PHP**

**Tip**
To learn how to set up and run this example, see GitHub.

```
    public function getFunction($functionName)
    {
        return $this->lambdaClient->getFunction([
            'FunctionName' => $functionName,
        ]);
    }
```

- For API details, see GetFunction in *AWS SDK for PHP API Reference*.

Python

**SDK for Python (Boto3)**

**Tip**
To learn how to set up and run this example, see GitHub.

```
class LambdaWrapper:
    def __init__(self, lambda_client, iam_resource):
        self.lambda_client = lambda_client
        self.iam_resource = iam_resource

    def get_function(self, function_name):
        """
        Gets data about a Lambda function.

        :param function_name: The name of the function.
        :return: The function data.
        """
        response = None
        try:
            response = self.lambda_client.get_function(FunctionName=function_name)
        except ClientError as err:
            if err.response['Error']['Code'] == 'ResourceNotFoundException':
                logger.info("Function %s does not exist.", function_name)
            else:
                logger.error(
                    "Couldn't get function %s. Here's why: %s: %s", function_name,
                    err.response['Error']['Code'], err.response['Error']
['Message'])
                raise
        return response
```

- For API details, see GetFunction in *AWS SDK for Python (Boto3) API Reference*.

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Invoke a Lambda function using an AWS SDK

The following code examples show how to invoke a Lambda function.

.NET

**AWS SDK for .NET**

**Tip**
To learn how to set up and run this example, see GitHub.

```
using System.Threading.Tasks;
using Amazon.Lambda;
using Amazon.Lambda.Model;

/// <summary>
/// Shows how to invoke an existing Amazon Lambda Function from a C#
/// application. The example was created using the AWS SDK for .NET and
/// .NET Core 5.0.
/// </summary>
public class InvokeFunction
{
    /// <summary>
    /// Initializes the Lambda client and then invokes the Lambda Function
    /// called "CreateDDBTable" with the parameter "\"DDBWorkTable\"" to
    /// create the table called DDBWorkTable.
    /// </summary>
    public static async Task Main()
    {
        IAmazonLambda client = new AmazonLambdaClient();
        string functionName = "CreateDDBTable";
        string invokeArgs = "\"DDBWorkTable\"";

        var response = await client.InvokeAsync(
            new InvokeRequest
            {
                FunctionName = functionName,
                Payload = invokeArgs,
                InvocationType = "Event",
            });
    }
}
```

- For API details, see Invoke in *AWS SDK for .NET API Reference*.

Java

**SDK for Java 2.x**

**Tip**
To learn how to set up and run this example, see GitHub.

```
    public static void invokeFunction(LambdaClient awsLambda, String functionName)
 {

        InvokeResponse res = null ;
        try {
            // Need a SdkBytes instance for the payload.
            JSONObject jsonObj = new JSONObject();
            jsonObj.put("inputValue", "2000");
            String json = jsonObj.toString();
            SdkBytes payload = SdkBytes.fromUtf8String(json) ;

            // Setup an InvokeRequest.
            InvokeRequest request = InvokeRequest.builder()
                .functionName(functionName)
                .payload(payload)
                .build();

            res = awsLambda.invoke(request);
            String value = res.payload().asUtf8String() ;
            System.out.println(value);

        } catch(LambdaException e) {
            System.err.println(e.getMessage());
            System.exit(1);
        }
    }
```

- For API details, see Invoke in *AWS SDK for Java 2.x API Reference*.

JavaScript

**SDK for JavaScript V3**

**Tip**
To learn how to set up and run this example, see GitHub.

```
const invoke = async (funcName, payload) => {
  const client = createClientForDefaultRegion(LambdaClient);
  const command = new InvokeCommand({
    FunctionName: funcName,
    Payload: JSON.stringify(payload),
    LogType: LogType.Tail,
  });

  const { Payload, LogResult } = await client.send(command);
  const result = Buffer.from(Payload).toString();
  const logs = Buffer.from(LogResult, "base64").toString();
  return { logs, result };
};
```

- For API details, see Invoke in *AWS SDK for JavaScript API Reference*.

Kotlin

**SDK for Kotlin**

**Note**
This is prerelease documentation for a feature in preview release. It is subject to change.

**Tip**
To learn how to set up and run this example, see GitHub.

```
suspend fun invokeFunction(functionNameVal: String) {

    val json = """{"inputValue":"1000"}"""
    val byteArray = json.trimIndent().encodeToByteArray()
    val request = InvokeRequest {
        functionName = functionNameVal
        logType = LogType.Tail
        payload = byteArray
    }

    LambdaClient { region = "us-west-2" }.use { awsLambda ->
        val res = awsLambda.invoke(request)
        println("${res.payload?.toString(Charsets.UTF_8)}")
        println("The log result is ${res.logResult}")
    }
}
```

- For API details, see Invoke in *AWS SDK for Kotlin API reference*.

PHP

**SDK for PHP**

**Tip**
To learn how to set up and run this example, see GitHub.

```
    public function invoke($functionName, $params, $logType = 'None')
    {
        return $this->lambdaClient->invoke([
            'FunctionName' => $functionName,
            'Payload' => json_encode($params),
            'LogType' => $logType,
        ]);
    }
```

- For API details, see Invoke in *AWS SDK for PHP API Reference*.

Python

**SDK for Python (Boto3)**

**Tip**
To learn how to set up and run this example, see GitHub.

```
class LambdaWrapper:
    def __init__(self, lambda_client, iam_resource):
        self.lambda_client = lambda_client
        self.iam_resource = iam_resource

    def invoke_function(self, function_name, function_params, get_log=False):
        """
        Invokes a Lambda function.
```

```
        :param function_name: The name of the function to invoke.
        :param function_params: The parameters of the function as a dict. This dict
                                is serialized to JSON before it is sent to Lambda.
        :param get_log: When true, the last 4 KB of the execution log are included
in
                        the response.
        :return: The response from the function invocation.
        """
        try:
            response = self.lambda_client.invoke(
                FunctionName=function_name,
                Payload=json.dumps(function_params),
                LogType='Tail' if get_log else 'None')
            logger.info("Invoked function %s.", function_name)
        except ClientError:
            logger.exception("Couldn't invoke function %s.", function_name)
            raise
        return response
```

- For API details, see Invoke in *AWS SDK for Python (Boto3) API Reference*.

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# List Lambda functions using an AWS SDK

The following code examples show how to list Lambda functions.

.NET

**AWS SDK for .NET**

**Tip**
To learn how to set up and run this example, see GitHub.

```
using System;
using System.Collections.Generic;
using System.Threading.Tasks;
using Amazon;
using Amazon.Lambda;
using Amazon.Lambda.Model;

/// <summary>
/// This example shows two ways to list the AWS Lambda functions you have
/// created for your account. It will only list the functions within one
/// AWS Region at a time, however, so you need to pass the AWS Region you
/// are interested in to the Lambda client object constructor. This example
/// was created with the AWS SDK for .NET version 3.7 and .NET Core 5.0.
/// </summary>
public class ListFunctions
{
    public static async Task Main()
    {
        // If the AWS Region you are interested in listing is the same as
        // the AWS Region defined for the default user, you don't have to
        // supply the RegionEndpoint constant to the constructor.
        IAmazonLambda client = new AmazonLambdaClient(RegionEndpoint.USEast2);

        // First use the ListFunctionsAsync method.
```

```
            var functions1 = await ListFunctionsAsync(client);

            DisplayFunctionList(functions1);

            // Get the list again useing a Lambda client paginator.
            var functions2 = await ListFunctionsPaginatorAsync(client);

            DisplayFunctionList(functions2);
        }

        /// <summary>
        /// Calls the asynchronous ListFunctionsAsync method of the Lambda
        /// client to retrieve the list of functions in the AWS Region with
        /// which the Lambda client was initialized.
        /// </summary>
        /// <param name="client">The initialized Lambda client which will be
        /// used to retrieve the list of Lambda functions.</param>
        /// <returns>A list of Lambda functions configuration information.</
returns>
        public static async Task<List<FunctionConfiguration>>
 ListFunctionsAsync(IAmazonLambda client)
        {
            // Get the list of functions. The response will have a property
            // called Functions, a list of information about the Lambda
            // functions defined on your account in the specified Region.
            var response = await client.ListFunctionsAsync();

            return response.Functions;
        }

        /// <summary>
        /// Uses a Lambda paginator to retrieve the list of functions in the
        /// AWS Region with which the Lambda client was initialized.
        /// </summary>
        /// <param name="client">The initialized Lambda client which will be
        /// used to retrieve the list of Lambda functions.</param>
        /// <returns>A list of Lambda functions configuration information.</
returns>
        public static async Task<List<FunctionConfiguration>>
 ListFunctionsPaginatorAsync(IAmazonLambda client)
        {
            Console.WriteLine("\nNow let's show the list using a paginator.\n");

            // Get the list of functions using a paginator.
            var paginator = client.Paginators.ListFunctions(new
 ListFunctionsRequest());

            // Defined return a list of function information to the caller
            // for display using the DisplayFunctionList method.
            var functions = new List<FunctionConfiguration>();

            await foreach (var resp in paginator.Responses)
            {
                resp.Functions
                    .ForEach(f => functions.Add(f));
            }

            return functions;
        }

        /// <summary>
        /// Displays the details of each function in the list of functions
        /// passed to the method.
        /// </summary>
        /// <param name="functions">A list of FunctionConfiguration objects.</
param>
```

```
        public static void DisplayFunctionList(List<FunctionConfiguration>
 functions)
        {
            // Display a list of the Lambda functions on the console.
            functions
                .ForEach(f => Console.WriteLine($"{f.FunctionName}\t{f.Handler}"));
        }
    }
```

- For API details, see ListFunctions in *AWS SDK for .NET API Reference*.

JavaScript

**SDK for JavaScript V3**

**Tip**
To learn how to set up and run this example, see GitHub.

```
const listFunctions = async () => {
  const client = createClientForDefaultRegion(LambdaClient);
  const command = new ListFunctionsCommand({});

  return client.send(command);
};
```

- For API details, see ListFunctions in *AWS SDK for JavaScript API Reference*.

PHP

**SDK for PHP**

**Tip**
To learn how to set up and run this example, see GitHub.

```
    public function listFunctions($maxItems = 50, $marker = null)
    {
        if (is_null($marker)) {
            return $this->lambdaClient->listFunctions([
                'MaxItems' => $maxItems,
            ]);
        }

        return $this->lambdaClient->listFunctions([
            'Marker' => $marker,
            'MaxItems' => $maxItems,
        ]);
    }
```

- For API details, see ListFunctions in *AWS SDK for PHP API Reference*.

Python

**SDK for Python (Boto3)**

**Tip**
To learn how to set up and run this example, see GitHub.

```
class LambdaWrapper:
    def __init__(self, lambda_client, iam_resource):
        self.lambda_client = lambda_client
        self.iam_resource = iam_resource

    def list_functions(self):
        """
        Lists the Lambda functions for the current account.
        """
        try:
            func_paginator = self.lambda_client.get_paginator('list_functions')
            for func_page in func_paginator.paginate():
                for func in func_page['Functions']:
                    print(func['FunctionName'])
                    desc = func.get('Description')
                    if desc:
                        print(f"\t{desc}")
                    print(f"\t{func['Runtime']}: {func['Handler']}")
        except ClientError as err:
            logger.error(
                "Couldn't list functions. Here's why: %s: %s",
                err.response['Error']['Code'], err.response['Error']['Message'])
            raise
```

- For API details, see ListFunctions in *AWS SDK for Python (Boto3) API Reference*.

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Update Lambda function code using an AWS SDK

The following code examples show how to update Lambda function code.

JavaScript

**SDK for JavaScript V3**

**Tip**
To learn how to set up and run this example, see GitHub.

```
const updateFunctionCode = async (funcName, newFunc) => {
  const client = createClientForDefaultRegion(LambdaClient);
  const code = await zip(`${dirname}../functions/${newFunc}`);
  const command = new UpdateFunctionCodeCommand({
    ZipFile: code,
    FunctionName: funcName,
    Architectures: [Architecture.arm64],
    Handler: "index.handler", // Required when sending a .zip file
    PackageType: PackageType.Zip, // Required when sending a .zip file
    Runtime: Runtime.nodejs16x, // Required when sending a .zip file
  });

  return client.send(command);
};
```

- For API details, see UpdateFunctionCode in *AWS SDK for JavaScript API Reference*.

PHP

**SDK for PHP**

**Tip**
To learn how to set up and run this example, see GitHub.

```
    public function updateFunctionCode($functionName, $s3Bucket, $s3Key)
    {
        return $this->lambdaClient->updateFunctionCode([
            'FunctionName' => $functionName,
            'S3Bucket' => $s3Bucket,
            'S3Key' => $s3Key,
        ]);
    }
```

- For API details, see UpdateFunctionCode in *AWS SDK for PHP API Reference*.

Python

**SDK for Python (Boto3)**

**Tip**
To learn how to set up and run this example, see GitHub.

```
class LambdaWrapper:
    def __init__(self, lambda_client, iam_resource):
        self.lambda_client = lambda_client
        self.iam_resource = iam_resource

    def update_function_code(self, function_name, deployment_package):
        """
        Updates the code for a Lambda function by submitting a .zip archive that
 contains
        the code for the function.

        :param function_name: The name of the function to update.
        :param deployment_package: The function code to update, packaged as bytes
 in
                                   .zip format.
        :return: Data about the update, including the status.
        """
        try:
            response = self.lambda_client.update_function_code(
                FunctionName=function_name, ZipFile=deployment_package)
        except ClientError as err:
            logger.error(
                "Couldn't update function %s. Here's why: %s: %s", function_name,
                err.response['Error']['Code'], err.response['Error']['Message'])
            raise
        else:
            return response
```

- For API details, see UpdateFunctionCode in *AWS SDK for Python (Boto3) API Reference*.

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Update Lambda function configuration using an AWS SDK

The following code examples show how to update Lambda function configuration.

JavaScript

**SDK for JavaScript V3**

**Tip**
To learn how to set up and run this example, see GitHub.

```
const updateFunctionConfiguration = async (funcName) => {
  const client = createClientForDefaultRegion(LambdaClient);
  const config = readFileSync(
    `${dirname}../functions/${funcName}/config.json`
  ).toString();
  const command = new UpdateFunctionConfigurationCommand({
    ...JSON.parse(config),
    FunctionName: funcName,
  });
  return client.send(command);
};
```

- For API details, see UpdateFunctionConfiguration in *AWS SDK for JavaScript API Reference*.

PHP

**SDK for PHP**

**Tip**
To learn how to set up and run this example, see GitHub.

```
    public function updateFunctionConfiguration($functionName, $handler,
 $environment = '')
    {
        return $this->lambdaClient->updateFunctionConfiguration([
            'FunctionName' => $functionName,
            'Handler' => "$handler.lambda_handler",
            'Environment' => $environment,
        ]);
    }
```

- For API details, see UpdateFunctionConfiguration in *AWS SDK for PHP API Reference*.

Python

**SDK for Python (Boto3)**

**Tip**
To learn how to set up and run this example, see GitHub.

```
class LambdaWrapper:
```

```
    def __init__(self, lambda_client, iam_resource):
        self.lambda_client = lambda_client
        self.iam_resource = iam_resource

    def update_function_configuration(self, function_name, env_vars):
        """
        Updates the environment variables for a Lambda function.

        :param function_name: The name of the function to update.
        :param env_vars: A dict of environment variables to update.
        :return: Data about the update, including the status.
        """
        try:
            response = self.lambda_client.update_function_configuration(
                FunctionName=function_name, Environment={'Variables': env_vars})
        except ClientError as err:
            logger.error(
                "Couldn't update function configuration %s. Here's why: %s: %s",
function_name,
                err.response['Error']['Code'], err.response['Error']['Message'])
            raise
        else:
            return response
```

- For API details, see UpdateFunctionConfiguration in *AWS SDK for Python (Boto3) API Reference*.

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Scenarios for Lambda using AWS SDKs

The following code examples show you how to implement common scenarios in Lambda with AWS SDKs. These scenarios show you how to accomplish specific tasks by calling multiple functions within Lambda. Each scenario includes a link to GitHub, where you can find instructions on how to set up and run the code.

**Examples**

- Get started creating and invoking Lambda functions using an AWS SDK (p. 830)

## Get started creating and invoking Lambda functions using an AWS SDK

The following code examples show how to:

- Create an AWS Identity and Access Management (IAM) role that grants Lambda permission to write to logs.
- Create a Lambda function and upload handler code.
- Invoke the function with a single parameter and get results.
- Update the function code and configure its Lambda environment with an environment variable.
- Invoke the function with new parameters and get results. Display the execution log that's returned from the invocation.

- List the functions for your account.
- Delete the IAM role and the Lambda function.

For more information, see Create a Lambda function with the console.

Java

**SDK for Java 2.x**

**Tip**
To learn how to set up and run this example, see GitHub.

```
public class LambdaScenario {

    public static void main(String[] args) throws InterruptedException {

        final String usage = "\n" +
            "Usage:\n" +
            "    <functionName> <filePath> <role> <handler> <bucketName> <key> \n
\n" +
            "Where:\n" +
            "    functionName - The name of the Lambda function. \n"+
            "    filePath - The path to the .zip or .jar where the code is located.
 \n"+
            "    role - The AWS Identity and Access Management (IAM) service role
 that has Lambda permissions. \n"+
            "    handler - The fully qualified method name (for example,
 example.Handler::handleRequest). \n"+
            "    bucketName - The Amazon Simple Storage Service (Amazon S3) bucket
 name that contains the .zip or .jar used to update the Lambda function's code.
 \n"+
            "    key - The Amazon S3 key name that represents the .zip or .jar (for
 example, LambdaHello-1.0-SNAPSHOT.jar)." ;

        if (args.length != 6) {
            System.out.println(usage);
            System.exit(1);
        }

        String functionName = args[0];
        String filePath = args[1];
        String role = args[2];
        String handler = args[3];
        String bucketName = args[4];
        String key = args[5];
        Region region = Region.US_WEST_2;
        LambdaClient awsLambda = LambdaClient.builder()
            .region(region)
            .credentialsProvider(ProfileCredentialsProvider.create())
            .build();

        String funArn = createLambdaFunction(awsLambda, functionName, filePath,
 role, handler);
        System.out.println("The AWS Lambda ARN is "+funArn);

        // Get the Lambda function.
        System.out.println("Getting the " +functionName +" AWS Lambda function.");
        getFunction(awsLambda, functionName);

        // List the Lambda functions.
        System.out.println("Listing all functions.");
        LambdaScenario.listFunctions(awsLambda);
```

```
        System.out.println("*** Sleep for 1 min to get Lambda function ready.");
        Thread.sleep(60000);

        System.out.println("*** Invoke the Lambda function.");
        invokeFunction(awsLambda, functionName);

        System.out.println("*** Update the Lambda function code.");
        LambdaScenario.updateFunctionCode(awsLambda, functionName, bucketName,
key);

        System.out.println("*** Sleep for 1 min to get Lambda function ready.");
        Thread.sleep(60000);
        System.out.println("*** Invoke the Lambda function again with the updated
code.");
        invokeFunction(awsLambda, functionName);

        System.out.println("Update a Lambda function's configuration value.");
        updateFunctionConfiguration(awsLambda, functionName, handler);

        System.out.println("Delete the AWS Lambda function.");
        LambdaScenario.deleteLambdaFunction(awsLambda, functionName);
        awsLambda.close();
    }

    public static String createLambdaFunction(LambdaClient awsLambda,
                                               String functionName,
                                               String filePath,
                                               String role,
                                               String handler) {

        try {
            LambdaWaiter waiter = awsLambda.waiter();
            InputStream is = new FileInputStream(filePath);
            SdkBytes fileToUpload = SdkBytes.fromInputStream(is);

            FunctionCode code = FunctionCode.builder()
                .zipFile(fileToUpload)
                .build();

            CreateFunctionRequest functionRequest = CreateFunctionRequest.builder()
                .functionName(functionName)
                .description("Created by the Lambda Java API")
                .code(code)
                .handler(handler)
                .runtime(Runtime.JAVA8)
                .role(role)
                .build();

            // Create a Lambda function using a waiter
            CreateFunctionResponse functionResponse =
awsLambda.createFunction(functionRequest);
            GetFunctionRequest getFunctionRequest = GetFunctionRequest.builder()
                .functionName(functionName)
                .build();
            WaiterResponse<GetFunctionResponse> waiterResponse =
waiter.waitUntilFunctionExists(getFunctionRequest);
            waiterResponse.matched().response().ifPresent(System.out::println);
            return functionResponse.functionArn();

        } catch(LambdaException | FileNotFoundException e) {
            System.err.println(e.getMessage());
            System.exit(1);
        }
        return "";
    }
```

```
   public static void getFunction(LambdaClient awsLambda, String functionName) {
       try {
           GetFunctionRequest functionRequest = GetFunctionRequest.builder()
               .functionName(functionName)
               .build();

           GetFunctionResponse response = awsLambda.getFunction(functionRequest);
           System.out.println("The runtime of this Lambda function is "
+response.configuration().runtime());

       } catch(LambdaException e) {
           System.err.println(e.getMessage());
           System.exit(1);
       }
   }

   public static void listFunctions(LambdaClient awsLambda) {
       try {
           ListFunctionsResponse functionResult = awsLambda.listFunctions();
           List<FunctionConfiguration> list = functionResult.functions();
           for (FunctionConfiguration config: list) {
               System.out.println("The function name is "+config.functionName());
           }

       } catch(LambdaException e) {
           System.err.println(e.getMessage());
           System.exit(1);
       }
   }

   public static void invokeFunction(LambdaClient awsLambda, String functionName)
{

       InvokeResponse res;
       try {
           // Need a SdkBytes instance for the payload.
           JSONObject jsonObj = new JSONObject();
           jsonObj.put("inputValue", "2000");
           String json = jsonObj.toString();
           SdkBytes payload = SdkBytes.fromUtf8String(json) ;

           InvokeRequest request = InvokeRequest.builder()
               .functionName(functionName)
               .payload(payload)
               .build();

           res = awsLambda.invoke(request);
           String value = res.payload().asUtf8String() ;
           System.out.println(value);

       } catch(LambdaException e) {
           System.err.println(e.getMessage());
           System.exit(1);
       }
   }

   public static void updateFunctionCode(LambdaClient awsLambda, String
functionName, String bucketName, String key) {
       try {
           LambdaWaiter waiter = awsLambda.waiter();
           UpdateFunctionCodeRequest functionCodeRequest =
UpdateFunctionCodeRequest.builder()
               .functionName(functionName)
               .publish(true)
               .s3Bucket(bucketName)
               .s3Key(key)
```

```
                .build();

            UpdateFunctionCodeResponse response =
awsLambda.updateFunctionCode(functionCodeRequest) ;
            GetFunctionConfigurationRequest getFunctionConfigRequest =
GetFunctionConfigurationRequest.builder()
                .functionName(functionName)
                .build();

            WaiterResponse<GetFunctionConfigurationResponse> waiterResponse =
waiter.waitUntilFunctionUpdated(getFunctionConfigRequest);
            waiterResponse.matched().response().ifPresent(System.out::println);
            System.out.println("The last modified value is "
+response.lastModified());

        } catch(LambdaException e) {
            System.err.println(e.getMessage());
            System.exit(1);
        }
    }

    public static void updateFunctionConfiguration(LambdaClient awsLambda, String
functionName, String handler ){
        try {
            UpdateFunctionConfigurationRequest configurationRequest =
UpdateFunctionConfigurationRequest.builder()
                .functionName(functionName)
                .handler(handler)
                .runtime(Runtime.JAVA11 )
                .build();

            awsLambda.updateFunctionConfiguration(configurationRequest);

        } catch(LambdaException e) {
            System.err.println(e.getMessage());
            System.exit(1);
        }
    }

    public static void deleteLambdaFunction(LambdaClient awsLambda, String
functionName ) {
        try {
            DeleteFunctionRequest request = DeleteFunctionRequest.builder()
                .functionName(functionName)
                .build();

            awsLambda.deleteFunction(request);
            System.out.println("The "+functionName +" function was deleted");

        } catch(LambdaException e) {
            System.err.println(e.getMessage());
            System.exit(1);
        }
    }
}
```

- For API details, see the following topics in *AWS SDK for Java 2.x API Reference*.
  - CreateFunction
  - DeleteFunction
  - GetFunction
  - Invoke
  - ListFunctions

- UpdateFunctionCode
- UpdateFunctionConfiguration

JavaScript

**SDK for JavaScript V3**

**Tip**
To learn how to set up and run this example, see GitHub.

Create an AWS Identity and Access Management (IAM) role that grants Lambda permission to write to logs.

```
    log(`Creating role (${NAME_ROLE_LAMBDA})...`);
    const response = await createRole({
      AssumeRolePolicyDocument: parseString({
        Version: "2012-10-17",
        Statement: [
          {
            Effect: "Allow",
            Principal: {
              Service: "lambda.amazonaws.com",
            },
            Action: "sts:AssumeRole",
          },
        ],
      }),
      RoleName: NAME_ROLE_LAMBDA,
    });

const attachRolePolicy = async (roleName, policyArn) => {
  const client = createClientForDefaultRegion(IAMClient);
  const command = new AttachRolePolicyCommand({
    PolicyArn: policyArn, // For example, arn:aws:iam::aws:policy/service-role/
AWSLambdaBasicExecutionRole
    RoleName: roleName, // For example, lambda-basic-execution-role
  });

  return client.send(command);
};
```

Create a Lambda function and upload handler code.

```
const createFunction = async (funcName, roleArn) => {
  const client = createClientForDefaultRegion(LambdaClient);
  const code = await zip(`${dirname}../functions/${funcName}`);

  const command = new CreateFunctionCommand({
    Code: { ZipFile: code },
    FunctionName: funcName,
    Role: roleArn,
    Architectures: [Architecture.arm64],
    Handler: "index.handler", // Required when sending a .zip file
    PackageType: PackageType.Zip, // Required when sending a .zip file
    Runtime: Runtime.nodejs16x, // Required when sending a .zip file
  });

  return client.send(command);
};
```

Invoke the function with a single parameter and get results.

```
const invoke = async (funcName, payload) => {
  const client = createClientForDefaultRegion(LambdaClient);
  const command = new InvokeCommand({
    FunctionName: funcName,
    Payload: JSON.stringify(payload),
    LogType: LogType.Tail,
  });

  const { Payload, LogResult } = await client.send(command);
  const result = Buffer.from(Payload).toString();
  const logs = Buffer.from(LogResult, "base64").toString();
  return { logs, result };
};
```

Update the function code and configure its Lambda environment with an environment variable.

```
const updateFunctionCode = async (funcName, newFunc) => {
  const client = createClientForDefaultRegion(LambdaClient);
  const code = await zip(`${dirname}../functions/${newFunc}`);
  const command = new UpdateFunctionCodeCommand({
    ZipFile: code,
    FunctionName: funcName,
    Architectures: [Architecture.arm64],
    Handler: "index.handler", // Required when sending a .zip file
    PackageType: PackageType.Zip, // Required when sending a .zip file
    Runtime: Runtime.nodejs16x, // Required when sending a .zip file
  });

  return client.send(command);
};

const updateFunctionConfiguration = async (funcName) => {
  const client = createClientForDefaultRegion(LambdaClient);
  const config = readFileSync(
    `${dirname}../functions/${funcName}/config.json`
  ).toString();
  const command = new UpdateFunctionConfigurationCommand({
    ...JSON.parse(config),
    FunctionName: funcName,
  });
  return client.send(command);
};
```

List the functions for your account.

```
const listFunctions = async () => {
  const client = createClientForDefaultRegion(LambdaClient);
  const command = new ListFunctionsCommand({});

  return client.send(command);
};
```

Delete the IAM role and the Lambda function.

```
const deleteRole = (roleName) => {
  const client = createClientForDefaultRegion(IAMClient);
```

```
  const command = new DeleteRoleCommand({ RoleName: roleName });
  return client.send(command);
};

const deleteFunction = (funcName) => {
  const client = createClientForDefaultRegion(LambdaClient);
  const command = new DeleteFunctionCommand({ FunctionName: funcName });
  return client.send(command);
};
```

- For API details, see the following topics in *AWS SDK for JavaScript API Reference*.
  - CreateFunction
  - DeleteFunction
  - GetFunction
  - Invoke
  - ListFunctions
  - UpdateFunctionCode
  - UpdateFunctionConfiguration

Kotlin

**SDK for Kotlin**

**Note**
This is prerelease documentation for a feature in preview release. It is subject to change.

**Tip**
To learn how to set up and run this example, see GitHub.

```
suspend fun main(args: Array<String>) {

    val usage = """
        Usage:
            <functionName> <role> <handler> <bucketName> <updatedBucketName> <key>

        Where:
            functionName - The name of the AWS Lambda function.
            role - The AWS Identity and Access Management (IAM) service role that
 has AWS Lambda permissions.
            handler - The fully qualified method name (for example,
 example.Handler::handleRequest).
            bucketName - The Amazon Simple Storage Service (Amazon S3) bucket name
 that contains the ZIP or JAR used for the Lambda function's code.
            updatedBucketName - The Amazon S3 bucket name that contains the .zip
 or .jar used to update the Lambda function's code.
            key - The Amazon S3 key name that represents the .zip or .jar file (for
 example, LambdaHello-1.0-SNAPSHOT.jar).
            """

    if (args.size != 6) {
        println(usage)
        exitProcess(1)
    }

    val functionName = args[0]
    val role = args[1]
    val handler = args[2]
    val bucketName = args[3]
```

```
    val updatedBucketName = args[4]
    val key = args[5]

    println("Creating a Lambda function named $functionName.")
    val funArn = createScFunction(functionName, bucketName, key, handler, role)
    println("The AWS Lambda ARN is $funArn")

    // Get a specific Lambda function.
    println("Getting the $functionName AWS Lambda function.")
    getFunction(functionName)

    // List the Lambda functions.
    println("Listing all AWS Lambda functions.")
    listFunctionsSc()

    // Invoke the Lambda function.
    println("*** Invoke the Lambda function.")
    invokeFunctionSc(functionName)

    // Update the AWS Lambda function code.
    println("*** Update the Lambda function code.")
    updateFunctionCode(functionName, updatedBucketName, key)

    // println("*** Invoke the function again after updating the code.")
    invokeFunctionSc(functionName)

    // Update the AWS Lambda function configuration.
    println("Update the run time of the function.")
    UpdateFunctionConfiguration(functionName, handler)

    // Delete the AWS Lambda function.
    println("Delete the AWS Lambda function.")
    delFunction(functionName)
}

suspend fun createScFunction(
    myFunctionName: String,
    s3BucketName: String,
    myS3Key: String,
    myHandler: String,
    myRole: String
): String {

    val functionCode = FunctionCode {
        s3Bucket = s3BucketName
        s3Key = myS3Key
    }

    val request = CreateFunctionRequest {
        functionName = myFunctionName
        code = functionCode
        description = "Created by the Lambda Kotlin API"
        handler = myHandler
        role = myRole
        runtime = Runtime.Java8
    }

    // Create a Lambda function using a waiter
    LambdaClient { region = "us-west-2" }.use { awsLambda ->
        val functionResponse = awsLambda.createFunction(request)
        awsLambda.waitUntilFunctionActive {
            functionName = myFunctionName
        }
        return functionResponse.functionArn.toString()
    }
}
```

```
suspend fun getFunction(functionNameVal: String) {

    val functionRequest = GetFunctionRequest {
        functionName = functionNameVal
    }

    LambdaClient { region = "us-west-2" }.use { awsLambda ->
        val response = awsLambda.getFunction(functionRequest)
        println("The runtime of this Lambda function is
 ${response.configuration?.runtime}")
    }
}

suspend fun listFunctionsSc() {

    val request = ListFunctionsRequest {
        maxItems = 10
    }

    LambdaClient { region = "us-west-2" }.use { awsLambda ->
        val response = awsLambda.listFunctions(request)
        response.functions?.forEach { function ->
            println("The function name is ${function.functionName}")
        }
    }
}

suspend fun invokeFunctionSc(functionNameVal: String) {

    val json = """{"inputValue":"1000"}"""
    val byteArray = json.trimIndent().encodeToByteArray()
    val request = InvokeRequest {
        functionName = functionNameVal
        payload = byteArray
        logType = LogType.Tail
    }

    LambdaClient { region = "us-west-2" }.use { awsLambda ->
        val res = awsLambda.invoke(request)
        println("The function payload is ${res.payload?.toString(Charsets.UTF_8)}")
    }
}

suspend fun updateFunctionCode(functionNameVal: String?, bucketName: String?, key:
 String?) {

    val functionCodeRequest = UpdateFunctionCodeRequest {
        functionName = functionNameVal
        publish = true
        s3Bucket = bucketName
        s3Key = key
    }

    LambdaClient { region = "us-west-2" }.use { awsLambda ->
        val response = awsLambda.updateFunctionCode(functionCodeRequest)
        awsLambda.waitUntilFunctionUpdated {
            functionName = functionNameVal
        }
        println("The last modified value is " + response.lastModified)
    }
}

suspend fun UpdateFunctionConfiguration(functionNameVal: String?, handlerVal:
 String?) {
```

```
    val configurationRequest = UpdateFunctionConfigurationRequest {
        functionName = functionNameVal
        handler = handlerVal
        runtime = Runtime.Java11
    }

    LambdaClient { region = "us-west-2" }.use { awsLambda ->
        awsLambda.updateFunctionConfiguration(configurationRequest)
    }
}

suspend fun delFunction(myFunctionName: String) {

    val request = DeleteFunctionRequest {
        functionName = myFunctionName
    }

    LambdaClient { region = "us-west-2" }.use { awsLambda ->
        awsLambda.deleteFunction(request)
        println("$myFunctionName was deleted")
    }
}
```

- For API details, see the following topics in *AWS SDK for Kotlin API reference*.
  - CreateFunction
  - DeleteFunction
  - GetFunction
  - Invoke
  - ListFunctions
  - UpdateFunctionCode
  - UpdateFunctionConfiguration

PHP

**SDK for PHP**

**Tip**
To learn how to set up and run this example, see GitHub.

```
namespace Lambda;

use Aws\S3\S3Client;
use GuzzleHttp\Psr7\Stream;
use Iam\IamService;

class GettingStartedWithLambda
{
    public function run()
    {
        echo("---------------------------------------\n");
        print("Welcome to the AWS Lambda getting started demo using PHP!\n");
        echo("---------------------------------------\n");

        $clientArgs = [
            'region' => 'us-west-2',
            'version' => 'latest',
            'profile' => 'default',
        ];
        $uniqid = uniqid();
```

```
        $iamService = new IamService();
        $s3client = new S3Client($clientArgs);
        $lambdaService = new LambdaService();

        echo "First, let's create a role to run our Lambda code.\n";
        $roleName = "test-lambda-role-$uniqid";
        $rolePolicyDocument = "{
            \"Version\": \"2012-10-17\",
            \"Statement\": [
                {
                    \"Effect\": \"Allow\",
                    \"Principal\": {
                        \"Service\": \"lambda.amazonaws.com\"
                    },
                    \"Action\": \"sts:AssumeRole\"
                }
            ]
        }";
        $role = $iamService->createRole($roleName, $rolePolicyDocument);
        echo "Created role {$role['RoleName']}.\n";

        $iamService->attachRolePolicy(
            $role['RoleName'],
            "arn:aws:iam::aws:policy/service-role/AWSLambdaBasicExecutionRole"
        );
        echo "Attached the AWSLambdaBasicExecutionRole to {$role['RoleName']}.\n";

        echo "\nNow let's create an S3 bucket and upload our Lambda code there.\n";
        $bucketName = "test-example-bucket-$uniqid";
        $s3client->createBucket([
            'Bucket' => $bucketName,
        ]);
        echo "Created bucket $bucketName.\n";

        $functionName = "doc_example_lambda_$uniqid";
        $codeBasic = "lambda_handler_basic.zip";
        $handler = "lambda_handler_basic";
        $file = file_get_contents($codeBasic);
        $s3client->putObject([
            'Bucket' => $bucketName,
            'Key' => $functionName,
            'Body' => $file,
        ]);
        echo "Uploaded the Lambda code.\n";

        $createLambdaFunction = $lambdaService->createFunction($functionName,
 $role, $bucketName, $handler);
        // Wait until the function has finished being created.
        do {
            $getLambdaFunction = $lambdaService-
>getFunction($createLambdaFunction['FunctionName']);
        } while ($getLambdaFunction['Configuration']['State'] == "Pending");
        echo "Created Lambda function {$getLambdaFunction['Configuration']
['FunctionName']}.\n";

        sleep(1);

        echo "\nOk, let's invoke that Lambda code.\n";
        $basicParams = [
            'action' => 'increment',
            'number' => 3,
        ];
        /** @var Stream $invokeFunction */
        $invokeFunction = $lambdaService->invoke($functionName, $basicParams)
['Payload'];
```

```
        $result = json_decode($invokeFunction->getContents())->result;
        echo "After invoking the Lambda code with the input of
 {$basicParams['number']} we received $result.\n";

        echo "\nSince that's working, let's update the Lambda code.\n";
        $codeCalculator = "lambda_handler_calculator.zip";
        $handlerCalculator = "lambda_handler_calculator";
        echo "First, put the new code into the S3 bucket.\n";
        $file = file_get_contents($codeCalculator);
        $s3client->putObject([
            'Bucket' => $bucketName,
            'Key' => $functionName,
            'Body' => $file,
        ]);
        echo "New code uploaded.\n";

        $lambdaService->updateFunctionCode($functionName, $bucketName,
 $functionName);
        // Wait for the Lambda code to finish updating.
        do {
            $getLambdaFunction = $lambdaService-
>getFunction($createLambdaFunction['FunctionName']);
        } while ($getLambdaFunction['Configuration']['LastUpdateStatus'] !==
 "Successful");
        echo "New Lambda code uploaded.\n";

        $environment = [
            'Variable' => ['Variables' => ['LOG_LEVEL' => 'DEBUG']],
        ];
        $lambdaService->updateFunctionConfiguration($functionName,
 $handlerCalculator, $environment);
        do {
            $getLambdaFunction = $lambdaService-
>getFunction($createLambdaFunction['FunctionName']);
        } while ($getLambdaFunction['Configuration']['LastUpdateStatus'] !==
 "Successful");
        echo "Lambda code updated with new handler and a LOG_LEVEL of DEBUG for
 more information.\n";

        echo "Invoke the new code with some new data.\n";
        $calculatorParams = [
            'action' => 'plus',
            'x' => 5,
            'y' => 4,
        ];
        $invokeFunction = $lambdaService->invoke($functionName, $calculatorParams,
 "Tail");
        $result = json_decode($invokeFunction['Payload']->getContents())->result;
        echo "Indeed, {$calculatorParams['x']} + {$calculatorParams['y']} does
 equal $result.\n";
        echo "Here's the extra debug info: ";
        echo base64_decode($invokeFunction['LogResult']) . "\n";

        echo "\nBut what happens if you try to divide by zero?\n";
        $divZeroParams = [
            'action' => 'divide',
            'x' => 5,
            'y' => 0,
        ];
        $invokeFunction = $lambdaService->invoke($functionName, $divZeroParams,
 "Tail");
        $result = json_decode($invokeFunction['Payload']->getContents())->result;
        echo "You get a |$result| result.\n";
        echo "And an error message: ";
        echo base64_decode($invokeFunction['LogResult']) . "\n";
```

```
        echo "\nHere's all the Lambda functions you have in this Region:\n";
        $listLambdaFunctions = $lambdaService->listFunctions(5);
        $allLambdaFunctions = $listLambdaFunctions['Functions'];
        $next = $listLambdaFunctions->get('NextMarker');
        while ($next != false) {
            $listLambdaFunctions = $lambdaService->listFunctions(5, $next);
            $next = $listLambdaFunctions->get('NextMarker');
            $allLambdaFunctions = array_merge($allLambdaFunctions,
 $listLambdaFunctions['Functions']);
        }
        foreach ($allLambdaFunctions as $function) {
            echo "{$function['FunctionName']}\n";
        }

        echo "\n\nAnd don't forget to clean up your data!\n";

        $lambdaService->deleteFunction($functionName);
        echo "Deleted Lambda function.\n";
        $iamService->deleteRole($role['RoleName']);
        echo "Deleted Role.\n";
        $deleteObjects = $s3client->listObjectsV2([
            'Bucket' => $bucketName,
        ]);
        $deleteObjects = $s3client->deleteObjects([
            'Bucket' => $bucketName,
            'Delete' => [
                'Objects' => $deleteObjects['Contents'],
            ]
        ]);
        echo "Deleted all objects from the S3 bucket.\n";
        $s3client->deleteBucket(['Bucket' => $bucketName]);
        echo "Deleted the bucket.\n";
    }
}
```

- For API details, see the following topics in *AWS SDK for PHP API Reference*.
  - CreateFunction
  - DeleteFunction
  - GetFunction
  - Invoke
  - ListFunctions
  - UpdateFunctionCode
  - UpdateFunctionConfiguration

Python

**SDK for Python (Boto3)**

> **Tip**
> To learn how to set up and run this example, see GitHub.

Define a Lambda handler that increments a number.

```
import logging

logger = logging.getLogger()
logger.setLevel(logging.INFO)
```

```
def lambda_handler(event, context):
    """
    Accepts an action and a single number, performs the specified action on the
 number,
    and returns the result. The only allowable action is 'increment'.

    :param event: The event dict that contains the parameters sent when the
 function
                  is invoked.
    :param context: The context in which the function is called.
    :return: The result of the action.
    """
    result = None
    action = event.get('action')
    if action == 'increment':
        result = event.get('number', 0) + 1
        logger.info('Calculated result of %s', result)
    else:
        logger.error("%s is not a valid action.", action)

    response = {'result': result}
    return response
```

Define a second Lambda handler that performs arithmetic operations.

```
import logging
import os


logger = logging.getLogger()

# Define a list of Python lambda functions that are called by this AWS Lambda
 function.
ACTIONS = {
    'plus': lambda x, y: x + y,
    'minus': lambda x, y: x - y,
    'times': lambda x, y: x * y,
    'divided-by': lambda x, y: x / y}


def lambda_handler(event, context):
    """
    Accepts an action and two numbers, performs the specified action on the
 numbers,
    and returns the result.

    :param event: The event dict that contains the parameters sent when the
 function
                  is invoked.
    :param context: The context in which the function is called.
    :return: The result of the specified action.
    """
    # Set the log level based on a variable configured in the Lambda environment.
    logger.setLevel(os.environ.get('LOG_LEVEL', logging.INFO))
    logger.debug('Event: %s', event)

    action = event.get('action')
    func = ACTIONS.get(action)
    x = event.get('x')
    y = event.get('y')
    result = None
    try:
        if func is not None and x is not None and y is not None:
            result = func(x, y)
```

```
            logger.info("%s %s %s is %s", x, action, y, result)
        else:
            logger.error("I can't calculate %s %s %s.", x, action, y)
    except ZeroDivisionError:
        logger.warning("I can't divide %s by 0!", x)

    response = {'result': result}
    return response
```

Create functions that wrap Lambda actions.

```
class LambdaWrapper:
    def __init__(self, lambda_client, iam_resource):
        self.lambda_client = lambda_client
        self.iam_resource = iam_resource

    @staticmethod
    def create_deployment_package(source_file, destination_file):
        """
        Creates a Lambda deployment package in .zip format in an in-memory buffer.
 This
        buffer can be passed directly to Lambda when creating the function.

        :param source_file: The name of the file that contains the Lambda handler
                            function.
        :param destination_file: The name to give the file when it's deployed to
 Lambda.
        :return: The deployment package.
        """
        buffer = io.BytesIO()
        with zipfile.ZipFile(buffer, 'w') as zipped:
            zipped.write(source_file, destination_file)
        buffer.seek(0)
        return buffer.read()

    def get_iam_role(self, iam_role_name):
        """
        Get an AWS Identity and Access Management (IAM) role.

        :param iam_role_name: The name of the role to retrieve.
        :return: The IAM role.
        """
        role = None
        try:
            temp_role = self.iam_resource.Role(iam_role_name)
            temp_role.load()
            role = temp_role
            logger.info("Got IAM role %s", role.name)
        except ClientError as err:
            if err.response['Error']['Code'] == 'NoSuchEntity':
                logger.info("IAM role %s does not exist.", iam_role_name)
            else:
                logger.error(
                    "Couldn't get IAM role %s. Here's why: %s: %s", iam_role_name,
                    err.response['Error']['Code'], err.response['Error']
['Message'])
                raise
        return role

    def create_iam_role_for_lambda(self, iam_role_name):
        """
        Creates an IAM role that grants the Lambda function basic permissions. If a
        role with the specified name already exists, it is used for the demo.
```

```
        :param iam_role_name: The name of the role to create.
        :return: The role and a value that indicates whether the role is newly
 created.
        """
        role = self.get_iam_role(iam_role_name)
        if role is not None:
            return role, False

        lambda_assume_role_policy = {
            'Version': '2012-10-17',
            'Statement': [
                {
                    'Effect': 'Allow',
                    'Principal': {
                        'Service': 'lambda.amazonaws.com'
                    },
                    'Action': 'sts:AssumeRole'
                }
            ]
        }
        policy_arn = 'arn:aws:iam::aws:policy/service-role/
AWSLambdaBasicExecutionRole'

        try:
            role = self.iam_resource.create_role(
                RoleName=iam_role_name,
                AssumeRolePolicyDocument=json.dumps(lambda_assume_role_policy))
            logger.info("Created role %s.", role.name)
            role.attach_policy(PolicyArn=policy_arn)
            logger.info("Attached basic execution policy to role %s.", role.name)
        except ClientError as error:
            if error.response['Error']['Code'] == 'EntityAlreadyExists':
                role = self.iam_resource.Role(iam_role_name)
                logger.warning("The role %s already exists. Using it.",
 iam_role_name)
            else:
                logger.exception(
                    "Couldn't create role %s or attach policy %s.",
                    iam_role_name, policy_arn)
                raise

        return role, True

    def get_function(self, function_name):
        """
        Gets data about a Lambda function.

        :param function_name: The name of the function.
        :return: The function data.
        """
        response = None
        try:
            response = self.lambda_client.get_function(FunctionName=function_name)
        except ClientError as err:
            if err.response['Error']['Code'] == 'ResourceNotFoundException':
                logger.info("Function %s does not exist.", function_name)
            else:
                logger.error(
                    "Couldn't get function %s. Here's why: %s: %s", function_name,
                    err.response['Error']['Code'], err.response['Error']
['Message'])
                raise
        return response

    def create_function(self, function_name, handler_name, iam_role,
 deployment_package):
```

```
        """
        Deploys a Lambda function.

        :param function_name: The name of the Lambda function.
        :param handler_name: The fully qualified name of the handler function. This
                             must include the file name and the function name.
        :param iam_role: The IAM role to use for the function.
        :param deployment_package: The deployment package that contains the
function
                                   code in .zip format.
        :return: The Amazon Resource Name (ARN) of the newly created function.
        """
        try:
            response = self.lambda_client.create_function(
                FunctionName=function_name,
                Description="AWS Lambda doc example",
                Runtime='python3.8',
                Role=iam_role.arn,
                Handler=handler_name,
                Code={'ZipFile': deployment_package},
                Publish=True)
            function_arn = response['FunctionArn']
            waiter = self.lambda_client.get_waiter('function_active_v2')
            waiter.wait(FunctionName=function_name)
            logger.info("Created function '%s' with ARN: '%s'.",
                        function_name, response['FunctionArn'])
        except ClientError:
            logger.error("Couldn't create function %s.", function_name)
            raise
        else:
            return function_arn

    def delete_function(self, function_name):
        """
        Deletes a Lambda function.

        :param function_name: The name of the function to delete.
        """
        try:
            self.lambda_client.delete_function(FunctionName=function_name)
        except ClientError:
            logger.exception("Couldn't delete function %s.", function_name)
            raise

    def invoke_function(self, function_name, function_params, get_log=False):
        """
        Invokes a Lambda function.

        :param function_name: The name of the function to invoke.
        :param function_params: The parameters of the function as a dict. This dict
                                is serialized to JSON before it is sent to Lambda.
        :param get_log: When true, the last 4 KB of the execution log are included
in
                        the response.
        :return: The response from the function invocation.
        """
        try:
            response = self.lambda_client.invoke(
                FunctionName=function_name,
                Payload=json.dumps(function_params),
                LogType='Tail' if get_log else 'None')
            logger.info("Invoked function %s.", function_name)
        except ClientError:
            logger.exception("Couldn't invoke function %s.", function_name)
            raise
        return response
```

```
   def update_function_code(self, function_name, deployment_package):
       """
       Updates the code for a Lambda function by submitting a .zip archive that
contains
       the code for the function.

       :param function_name: The name of the function to update.
       :param deployment_package: The function code to update, packaged as bytes
in
                                  .zip format.
       :return: Data about the update, including the status.
       """
       try:
           response = self.lambda_client.update_function_code(
               FunctionName=function_name, ZipFile=deployment_package)
       except ClientError as err:
           logger.error(
               "Couldn't update function %s. Here's why: %s: %s", function_name,
               err.response['Error']['Code'], err.response['Error']['Message'])
           raise
       else:
           return response

   def update_function_configuration(self, function_name, env_vars):
       """
       Updates the environment variables for a Lambda function.

       :param function_name: The name of the function to update.
       :param env_vars: A dict of environment variables to update.
       :return: Data about the update, including the status.
       """
       try:
           response = self.lambda_client.update_function_configuration(
               FunctionName=function_name, Environment={'Variables': env_vars})
       except ClientError as err:
           logger.error(
               "Couldn't update function configuration %s. Here's why: %s: %s",
function_name,
               err.response['Error']['Code'], err.response['Error']['Message'])
           raise
       else:
           return response

   def list_functions(self):
       """
       Lists the Lambda functions for the current account.
       """
       try:
           func_paginator = self.lambda_client.get_paginator('list_functions')
           for func_page in func_paginator.paginate():
               for func in func_page['Functions']:
                   print(func['FunctionName'])
                   desc = func.get('Description')
                   if desc:
                       print(f"\t{desc}")
                   print(f"\t{func['Runtime']}: {func['Handler']}")
       except ClientError as err:
           logger.error(
               "Couldn't list functions. Here's why: %s: %s",
               err.response['Error']['Code'], err.response['Error']['Message'])
           raise
```

Create a function that runs the scenario.

```
class UpdateFunctionWaiter(CustomWaiter):
    """A custom waiter that waits until a function is successfully updated."""
    def __init__(self, client):
        super().__init__(
            'UpdateSuccess', 'GetFunction',
            'Configuration.LastUpdateStatus',
            {'Successful': WaitState.SUCCESS, 'Failed': WaitState.FAILURE},
            client)

    def wait(self, function_name):
        self._wait(FunctionName=function_name)


def run_scenario(lambda_client, iam_resource, basic_file, calculator_file,
 lambda_name):
    """
    Runs the scenario.

    :param lambda_client: A Boto3 Lambda client.
    :param iam_resource: A Boto3 IAM resource.
    :param basic_file: The name of the file that contains the basic Lambda handler.
    :param calculator_file: The name of the file that contains the calculator
 Lambda handler.
    :param lambda_name: The name to give resources created for the scenario, such
 as the
                        IAM role and the Lambda function.
    """
    logging.basicConfig(level=logging.INFO, format='%(levelname)s: %(message)s')

    print('-'*88)
    print("Welcome to the AWS Lambda getting started with functions demo.")
    print('-'*88)

    wrapper = LambdaWrapper(lambda_client, iam_resource)

    print("Checking for IAM role for Lambda...")
    iam_role, should_wait = wrapper.create_iam_role_for_lambda(lambda_name)
    if should_wait:
        logger.info("Giving AWS time to create resources...")
        wait(10)

    print(f"Looking for function {lambda_name}...")
    function = wrapper.get_function(lambda_name)
    if function is None:
        print("Zipping the Python script into a deployment package...")
        deployment_package = wrapper.create_deployment_package(basic_file,
 f"{lambda_name}.py")
        print(f"...and creating the {lambda_name} Lambda function.")
        wrapper.create_function(
            lambda_name, f'{lambda_name}.lambda_handler', iam_role,
 deployment_package)
    else:
        print(f"Function {lambda_name} already exists.")
    print('-'*88)

    print(f"Let's invoke {lambda_name}. This function increments a number.")
    action_params = {
        'action': 'increment',
        'number': q.ask("Give me a number to increment: ", q.is_int)}
    print(f"Invoking {lambda_name}...")
    response = wrapper.invoke_function(lambda_name, action_params)
    print(f"Incrementing {action_params['number']} resulted in "
          f"{json.load(response['Payload'])}")
    print('-'*88)
```

```
    print(f"Let's update the function to an arithmetic calculator.")
    q.ask("Press Enter when you're ready.")
    print("Creating a new deployment package...")
    deployment_package = wrapper.create_deployment_package(calculator_file,
 f"{lambda_name}.py")
    print(f"...and updating the {lambda_name} Lambda function.")
    update_waiter = UpdateFunctionWaiter(lambda_client)
    wrapper.update_function_code(lambda_name, deployment_package)
    update_waiter.wait(lambda_name)
    print(f"This function uses an environment variable to control logging level.")
    print(f"Let's set it to DEBUG to get the most logging.")
    wrapper.update_function_configuration(
        lambda_name, {'LOG_LEVEL': logging.getLevelName(logging.DEBUG)})

    actions = ['plus', 'minus', 'times', 'divided-by']
    want_invoke = True
    while want_invoke:
        print(f"Let's invoke {lambda_name}. You can invoke these actions:")
        for index, action in enumerate(actions):
            print(f"{index + 1}: {action}")
        action_params = {}
        action_index = q.ask(
            "Enter the number of the action you want to take: ",
            q.is_int, q.in_range(1, len(actions)))
        action_params['action'] = actions[action_index - 1]
        print(f"You've chosen to invoke 'x {action_params['action']} y'.")
        action_params['x'] = q.ask("Enter a value for x: ", q.is_int)
        action_params['y'] = q.ask("Enter a value for y: ", q.is_int)
        print(f"Invoking {lambda_name}...")
        response = wrapper.invoke_function(lambda_name, action_params, True)
        print(f"Calculating {action_params['x']} {action_params['action']}
 {action_params['y']} "
              f"resulted in {json.load(response['Payload'])}")
        q.ask("Press Enter to see the logs from the call.")
        print(base64.b64decode(response['LogResult']).decode())
        want_invoke = q.ask("That was fun. Shall we do it again? (y/n) ",
 q.is_yesno)
    print('-'*88)

    if q.ask("Do you want to list all of the functions in your account? (y/n) "):
        wrapper.list_functions()
    print('-'*88)

    if q.ask("Ready to delete the function and role? (y/n) ", q.is_yesno):
        for policy in iam_role.attached_policies.all():
            policy.detach_role(RoleName=iam_role.name)
        iam_role.delete()
        print(f"Deleted role {lambda_name}.")
        wrapper.delete_function(lambda_name)
        print(f"Deleted function {lambda_name}.")

    print("\nThanks for watching!")
    print('-'*88)


if __name__ == '__main__':
    try:
        run_scenario(
            boto3.client('lambda'), boto3.resource('iam'),
 'lambda_handler_basic.py',
            'lambda_handler_calculator.py', 'doc_example_lambda_calculator')
    except Exception:
        logging.exception("Something went wrong with the demo!")
```

- For API details, see the following topics in *AWS SDK for Python (Boto3) API Reference*.
  - CreateFunction
  - DeleteFunction
  - GetFunction
  - Invoke
  - ListFunctions
  - UpdateFunctionCode
  - UpdateFunctionConfiguration

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Cross-service examples for Lambda using AWS SDKs

The following sample applications use AWS SDKs to combine Lambda with other AWS services. Each example includes a link to GitHub, where you can find instructions on how to set up and run the application.

**Examples**

- Create an API Gateway REST API to track COVID-19 data (p. 851)
- Create a lending library REST API (p. 852)
- Create a messenger application with Step Functions (p. 853)
- Create a websocket chat application with API Gateway (p. 853)
- Invoke a Lambda function from a browser (p. 854)
- Use API Gateway to invoke a Lambda function (p. 854)
- Use Step Functions to invoke Lambda functions (p. 856)
- Use scheduled events to invoke a Lambda function (p. 857)

## Create an API Gateway REST API to track COVID-19 data

The following code example shows how to create a REST API that simulates a system to track daily cases of COVID-19 in the United States, using fictional data.

Python

**SDK for Python (Boto3)**

Shows how to use AWS Chalice with the AWS SDK for Python (Boto3) to create a serverless REST API that uses Amazon API Gateway, AWS Lambda, and Amazon DynamoDB. The REST API simulates a system that tracks daily cases of COVID-19 in the United States, using fictional data. Learn how to:

- Use AWS Chalice to define routes in Lambda functions that are called to handle REST requests that come through API Gateway.

- Use Lambda functions to retrieve and store data in a DynamoDB table to serve REST requests.
- Define table structure and security role resources in an AWS CloudFormation template.
- Use AWS Chalice and CloudFormation to package and deploy all necessary resources.
- Use CloudFormation to clean up all created resources.

For complete source code and instructions on how to set up and run, see the full example on GitHub.

**Services used in this example**

- API Gateway
- AWS CloudFormation
- DynamoDB
- Lambda

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Create a lending library REST API

The following code example shows how to create a lending library where patrons can borrow and return books by using a REST API backed by an Amazon Aurora database.

Python

**SDK for Python (Boto3)**

Shows how to use the AWS SDK for Python (Boto3) with the Amazon Relational Database Service (Amazon RDS) API and AWS Chalice to create a REST API backed by an Amazon Aurora database. The web service is fully serverless and represents a simple lending library where patrons can borrow and return books. Learn how to:

- Create and manage a serverless Aurora database cluster.
- Use AWS Secrets Manager to manage database credentials.
- Implement a data storage layer that uses Amazon RDS to move data into and out of the database.
- Use AWS Chalice to deploy a serverless REST API to Amazon API Gateway and AWS Lambda.
- Use the Requests package to send requests to the web service.

For complete source code and instructions on how to set up and run, see the full example on GitHub.

**Services used in this example**

- API Gateway
- Lambda
- Amazon RDS
- Secrets Manager

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Create a messenger application with Step Functions

The following code example shows how to create an AWS Step Functions messenger application that retrieves message records from a database table.

Python

**SDK for Python (Boto3)**

Shows how to use the AWS SDK for Python (Boto3) with AWS Step Functions to create a messenger application that retrieves message records from an Amazon DynamoDB table and sends them with Amazon Simple Queue Service (Amazon SQS). The state machine integrates with an AWS Lambda function to scan the database for unsent messages.

- Create a state machine that retrieves and updates message records from an Amazon DynamoDB table.
- Update the state machine definition to also send messages to Amazon Simple Queue Service (Amazon SQS).
- Start and stop state machine runs.
- Connect to Lambda, DynamoDB, and Amazon SQS from a state machine by using service integrations.

For complete source code and instructions on how to set up and run, see the full example on GitHub.

**Services used in this example**

- DynamoDB
- Lambda
- Amazon SQS
- Step Functions

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Create a websocket chat application with API Gateway

The following code example shows how to create a chat application that is served by a websocket API built on Amazon API Gateway.

Python

**SDK for Python (Boto3)**

Shows how to use the AWS SDK for Python (Boto3) with Amazon API Gateway V2 to create a websocket API that integrates with AWS Lambda and Amazon DynamoDB.

- Create a websocket API served by API Gateway.
- Define a Lambda handler that stores connections in DynamoDB and posts messages to other chat participants.
- Connect to the websocket chat application and send messages with the Websockets package.

For complete source code and instructions on how to set up and run, see the full example on GitHub.

**Services used in this example**

- API Gateway
- DynamoDB
- Lambda

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Invoke a Lambda function from a browser

The following code example shows how to invoke an AWS Lambda function from a browser.

JavaScript

**SDK for JavaScript V2**

You can create a browser-based application that uses an AWS Lambda function to update an Amazon DynamoDB table with user selections.

For complete source code and instructions on how to set up and run, see the full example on GitHub.

**Services used in this example**

- DynamoDB
- Lambda

**SDK for JavaScript V3**

You can create a browser-based application that uses an AWS Lambda function to update an Amazon DynamoDB table with user selections. This app uses AWS SDK for JavaScript v3.

For complete source code and instructions on how to set up and run, see the full example on GitHub.

**Services used in this example**

- DynamoDB
- Lambda

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Use API Gateway to invoke a Lambda function

The following code examples show how to create an AWS Lambda function invoked by Amazon API Gateway.

Java

**SDK for Java 2.x**

Shows how to create an AWS Lambda function by using the Lambda Java runtime API. This example invokes different AWS services to perform a specific use case. This example

demonstrates how to create a Lambda function invoked by Amazon API Gateway that scans an Amazon DynamoDB table for work anniversaries and uses Amazon Simple Notification Service (Amazon SNS) to send a text message to your employees that congratulates them at their one year anniversary date.

For complete source code and instructions on how to set up and run, see the full example on GitHub.

#### Services used in this example

- API Gateway
- DynamoDB
- Lambda
- Amazon SNS

JavaScript

**SDK for JavaScript V3**

Shows how to create an AWS Lambda function by using the Lambda JavaScript runtime API. This example invokes different AWS services to perform a specific use case. This example demonstrates how to create a Lambda function invoked by Amazon API Gateway that scans an Amazon DynamoDB table for work anniversaries and uses Amazon Simple Notification Service (Amazon SNS) to send a text message to your employees that congratulates them at their one year anniversary date.

For complete source code and instructions on how to set up and run, see the full example on GitHub.

This example is also available in the AWS SDK for JavaScript v3 developer guide.

#### Services used in this example

- API Gateway
- DynamoDB
- Lambda
- Amazon SNS

Python

**SDK for Python (Boto3)**

This example shows how to create and use an Amazon API Gateway REST API that targets an AWS Lambda function. The Lambda handler demonstrates how to route based on HTTP methods; how to get data from the query string, header, and body; and how to return a JSON response.

- Deploy a Lambda function.
- Create an API Gateway REST API.
- Create a REST resource that targets the Lambda function.
- Grant permission to let API Gateway invoke the Lambda function.
- Use the Requests package to send requests to the REST API.
- Clean up all resources created during the demo.

This example is best viewed on GitHub. For complete source code and instructions on how to set up and run, see the full example on GitHub.

**Services used in this example**

- API Gateway
- Lambda

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Use Step Functions to invoke Lambda functions

The following code examples show how to create an AWS Step Functions state machine that invokes AWS Lambda functions in sequence.

Java

**SDK for Java 2.x**

Shows how to create an AWS serverless workflow by using AWS Step Functions and the AWS SDK for Java 2.x. Each workflow step is implemented using an AWS Lambda function.

For complete source code and instructions on how to set up and run, see the full example on GitHub.

**Services used in this example**

- DynamoDB
- Lambda
- Amazon SES
- Step Functions

JavaScript

**SDK for JavaScript V3**

Shows how to create an AWS serverless workflow by using AWS Step Functions and the AWS SDK for JavaScript. Each workflow step is implemented using an AWS Lambda function.

Lambda is a compute service that enables you to run code without provisioning or managing servers. Step Functions is a serverless orchestration service that lets you combine Lambda functions and other AWS services to build business-critical applications.

For complete source code and instructions on how to set up and run, see the full example on GitHub.

This example is also available in the AWS SDK for JavaScript v3 developer guide.

**Services used in this example**

- DynamoDB
- Lambda
- Amazon SES
- Step Functions

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# Use scheduled events to invoke a Lambda function

The following code examples show how to create an AWS Lambda function invoked by an Amazon EventBridge scheduled event.

Java

**SDK for Java 2.x**

Shows how to create an Amazon EventBridge scheduled event that invokes an AWS Lambda function. Configure EventBridge to use a cron expression to schedule when the Lambda function is invoked. In this example, you create a Lambda function by using the Lambda Java runtime API. This example invokes different AWS services to perform a specific use case. This example demonstrates how to create an app that sends a mobile text message to your employees that congratulates them at the one year anniversary date.

For complete source code and instructions on how to set up and run, see the full example on GitHub.

### Services used in this example

- DynamoDB
- EventBridge
- Lambda
- Amazon SNS

JavaScript

**SDK for JavaScript V3**

Shows how to create an Amazon EventBridge scheduled event that invokes an AWS Lambda function. Configure EventBridge to use a cron expression to schedule when the Lambda function is invoked. In this example, you create a Lambda function by using the Lambda JavaScript runtime API. This example invokes different AWS services to perform a specific use case. This example demonstrates how to create an app that sends a mobile text message to your employees that congratulates them at the one year anniversary date.

For complete source code and instructions on how to set up and run, see the full example on GitHub.

This example is also available in the AWS SDK for JavaScript v3 developer guide.

### Services used in this example

- DynamoDB
- EventBridge
- Lambda
- Amazon SNS

Python

**SDK for Python (Boto3)**

This example shows how to register an AWS Lambda function as the target of a scheduled Amazon EventBridge event. The Lambda handler writes a friendly message and the full event data to Amazon CloudWatch Logs for later retrieval.

- Deploys a Lambda function.
- Creates an EventBridge scheduled event and makes the Lambda function the target.
- Grants permission to let EventBridge invoke the Lambda function.
- Prints the latest data from CloudWatch Logs to show the result of the scheduled invocations.
- Cleans up all resources created during the demo.

This example is best viewed on GitHub. For complete source code and instructions on how to set up and run, see the full example on GitHub.

### Services used in this example

- CloudWatch Logs
- EventBridge
- Lambda

For a complete list of AWS SDK developer guides and code examples, see Using Lambda with an AWS SDK (p. 799). This topic also includes information about getting started and details about previous SDK versions.

# AWS Lambda releases

The following table describes the important changes to the *AWS Lambda Developer Guide* since May 2018. For notification about updates to this documentation, subscribe to the RSS feed.

| Change | Description | Date |
| --- | --- | --- |
| lambda:SourceFunctionArn condition key | For an AWS resource, the `lambda:SourceFunctionArn` condition key filters access to the resource by the ARN of a Lambda function. For details, see Working with Lambda execution environment credentials. | July 1, 2022 |
| Node.js 16 runtime | Lambda now supports a new runtime for Node.js 16. Node.js 16 uses Amazon Linux 2. For details, see Building Lambda functions with Node.js. | May 11, 2022 |
| Lambda function URLs | Lambda now supports function URLs, which are dedicated HTTP(S) endpoints for Lambda functions. For details, see Lambda function URLs. | April 6, 2022 |
| Shared test events in the AWS Lambda console | Lambda now supports sharing test events with other IAM users in the same AWS account. For details, see Testing Lambda functions in the console. | March 16, 2022 |
| PrincipalOrgId in resource-based policies | Lambda now supports granting permissions to an organization in AWS Organizations. For details, see Using resource-based policies for AWS Lambda. | March 11, 2022 |
| .NET 6 runtime | Lambda now supports a new runtime for .NET 6. For details, see Lambda runtimes. | February 23, 2022 |
| Event filtering for Kinesis, DynamoDB, and Amazon SQS event sources | Lambda now supports event filtering for Kinesis, DynamoDB, and Amazon SQS event sources. For details, see Lambda event filtering. | November 24, 2021 |
| mTLS authentication for Amazon MSK and self-managed Apache Kafka event sources | Lambda now supports mTLS authentication for Amazon MSK and self-managed Apache Kafka event sources. For details, see Using Lambda with Amazon MSK. | November 19, 2021 |

| | | |
|---|---|---|
| Lambda on Graviton2 | Lambda now supports Graviton2 for functions using arm64 architecture. For details, see Lambda instruction set architectures. | September 29, 2021 |
| Python 3.9 runtime | Lambda now supports a new runtime for Python 3.9. For details, see Lambda runtimes. | August 16, 2021 |
| New runtime versions for Node.js, Python, and Java | New runtime versions are available for Node.js, Python, and Java. For details, see Lambda runtimes. | July 21, 2021 |
| Support for RabbitMQ as an event source on Lambda | Lambda now supports Amazon MQ for RabbitMQ as an event source. Amazon MQ is a managed message broker service for Apache ActiveMQ and RabbitMQ that makes it easy to set up and operate message brokers in the cloud. For details, see Using Lambda with Amazon MQ. | July 7, 2021 |
| SASL/PLAIN authentication for self-managed Kafka on Lambda | SASL/PLAIN is now a supported authentication mechanism for self-managed Kafka event sources on Lambda Customers already using SASL/PLAIN on their self-managed Kafka cluster can now easily use Lambda to build consumer applications without having to modify the way they authenticate. For details, see Using Lambda with self-managed Apache Kafka. | June 29, 2021 |
| Lambda Extensions API | General availability for Lambda extensions. Use extensions to augment your Lambda functions. You can use extensions provided by Lambda Partners, or you can create your own Lambda extensions. For details, see Lambda Extensions API. | May 24, 2021 |
| New Lambda console experience (p. 859) | The Lambda console has been redesigned to improve performance and consistency. | March 2, 2021 |
| Node.js 14 runtime | Lambda now supports a new runtime for Node.js 14. Node.js 14 uses Amazon Linux 2. For details, see Building Lambda functions with Node.js. | January 27, 2021 |

| | | |
|---|---|---|
| Lambda container images | Lambda now supports functions defined as container images. You can combine the flexibility of container tooling with the agility and operational simplicity of Lambda to build applications. For details, see Using container images with Lambda. | December 1, 2020 |
| Code signing for Lambda functions | Lambda now supports code signing. Administrators can configure Lambda functions to accept only signed code on deployment. Lambda checks the signatures to ensure that the code is not altered or tampered. Additionally, Lambda ensures that the code is signed by trusted developers before accepting the deployment. For details, see Configuring code signing for Lambda. | November 23, 2020 |
| Preview: Lambda Runtime Logs API | Lambda now supports the Runtime Logs API. Lambda extensions can use the Logs API to subscribe to log streams in the execution environment. For details, see Lambda Runtime Logs API. | November 12, 2020 |
| New event source to for Amazon MQ | Lambda now supports Amazon MQ as an event source. Use a Lambda function to process records from your Amazon MQ message broker. For details, see Using Lambda with Amazon MQ. | November 5, 2020 |
| Preview: Lambda Extensions API | Use Lambda extensions to augment your Lambda functions. You can use extensions provided by Lambda Partners, or you can create your own Lambda extensions. For details, see Lambda Extensions API. | October 8, 2020 |
| Support for Java 8 and custom runtimes on AL2 | Lambda now supports Java 8 and custom runtimes on Amazon Linux 2. For details, see Lambda runtimes. | August 12, 2020 |

| | | |
|---|---|---|
| New event source for Amazon Managed Streaming for Apache Kafka | Lambda now supports Amazon MSK as an event source. Use a Lambda function with Amazon MSK to process records in a Kafka topic. For details, see Using Lambda with Amazon MSK. | August 11, 2020 |
| IAM condition keys for Amazon VPC settings | You can now use Lambda-specific condition keys for VPC settings. For example, you can require that all functions in your organization are connected to a VPC. You can also specify the subnets and security groups that the function's users can and can't use. For details, see Configuring VPC for IAM functions. | August 10, 2020 |
| Concurrency settings for Kinesis HTTP/2 stream consumers | You can now use the following concurrency settings for Kinesis consumers with enhanced fan-out (HTTP/2 streams): ParallelizationFactor, MaximumRetryAttempts, MaximumRecordAgeInSeconds, DestinationConfig, and BisectBatchOnFunctionError. For details, see Using AWS Lambda with Amazon Kinesis. | July 7, 2020 |
| Batch window for Kinesis HTTP/2 stream consumers | You can now configure a batch window (MaximumBatchingWindowInSeconds) for HTTP/2 streams. Lambda reads records from the stream until it has gathered a full batch, or until the batch window expires. For details, see Using AWS Lambda with Amazon Kinesis. | June 18, 2020 |
| Support for Amazon EFS file systems | You can now connect an Amazon EFS file system to your Lambda functions for shared network file access. For details, see Configuring file system access for Lambda functions. | June 16, 2020 |

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|---|---|---|
| AWS CDK sample applications in the Lambda console | The Lambda console now includes sample applications that use the AWS Cloud Development Kit (AWS CDK) for TypeScript. The AWS CDK is a framework that enables you to define your application resources in TypeScript, Python, Java, or .NET. For a tutorial on creating applications, see Creating an application with continuous delivery in the Lambda console. | June 1, 2020 |
| Support for .NET Core 3.1.0 runtime in AWS Lambda | AWS Lambda now supports the .NET Core 3.1.0 runtime. For details, see .NET Core CLI. | March 31, 2020 |
| Support for API Gateway HTTP APIs | Updated and expanded documentation for using Lambda with API Gateway, including support for HTTP APIs. Added a sample application that creates an API and function with AWS CloudFormation. For details, see Using Lambda with Amazon API Gateway. | March 23, 2020 |
| Ruby 2.7 | A new runtime is available for Ruby 2.7, ruby2.7, which is the first Ruby runtime to use Amazon Linux 2. For details, see Building Lambda functions with Ruby. | February 19, 2020 |
| Concurrency metrics | Lambda now reports the `ConcurrentExecutions` metric for all functions, aliases, and versions. You can view a graph for this metric on the monitoring page for your function. Previously, `ConcurrentExecutions` was only reported at the account level and for functions that use reserved concurrency. For details, see AWS Lambda function metrics. | February 18, 2020 |

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|---|---|---|
| Update to function states | Function states are now enforced for all functions by default. When you connect a function to a VPC, Lambda creates shared elastic network interfaces. This enables your function to scale up without creating additional network interfaces. During this time, you can't perform additional operations on the function, including updating its configuration and publishing versions. In some cases, invocation is also impacted. Details about a function's current state are available from the Lambda API.<br><br>This update is being released in phases. For details, see Updated Lambda states lifecycle for VPC networking on the AWS Compute Blog. For more information about states, see AWS Lambda function states. | January 24, 2020 |
| Updates to function configuration API output | Added reason codes to StateReasonCode (InvalidSubnet, InvalidSecurityGroup) and LastUpdateStatusReasonCode (SubnetOutOfIPAddresses, InvalidSubnet, InvalidSecurityGroup) for functions that connect to a VPC. For more information about states, see AWS Lambda function states. | January 20, 2020 |
| Provisioned concurrency | You can now allocate provisioned concurrency for a function version or alias. Provisioned concurrency enables a function to scale without fluctuations in latency. For details, see Managing concurrency for a Lambda function. | December 3, 2019 |

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|---|---|---|
| Create a database proxy | You can now use the Lambda console to create a database proxy for a Lambda function. A database proxy enables a function to reach high concurrency levels without exhausting database connections. For details, see Configuring database access for a Lambda function. | December 3, 2019 |
| Percentiles support for the duration metric | You can now filter the duration metric based on percentiles. For details, see AWS Lambda metrics. | November 26, 2019 |
| Increased concurrency for stream event sources | A new option for DynamoDB stream and Kinesis stream event source mappings enables you to process more than one batch at a time from each shard. When you increase the number of concurrent batches per shard, your function's concurrency can be up to 10 times the number of shards in your stream. For details, see Lambda event source mapping. | November 25, 2019 |
| Function states | When you create or update a function, it enters a pending state while Lambda provisions resources to support it. If you connect your function to a VPC, Lambda can create a shared elastic network interface right away, instead of creating network interfaces when your function is invoked. This results in better performance for VPC-connected functions, but might require an update to your automation. For details, see AWS Lambda function states. | November 25, 2019 |
| Error handling options for asynchronous invocation | New configuration options are available for asynchronous invocation. You can configure Lambda to limit retries and set a maximum event age. For details, see Configuring error handling for asynchronous invocation. | November 25, 2019 |

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|---|---|---|
| Error handling for stream event sources | New configuration options are available for event source mappings that read from streams. You can configure DynamoDB stream and Kinesis stream event source mappings to limit retries and set a maximum record age. When errors occur, you can configure the event source mapping to split batches before retrying, and to send invocation records for failed batches to a queue or topic. For details, see Lambda event source mapping. | November 25, 2019 |
| Destinations for asynchronous invocation | You can now configure Lambda to send records of asynchronous invocations to another service. Invocation records contain details about the event, context, and function response. You can send invocation records to an SQS queue, SNS topic, Lambda function, or EventBridge event bus. For details, see Configuring destinations for asynchronous invocation. | November 25, 2019 |
| New runtimes for Node.js, Python, and Java | New runtimes are available for Node.js 12, Python 3.8, and Java 11. For details, see Lambda runtimes. | November 18, 2019 |
| FIFO queue support for Amazon SQS event sources | You can now create an event source mapping that reads from a first-in, first-out (FIFO) queue. Previously, only standard queues were supported. For details, see Using Lambda with Amazon SQS. | November 18, 2019 |
| Create applications in the Lambda console | Application creation in the Lambda console is now generally available. For instructions, see Creating an application with continuous delivery in the Lambda console. | October 31, 2019 |

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|---|---|---|
| Create applications in the Lambda console (beta) | You can now create a Lambda application with an integrated continuous delivery pipeline in the Lambda console. The console provides sample applications that you can use as a starting point for your own project. Choose between AWS CodeCommit and GitHub for source control. Each time you push changes to your repository, the included pipeline builds and deploys them automatically. For instructions, see Creating an application with continuous delivery in the Lambda console. | October 3, 2019 |
| Performance improvements for VPC-connected functions | Lambda now uses a new type of elastic network interface that is shared by all functions in a virtual private cloud (VPC) subnet. When you connect a function to a VPC, Lambda creates a network interface for each combination of security group and subnet that you choose. When the shared network interfaces are available, the function no longer needs to create additional network interfaces as it scales up. This dramatically improves startup times. For details, see Configuring a Lambda function to access resources in a VPC. | September 3, 2019 |
| Stream batch settings | You can now configure a batch window for Amazon DynamoDB and Amazon Kinesis event source mappings. Configure a batch window of up to five minutes to buffer incoming records until a full batch is available. This reduces the number of times that your function is invoked when the stream is less active. | August 29, 2019 |
| CloudWatch Logs Insights integration | The monitoring page in the Lambda console now includes reports from Amazon CloudWatch Logs Insights. For details, see Monitoring functions in the AWS Lambda console. | June 18, 2019 |

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|---|---|---|
| Amazon Linux 2018.03 | The Lambda execution environment is being updated to use Amazon Linux 2018.03. For details, see Execution environment. | May 21, 2019 |
| Node.js 10 | A new runtime is available for Node.js 10, nodejs10.x. This runtime uses Node.js 10.15 and will be updated with the latest point release of Node.js 10 periodically. Node.js 10 is also the first runtime to use Amazon Linux 2. For details, see Building Lambda functions with Node.js. | May 13, 2019 |
| GetLayerVersionByArn API | Use the GetLayerVersionByArn API to download layer version information with the version ARN as input. Compared to GetLayerVersion, GetLayerVersionByArn lets you use the ARN directly instead of parsing it to get the layer name and version number. | April 25, 2019 |
| Ruby | AWS Lambda now supports Ruby 2.5 with a new runtime. For details, see Building Lambda functions with Ruby. | November 29, 2018 |
| Layers | With Lambda layers, you can package and deploy libraries, custom runtimes, and other dependencies separately from your function code. Share your layers with your other accounts or the whole world. For details, see Lambda layers. | November 29, 2018 |
| Custom runtimes | Build a custom runtime to run Lambda functions in your favorite programming language. For details, see Custom Lambda runtimes. | November 29, 2018 |
| Application Load Balancer triggers | Elastic Load Balancing now supports Lambda functions as a target for Application Load Balancers. For details, see Using Lambda with application load balancers. | November 29, 2018 |

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|---|---|---|
| Use Kinesis HTTP/2 stream consumers as a trigger | You can use Kinesis HTTP/2 data stream consumers to send events to AWS Lambda. Stream consumers have dedicated read throughput from each shard in your data stream and use HTTP/2 to minimize latency. For details, see Using Lambda with Kinesis. | November 19, 2018 |
| Python 3.7 | AWS Lambda now supports Python 3.7 with a new runtime. For more information, see Building Lambda functions with Python. | November 19, 2018 |
| Payload limit increase for asynchronous function invocation | The maximum payload size for asynchronous invocations increased from 128 KB to 256 KB, which matches the maximum message size from an Amazon SNS trigger. For details, see Lambda quotas. | November 16, 2018 |
| AWS GovCloud (US-East) Region | AWS Lambda is now available in the AWS GovCloud (US-East) Region. | November 12, 2018 |
| Moved AWS SAM topics to a separate Developer Guide | A number of topics were focused on building serverless applications using the AWS Serverless Application Model (AWS SAM). These topics have been moved to AWS Serverless Application Model developer guide. | October 25, 2018 |
| View Lambda applications in the console | You can view the status of your Lambda applications on the Applications page in the Lambda console. This page shows the status of the AWS CloudFormation stack. It includes links to pages where you can view more information about the resources in the stack. You can also view aggregate metrics for the application and create custom monitoring dashboards. | October 11, 2018 |
| Function execution timeout limit | To allow for long-running functions, the maximum configurable execution timeout increased from 5 minutes to 15 minutes. For details, see Lambda limits. | October 10, 2018 |

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|---|---|---|
| Support for PowerShell Core language in AWS Lambda | AWS Lambda now supports the PowerShell Core language. For more information, see Programming model for authoring Lambda functions in PowerShell. | September 11, 2018 |
| Support for .NET Core 2.1.0 runtime in AWS Lambda | AWS Lambda now supports the .NET Core 2.1.0 runtime. For more information, see .NET Core CLI. | July 9, 2018 |
| Updates now available over RSS | You can now subscribe to an RSS feed to follow releases for this guide. | July 5, 2018 |
| Support for Amazon SQS as event source | AWS Lambda now supports Amazon Simple Queue Service (Amazon SQS) as an event source. For more information, see Invoking Lambda functions. | June 28, 2018 |
| China (Ningxia) Region | AWS Lambda is now available in the China (Ningxia) Region. For more information about Lambda Regions and endpoints, see Regions and endpoints in the *AWS General Reference*. | June 28, 2018 |

# Earlier updates

The following table describes the important changes in each release of the *AWS Lambda Developer Guide* before June 2018.

| Change | Description | Date |
|---|---|---|
| Runtime support for Node.js runtime 8.10 | AWS Lambda now supports Node.js runtime version 8.10. For more information, see Building Lambda functions with Node.js (p. 282). | April 2, 2018 |
| Function and alias revision IDs | AWS Lambda now supports revision IDs on your function versions and aliases. You can use these IDs to track and apply conditional updates when you are updating your function version or alias resources. | January 25, 2018 |
| Runtime support for Go and .NET 2.0 | AWS Lambda has added runtime support for Go and .NET 2.0. For more information, see Building Lambda functions with Go (p. 420) and Building Lambda functions with C# (p. 449). | January 15, 2018 |
| Console Redesign | AWS Lambda has introduced a new Lambda console to simplify your experience and added a Cloud9 Code Editor to enhance your ability debug and revise your function code. For more information, see Edit code using the console editor (p. 38). | November 30,2017 |

| Change | Description | Date |
| --- | --- | --- |
| Setting Concurrency Limits on Individual Functions | AWS Lambda now supports setting concurrency limits on individual functions. For more information, see Managing Lambda reserved concurrency (p. 180). | November 30,2017 |
| Shifting Traffic with Aliases | AWS Lambda now supports shifting traffic with aliases. For more information, see Rolling deployments for Lambda functions (p. 773). | November 28, 2017 |
| Gradual Code Deployment | AWS Lambda now supports safely deploying new versions of your Lambda function by leveraging Code Deploy. For more information, see Gradual code deployment. | November 28, 2017 |
| China (Beijing) Region | AWS Lambda is now available in the China (Beijing) Region. For more information about Lambda regions and endpoints, see Regions and endpoints in the *AWS General Reference*. | November 9, 2017 |
| Introducing SAM Local | AWS Lambda introduces SAM Local (now known as SAM CLI), a AWS CLI tool that provides an environment for you to develop, test, and analyze your serverless applications locally before uploading them to the Lambda runtime. For more information, see Testing and debugging serverless applications. | August 11, 2017 |
| Canada (Central) Region | AWS Lambda is now available in the Canada (Central) Region. For more information about Lambda regions and endpoints, see Regions and endpoints in the *AWS General Reference*. | June 22, 2017 |
| South America (São Paulo) Region | AWS Lambda is now available in the South America (São Paulo) Region. For more information about Lambda regions and endpoints, see Regions and endpoints in the *AWS General Reference*. | June 6, 2017 |
| AWS Lambda support for AWS X-Ray. | Lambda introduces support for X-Ray, which allows you to detect, analyze, and optimize performance issues with your Lambda applications. For more information, see Using AWS Lambda with AWS X-Ray (p. 715). | April 19, 2017 |
| Asia Pacific (Mumbai) Region | AWS Lambda is now available in the Asia Pacific (Mumbai) Region. For more information about Lambda regions and endpoints, see Regions and endpoints in the *AWS General Reference*. | March 28, 2017 |
| AWS Lambda now supports Node.js runtime v6.10 | AWS Lambda added support for Node.js runtime v6.10. For more information, see Building Lambda functions with Node.js (p. 282). | March 22, 2017 |
| Europe (London) Region | AWS Lambda is now available in the Europe (London) Region. For more information about Lambda regions and endpoints, see Regions and endpoints in the *AWS General Reference*. | February 1, 2017 |
| AWS Lambda support for the .NET runtime, Lambda@Edge (Preview), Dead Letter Queues and automated deployment of serverless applications. | AWS Lambda added support for C#. For more information, see Building Lambda functions with C# (p. 449).<br><br>Lambda@Edge allows you to run Lambda functions at the AWS Edge locations in response to CloudFront events. For more information, see Using AWS Lambda with CloudFront Lambda@Edge (p. 544). | December 3, 2016 |

| Change | Description | Date |
| --- | --- | --- |
| AWS Lambda adds Amazon Lex as a supported event source. | Using Lambda and Amazon Lex, you can quickly build chat bots for various services like Slack and Facebook. For more information, see Using AWS Lambda with Amazon Lex (p. 635). | November 30, 2016 |
| US West (N. California) Region | AWS Lambda is now available in the US West (N. California) Region. For more information about Lambda regions and endpoints, see Regions and endpoints in the *AWS General Reference*. | November 21, 2016 |
| Introduced the AWS SAM for creating and deploying Lambda-based applications and using environment variables for Lambda function configuration settings. | AWS SAM: You can now use the AWS SAM to define the syntax for expressing resources within a serverless application. In order to deploy your application, simply specify the resources you need as part of your application, along with their associated permissions policies in a AWS CloudFormation template file (written in either JSON or YAML), package your deployment artifacts, and deploy the template. For more information, see AWS Lambda applications (p. 760).<br><br>Environment variables: You can use environment variables to specify configuration settings for your Lambda function outside of your function code. For more information, see Using AWS Lambda environment variables (p. 166). | November 18, 2016 |
| Asia Pacific (Seoul) Region | AWS Lambda is now available in the Asia Pacific (Seoul) Region. For more information about Lambda regions and endpoints, see Regions and endpoints in the *AWS General Reference*. | August 29, 2016 |
| Asia Pacific (Sydney) Region | Lambda is now available in the Asia Pacific (Sydney) Region. For more information about Lambda regions and endpoints, see Regions and endpoints in the *AWS General Reference*. | June 23, 2016 |
| Updates to the Lambda console | The Lambda console has been updated to simplify the role-creation process. For more information, see Create a Lambda function with the console (p. 8). | June 23, 2016 |
| AWS Lambda now supports Node.js runtime v4.3 | AWS Lambda added support for Node.js runtime v4.3. For more information, see Building Lambda functions with Node.js (p. 282). | April 07, 2016 |
| Europe (Frankfurt) region | Lambda is now available in the Europe (Frankfurt) region. For more information about Lambda regions and endpoints, see Regions and endpoints in the *AWS General Reference*. | March 14, 2016 |
| VPC support | You can now configure a Lambda function to access resources in your VPC. For more information, see Configuring a Lambda function to access resources in a VPC (p. 191). | February 11, 2016 |
| Lambda runtime has been updated. | The execution environment (p. 82) has been updated. | November 4, 2015 |

| Change | Description | Date |
| --- | --- | --- |
| Versioning support, Python for developing code for Lambdafunctions, scheduled events, and increase in execution time | You can now develop your Lambda function code using Python. For more information, see Building Lambda functions with Python (p. 324).<br><br>Versioning: You can maintain one or more versions of your Lambda function. Versioning allows you to control which Lambda function version is executed in different environments (for example, development, testing, or production). For more information, see Lambda function versions (p. 173).<br><br>Scheduled events: You can also set up Lambda to invoke your code on a regular, scheduled basis using the Lambda console. You can specify a fixed rate (number of hours, days, or weeks) or you can specify a cron expression. For an example, see Using AWS Lambda with Amazon EventBridge (CloudWatch Events) (p. 535).<br><br>Increase in execution time: You can now set up your Lambda functions to run for up to five minutes allowing longer running functions such as large volume data ingestion and processing jobs. | October 08, 2015 |
| Support for DynamoDB Streams | DynamoDB Streams is now generally available and you can use it in all the regions where DynamoDB is available. You can enable DynamoDB Streams for your table and use a Lambda function as a trigger for the table. Triggers are custom actions you take in response to updates made to the DynamoDB table. For an example walkthrough, see Tutorial: Using AWS Lambda with Amazon DynamoDB streams (p. 571) . | July 14, 2015 |
| Lambda now supports invoking Lambda functions with REST-compatible clients. | Until now, to invoke your Lambda function from your web, mobile, or IoT application you needed the AWS SDKs (for example, AWS SDK for Java, AWS SDK for Android, or AWS SDK for iOS). Now, Lambda supports invoking a Lambda function with REST-compatible clients through a customized API that you can create using Amazon API Gateway. You can send requests to your Lambda function endpoint URL. You can configure security on the endpoint to allow open access, leverage AWS Identity and Access Management (IAM) to authorize access, or use API keys to meter access to your Lambda functions by others.<br><br>For an example Getting Started exercise, see Using AWS Lambda with Amazon API Gateway (p. 502).<br><br>For more information about the Amazon API Gateway, see https://aws.amazon.com/api-gateway/. | July 09, 2015 |
| The Lambda console now provides blueprints to easily create Lambda functions and test them. | Lambda console provides a set of *blueprints*. Each blueprint provides a sample event source configuration and sample code for your Lambda function that you can use to easily create Lambda-based applications. All of the Lambda Getting Started exercises now use the blueprints. For more information, see Getting started with Lambda (p. 8). | July 09, 2015 |

| Change | Description | Date |
| --- | --- | --- |
| Lambda now supports Java to author your Lambda functions. | You can now author Lambda code in Java. For more information, see Building Lambda functions with Java (p. 379). | June 15, 2015 |
| Lambda now supports specifying an Amazon S3 object as the function .zip when creating or updating a Lambda function. | You can upload a Lambda function deployment package (.zip file) to an Amazon S3 bucket in the same region where you want to create a Lambda function. Then, you can specify the bucket name and object key name when you create or update a Lambda function. | May 28, 2015 |
| Lambda now generally available with added support for mobile backends | Lambda is now generally available for production use. The release also introduces new features that make it easier to build mobile, tablet, and Internet of Things (IoT) backends using Lambda that scale automatically without provisioning or managing infrastructure. Lambda now supports both real-time (synchronous) and asynchronous events. Additional features include easier event source configuration and management. The permission model and the programming model have been simplified by the introduction of resource policies for your Lambda functions.<br><br>The documentation has been updated accordingly. For information, see the following topics:<br><br>Getting started with Lambda (p. 8)<br><br>AWS Lambda | April 9, 2015 |
| Preview release | Preview release of the *AWS Lambda Developer Guide*. | November 13, 2014 |

# API reference

This section contains the AWS Lambda API Reference documentation. When making the API calls, you will need to authenticate your request by providing a signature. AWS Lambda supports signature version 4. For more information, see Signature Version 4 signing process in the *Amazon Web Services General Reference*.

For an overview of the service, see What is AWS Lambda? (p. 1).

You can use the AWS CLI to explore the AWS Lambda API. This guide provides several tutorials that use the AWS CLI.

**Topics**


- Actions (p. 875)
- Data Types (p. 1116)


## Actions

The following actions are supported:


- AddLayerVersionPermission (p. 877)
- AddPermission (p. 881)
- CreateAlias (p. 886)
- CreateCodeSigningConfig (p. 890)
- CreateEventSourceMapping (p. 893)
- CreateFunction (p. 904)
- CreateFunctionUrlConfig (p. 917)
- DeleteAlias (p. 921)
- DeleteCodeSigningConfig (p. 923)
- DeleteEventSourceMapping (p. 925)
- DeleteFunction (p. 931)
- DeleteFunctionCodeSigningConfig (p. 933)
- DeleteFunctionConcurrency (p. 935)
- DeleteFunctionEventInvokeConfig (p. 937)
- DeleteFunctionUrlConfig (p. 939)
- DeleteLayerVersion (p. 941)
- DeleteProvisionedConcurrencyConfig (p. 943)
- GetAccountSettings (p. 945)
- GetAlias (p. 947)
- GetCodeSigningConfig (p. 950)
- GetEventSourceMapping (p. 952)
- GetFunction (p. 958)
- GetFunctionCodeSigningConfig (p. 962)
- GetFunctionConcurrency (p. 965)
- GetFunctionConfiguration (p. 967)

- GetFunctionEventInvokeConfig (p. 974)
- GetFunctionUrlConfig (p. 977)
- GetLayerVersion (p. 980)
- GetLayerVersionByArn (p. 983)
- GetLayerVersionPolicy (p. 986)
- GetPolicy (p. 988)
- GetProvisionedConcurrencyConfig (p. 990)
- Invoke (p. 993)
- InvokeAsync (p. 999)
- ListAliases (p. 1001)
- ListCodeSigningConfigs (p. 1004)
- ListEventSourceMappings (p. 1006)
- ListFunctionEventInvokeConfigs (p. 1010)
- ListFunctions (p. 1013)
- ListFunctionsByCodeSigningConfig (p. 1017)
- ListFunctionUrlConfigs (p. 1019)
- ListLayers (p. 1022)
- ListLayerVersions (p. 1025)
- ListProvisionedConcurrencyConfigs (p. 1028)
- ListTags (p. 1031)
- ListVersionsByFunction (p. 1033)
- PublishLayerVersion (p. 1037)
- PublishVersion (p. 1042)
- PutFunctionCodeSigningConfig (p. 1050)
- PutFunctionConcurrency (p. 1053)
- PutFunctionEventInvokeConfig (p. 1056)
- PutProvisionedConcurrencyConfig (p. 1060)
- RemoveLayerVersionPermission (p. 1063)
- RemovePermission (p. 1065)
- TagResource (p. 1067)
- UntagResource (p. 1069)
- UpdateAlias (p. 1071)
- UpdateCodeSigningConfig (p. 1075)
- UpdateEventSourceMapping (p. 1078)
- UpdateFunctionCode (p. 1088)
- UpdateFunctionConfiguration (p. 1098)
- UpdateFunctionEventInvokeConfig (p. 1109)
- UpdateFunctionUrlConfig (p. 1113)

# AddLayerVersionPermission

Adds permissions to the resource-based policy of a version of an AWS Lambda layer. Use this action to grant layer usage permission to other accounts. You can grant permission to a single account, all accounts in an organization, or all AWS accounts.

To revoke permission, call RemoveLayerVersionPermission (p. 1063) with the statement ID that you specified when you added it.

## Request Syntax

```
POST /2018-10-31/layers/LayerName/versions/VersionNumber/policy?RevisionId=RevisionId
 HTTP/1.1
Content-type: application/json

{
   "Action": "string",
   "OrganizationId": "string",
   "Principal": "string",
   "StatementId": "string"
}
```

## URI Request Parameters

The request uses the following URI parameters.

**LayerName (p. 877)**

The name or Amazon Resource Name (ARN) of the layer.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+)|[a-zA-Z0-9-_]+`

Required: Yes

**RevisionId (p. 877)**

Only update the policy if the revision ID matches the ID specified. Use this option to avoid modifying a policy that has changed since you last read it.

**VersionNumber (p. 877)**

The version number.

Required: Yes

## Request Body

The request accepts the following data in JSON format.

**Action (p. 877)**

The API action that grants access to the layer. For example, `lambda:GetLayerVersion`.

Type: String

Length Constraints: Maximum length of 22.

Pattern: `lambda:GetLayerVersion`

Required: Yes

**OrganizationId (p. 877)**

With the principal set to `*`, grant permission to all accounts in the specified organization.

Type: String

Length Constraints: Maximum length of 34.

Pattern: `o-[a-z0-9]{10,32}`

Required: No

**Principal (p. 877)**

An account ID, or `*` to grant layer usage permission to all accounts in an organization, or all AWS accounts (if `organizationId` is not specified). For the last case, make sure that you really do want all AWS accounts to have usage permission to this layer.

Type: String

Pattern: `\d{12}|\*|arn:(aws[a-zA-Z-]*):iam::\d{12}:root`

Required: Yes

**StatementId (p. 877)**

An identifier that distinguishes the policy from others on the same layer version.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 100.

Pattern: `([a-zA-Z0-9-_]+)`

Required: Yes

## Response Syntax

```
HTTP/1.1 201
Content-type: application/json

{
   "RevisionId": "string",
   "Statement": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 201 response.

The following data is returned in JSON format by the service.

**RevisionId (p. 878)**

A unique identifier for the current revision of the policy.

Type: String

**Statement (p. 878)**

The permission statement.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**PolicyLengthExceededException**

The permissions policy for the resource is too large. Learn more

HTTP Status Code: 400

**PreconditionFailedException**

The RevisionId provided does not match the latest RevisionId for the Lambda function or alias. Call the `GetFunction` or the `GetAlias` API to retrieve the latest RevisionId for your resource.

HTTP Status Code: 412

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript

- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# AddPermission

Grants an AWS service, account, or organization permission to use a function. You can apply the policy at the function level, or specify a qualifier to restrict access to a single version or alias. If you use a qualifier, the invoker must use the full Amazon Resource Name (ARN) of that version or alias to invoke the function. Note: Lambda does not support adding policies to version $LATEST.

To grant permission to another account, specify the account ID as the `Principal`. To grant permission to an organization defined in AWS Organizations, specify the organization ID as the `PrincipalOrgID`. For AWS services, the principal is a domain-style identifier defined by the service, like `s3.amazonaws.com` or `sns.amazonaws.com`. For AWS services, you can also specify the ARN of the associated resource as the `SourceArn`. If you grant permission to a service principal without specifying the source, other accounts could potentially configure resources in their account to invoke your Lambda function.

This action adds a statement to a resource-based permissions policy for the function. For more information about function policies, see Lambda Function Policies.

## Request Syntax

```
POST /2015-03-31/functions/FunctionName/policy?Qualifier=Qualifier HTTP/1.1
Content-type: application/json

{
   "Action": "string",
   "EventSourceToken": "string",
   "FunctionUrlAuthType": "string",
   "Principal": "string",
   "PrincipalOrgID": "string",
   "RevisionId": "string",
   "SourceAccount": "string",
   "SourceArn": "string",
   "StatementId": "string"
}
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 881)**

The name of the Lambda function, version, or alias.

**Name formats**

- **Function name** - `my-function` (name-only), `my-function:v1` (with alias).
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

You can append a version number or alias to any of the formats. The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 881)**

Specify a version or alias to add permissions to a published version of the function.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

## Request Body

The request accepts the following data in JSON format.

**Action (p. 881)**

The action that the principal can use on the function. For example, `lambda:InvokeFunction` or `lambda:GetFunction`.

Type: String

Pattern: `(lambda:[*]|lambda:[a-zA-Z]+|[*])`

Required: Yes

**EventSourceToken (p. 881)**

For Alexa Smart Home functions, a token that must be supplied by the invoker.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Pattern: `[a-zA-Z0-9._\-]+`

Required: No

**FunctionUrlAuthType (p. 881)**

The type of authentication that your function URL uses. Set to `AWS_IAM` if you want to restrict access to authenticated `IAM` users only. Set to `NONE` if you want to bypass IAM authentication to create a public endpoint. For more information, see Security and auth model for Lambda function URLs.

Type: String

Valid Values: `NONE | AWS_IAM`

Required: No

**Principal (p. 881)**

The AWS service or account that invokes the function. If you specify a service, use `SourceArn` or `SourceAccount` to limit who can invoke the function through that service.

Type: String

Pattern: `[^\s]+`

Required: Yes

**PrincipalOrgID (p. 881)**

The identifier for your organization in AWS Organizations. Use this to grant permissions to all the AWS accounts under this organization.

Type: String

Length Constraints: Minimum length of 12. Maximum length of 34.

Pattern: `^o-[a-z0-9]{10,32}$`

Required: No

**RevisionId (p. 881)**

Only update the policy if the revision ID matches the ID that's specified. Use this option to avoid modifying a policy that has changed since you last read it.

Type: String

Required: No

**SourceAccount (p. 881)**

For Amazon S3, the ID of the account that owns the resource. Use this together with `SourceArn` to ensure that the resource is owned by the specified account. It is possible for an Amazon S3 bucket to be deleted by its owner and recreated by another account.

Type: String

Length Constraints: Maximum length of 12.

Pattern: `\d{12}`

Required: No

**SourceArn (p. 881)**

For AWS services, the ARN of the AWS resource that invokes the function. For example, an Amazon S3 bucket or Amazon SNS topic.

Note that Lambda configures the comparison using the `StringLike` operator.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

Required: No

**StatementId (p. 881)**

A statement identifier that differentiates the statement from others in the same policy.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 100.

Pattern: `([a-zA-Z0-9-_]+)`

Required: Yes

## Response Syntax

```
HTTP/1.1 201
Content-type: application/json

{
   "Statement": "string"
```

```
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 201 response.

The following data is returned in JSON format by the service.

**Statement (p. 883)**

The permission statement that's added to the function policy.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**PolicyLengthExceededException**

The permissions policy for the resource is too large. Learn more

HTTP Status Code: 400

**PreconditionFailedException**

The RevisionId provided does not match the latest RevisionId for the Lambda function or alias. Call the `GetFunction` or the `GetAlias` API to retrieve the latest RevisionId for your resource.

HTTP Status Code: 412

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# CreateAlias

Creates an alias for a Lambda function version. Use aliases to provide clients with a function identifier that you can update to invoke a different version.

You can also map an alias to split invocation requests between two versions. Use the `RoutingConfig` parameter to specify a second version and the percentage of invocation requests that it receives.

## Request Syntax

```
POST /2015-03-31/functions/FunctionName/aliases HTTP/1.1
Content-type: application/json

{
   "Description": "string",
   "FunctionVersion": "string",
   "Name": "string",
   "RoutingConfig": {
      "AdditionalVersionWeights": {
         "string" : number
      }
   }
}
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 886)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

## Request Body

The request accepts the following data in JSON format.

**Description (p. 886)**

A description of the alias.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

**FunctionVersion (p. 886)**

The function version that the alias invokes.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

Required: Yes

**Name (p. 886)**

The name of the alias.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(?!^[0-9]+$)([a-zA-Z0-9-_]+)`

Required: Yes

**RoutingConfig (p. 886)**

The routing configuration of the alias.

Type: AliasRoutingConfiguration (p. 1122) object

Required: No

## Response Syntax

```
HTTP/1.1 201
Content-type: application/json

{
   "AliasArn": "string",
   "Description": "string",
   "FunctionVersion": "string",
   "Name": "string",
   "RevisionId": "string",
   "RoutingConfig": {
      "AdditionalVersionWeights": {
         "string" : number
      }
   }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 201 response.

The following data is returned in JSON format by the service.

**AliasArn (p. 887)**

The Amazon Resource Name (ARN) of the alias.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**Description (p. 887)**

A description of the alias.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

**FunctionVersion (p. 887)**

The function version that the alias invokes.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

**Name (p. 887)**

The name of the alias.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(?!^[0-9]+$)([a-zA-Z0-9-_]+)`

**RevisionId (p. 887)**

A unique identifier that changes when you update the alias.

Type: String

**RoutingConfig (p. 887)**

The routing configuration of the alias.

Type: AliasRoutingConfiguration (p. 1122) object

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# CreateCodeSigningConfig

Creates a code signing configuration. A code signing configuration defines a list of allowed signing profiles and defines the code-signing validation policy (action to be taken if deployment validation checks fail).

## Request Syntax

```
POST /2020-04-22/code-signing-configs/ HTTP/1.1
Content-type: application/json

{
   "AllowedPublishers": {
      "SigningProfileVersionArns": [ "string" ]
   },
   "CodeSigningPolicies": {
      "UntrustedArtifactOnDeployment": "string"
   },
   "Description": "string"
}
```

## URI Request Parameters

The request does not use any URI parameters.

## Request Body

The request accepts the following data in JSON format.

**AllowedPublishers (p. 890)**

Signing profiles for this code signing configuration.

Type: AllowedPublishers (p. 1123) object

Required: Yes

**CodeSigningPolicies (p. 890)**

The code signing policies define the actions to take if the validation checks fail.

Type: CodeSigningPolicies (p. 1127) object

Required: No

**Description (p. 890)**

Descriptive name for this code signing configuration.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

## Response Syntax

```
HTTP/1.1 201
```

```
Content-type: application/json

{
   "CodeSigningConfig": {
      "AllowedPublishers": {
         "SigningProfileVersionArns": [ "string" ]
      },
      "CodeSigningConfigArn": "string",
      "CodeSigningConfigId": "string",
      "CodeSigningPolicies": {
         "UntrustedArtifactOnDeployment": "string"
      },
      "Description": "string",
      "LastModified": "string"
   }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 201 response.

The following data is returned in JSON format by the service.

**CodeSigningConfig (p. 890)**

The code signing configuration.

Type: CodeSigningConfig (p. 1125) object

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# CreateEventSourceMapping

Creates a mapping between an event source and an AWS Lambda function. Lambda reads items from the event source and invokes the function.

For details about how to configure different event sources, see the following topics.

- Amazon DynamoDB Streams
- Amazon Kinesis
- Amazon SQS
- Amazon MQ and RabbitMQ
- Amazon MSK
- Apache Kafka

The following error handling options are available only for stream sources (DynamoDB and Kinesis):

- `BisectBatchOnFunctionError` - If the function returns an error, split the batch in two and retry.
- `DestinationConfig` - Send discarded records to an Amazon SQS queue or Amazon SNS topic.
- `MaximumRecordAgeInSeconds` - Discard records older than the specified age. The default value is infinite (-1). When set to infinite (-1), failed records are retried until the record expires
- `MaximumRetryAttempts` - Discard records after the specified number of retries. The default value is infinite (-1). When set to infinite (-1), failed records are retried until the record expires.
- `ParallelizationFactor` - Process multiple batches from each shard concurrently.

For information about which configuration parameters apply to each event source, see the following topics.

- Amazon DynamoDB Streams
- Amazon Kinesis
- Amazon SQS
- Amazon MQ and RabbitMQ
- Amazon MSK
- Apache Kafka

## Request Syntax

```
POST /2015-03-31/event-source-mappings/ HTTP/1.1
Content-type: application/json

{
   "AmazonManagedKafkaEventSourceConfig": {
      "ConsumerGroupId": "string"
   },
   "BatchSize": number,
   "BisectBatchOnFunctionError": boolean,
   "DestinationConfig": {
      "OnFailure": {
         "Destination": "string"
      },
      "OnSuccess": {
         "Destination": "string"
      }
   },
```

```
   "Enabled": boolean,
   "EventSourceArn": "string",
   "FilterCriteria": {
      "Filters": [
         {
            "Pattern": "string"
         }
      ]
   },
   "FunctionName": "string",
   "FunctionResponseTypes": [ "string" ],
   "MaximumBatchingWindowInSeconds": number,
   "MaximumRecordAgeInSeconds": number,
   "MaximumRetryAttempts": number,
   "ParallelizationFactor": number,
   "Queues": [ "string" ],
   "SelfManagedEventSource": {
      "Endpoints": {
         "string" : [ "string" ]
      }
   },
   "SelfManagedKafkaEventSourceConfig": {
      "ConsumerGroupId": "string"
   },
   "SourceAccessConfigurations": [
      {
         "Type": "string",
         "URI": "string"
      }
   ],
   "StartingPosition": "string",
   "StartingPositionTimestamp": number,
   "Topics": [ "string" ],
   "TumblingWindowInSeconds": number
}
```

## URI Request Parameters

The request does not use any URI parameters.

## Request Body

The request accepts the following data in JSON format.

**AmazonManagedKafkaEventSourceConfig (p. 893)**

Specific configuration settings for an Amazon Managed Streaming for Apache Kafka (Amazon MSK) event source.

Type: AmazonManagedKafkaEventSourceConfig (p. 1124) object

Required: No

**BatchSize (p. 893)**

The maximum number of records in each batch that Lambda pulls from your stream or queue and sends to your function. Lambda passes all of the records in the batch to the function in a single call, up to the payload limit for synchronous invocation (6 MB).

- **Amazon Kinesis** - Default 100. Max 10,000.
- **Amazon DynamoDB Streams** - Default 100. Max 10,000.
- **Amazon Simple Queue Service** - Default 10. For standard queues the max is 10,000. For FIFO queues the max is 10.

- **Amazon Managed Streaming for Apache Kafka** - Default 100. Max 10,000.
- **Self-managed Apache Kafka** - Default 100. Max 10,000.
- **Amazon MQ (ActiveMQ and RabbitMQ)** - Default 100. Max 10,000.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

Required: No

**BisectBatchOnFunctionError (p. 893)**

(Streams only) If the function returns an error, split the batch in two and retry.

Type: Boolean

Required: No

**DestinationConfig (p. 893)**

(Streams only) An Amazon SQS queue or Amazon SNS topic destination for discarded records.

Type: DestinationConfig (p. 1132) object

Required: No

**Enabled (p. 893)**

When true, the event source mapping is active. When false, Lambda pauses polling and invocation.

Default: True

Type: Boolean

Required: No

**EventSourceArn (p. 893)**

The Amazon Resource Name (ARN) of the event source.

- **Amazon Kinesis** - The ARN of the data stream or a stream consumer.
- **Amazon DynamoDB Streams** - The ARN of the stream.
- **Amazon Simple Queue Service** - The ARN of the queue.
- **Amazon Managed Streaming for Apache Kafka** - The ARN of the cluster.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

Required: No

**FilterCriteria (p. 893)**

(Streams and Amazon SQS) An object that defines the filter criteria that determine whether Lambda should process an event. For more information, see Lambda event filtering.

Type: FilterCriteria (p. 1144) object

Required: No

**FunctionName (p. 893)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Version or Alias ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction:PROD`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it's limited to 64 characters in length.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**FunctionResponseTypes (p. 893)**

(Streams and Amazon SQS) A list of current response type enums applied to the event source mapping.

Type: Array of strings

Array Members: Minimum number of 0 items. Maximum number of 1 item.

Valid Values: `ReportBatchItemFailures`

Required: No

**MaximumBatchingWindowInSeconds (p. 893)**

The maximum amount of time, in seconds, that Lambda spends gathering records before invoking the function. You can configure `MaximumBatchingWindowInSeconds` to any value from 0 seconds to 300 seconds in increments of seconds.

For streams and Amazon SQS event sources, the default batching window is 0 seconds. For Amazon MSK, Self-managed Apache Kafka, and Amazon MQ event sources, the default batching window is 500 ms. Note that because you can only change `MaximumBatchingWindowInSeconds` in increments of seconds, you cannot revert back to the 500 ms default batching window after you have changed it. To restore the default batching window, you must create a new event source mapping.

Related setting: For streams and Amazon SQS event sources, when you set `BatchSize` to a value greater than 10, you must set `MaximumBatchingWindowInSeconds` to at least 1.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 300.

Required: No

**MaximumRecordAgeInSeconds (p. 893)**

(Streams only) Discard records older than the specified age. The default value is infinite (-1).

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 604800.

Required: No

**MaximumRetryAttempts (p. 893)**

(Streams only) Discard records after the specified number of retries. The default value is infinite (-1). When set to infinite (-1), failed records are retried until the record expires.

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 10000.

Required: No

**ParallelizationFactor (p. 893)**

(Streams only) The number of batches to process from each shard concurrently.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10.

Required: No

**Queues (p. 893)**

(MQ) The name of the Amazon MQ broker destination queue to consume.

Type: Array of strings

Array Members: Fixed number of 1 item.

Length Constraints: Minimum length of 1. Maximum length of 1000.

Pattern: `[\s\S]*`

Required: No

**SelfManagedEventSource (p. 893)**

The self-managed Apache Kafka cluster to receive records from.

Type: SelfManagedEventSource (p. 1171) object

Required: No

**SelfManagedKafkaEventSourceConfig (p. 893)**

Specific configuration settings for a self-managed Apache Kafka event source.

Type: SelfManagedKafkaEventSourceConfig (p. 1172) object

Required: No

**SourceAccessConfigurations (p. 893)**

An array of authentication protocols or VPC components required to secure your event source.

Type: Array of SourceAccessConfiguration (p. 1173) objects

Array Members: Minimum number of 0 items. Maximum number of 22 items.

Required: No

**StartingPosition (p. 893)**

The position in a stream from which to start reading. Required for Amazon Kinesis, Amazon DynamoDB, and Amazon MSK Streams sources. `AT_TIMESTAMP` is supported only for Amazon Kinesis streams.

Type: String

Valid Values: `TRIM_HORIZON | LATEST | AT_TIMESTAMP`

Required: No

**StartingPositionTimestamp (p. 893)**

With `StartingPosition` set to `AT_TIMESTAMP`, the time from which to start reading, in Unix time seconds.

Type: Timestamp

Required: No

**Topics (p. 893)**

The name of the Kafka topic.

Type: Array of strings

Array Members: Fixed number of 1 item.

Length Constraints: Minimum length of 1. Maximum length of 249.

Pattern: `^[^.]([a-zA-Z0-9\-_.]+)`

Required: No

**TumblingWindowInSeconds (p. 893)**

(Streams only) The duration in seconds of a processing window. The range is between 1 second and 900 seconds.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 900.

Required: No

## Response Syntax

```
HTTP/1.1 202
Content-type: application/json

{
   "AmazonManagedKafkaEventSourceConfig": {
      "ConsumerGroupId": "string"
   },
   "BatchSize": number,
   "BisectBatchOnFunctionError": boolean,
   "DestinationConfig": {
      "OnFailure": {
         "Destination": "string"
      },
      "OnSuccess": {
         "Destination": "string"
      }
   },
   "EventSourceArn": "string",
   "FilterCriteria": {
      "Filters": [
         {
            "Pattern": "string"
```

```
            }
         ]
      },
      "FunctionArn": "string",
      "FunctionResponseTypes": [ "string" ],
      "LastModified": number,
      "LastProcessingResult": "string",
      "MaximumBatchingWindowInSeconds": number,
      "MaximumRecordAgeInSeconds": number,
      "MaximumRetryAttempts": number,
      "ParallelizationFactor": number,
      "Queues": [ "string" ],
      "SelfManagedEventSource": {
         "Endpoints": {
            "string" : [ "string" ]
         }
      },
      "SelfManagedKafkaEventSourceConfig": {
         "ConsumerGroupId": "string"
      },
      "SourceAccessConfigurations": [
         {
            "Type": "string",
            "URI": "string"
         }
      ],
      "StartingPosition": "string",
      "StartingPositionTimestamp": number,
      "State": "string",
      "StateTransitionReason": "string",
      "Topics": [ "string" ],
      "TumblingWindowInSeconds": number,
      "UUID": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 202 response.

The following data is returned in JSON format by the service.

**AmazonManagedKafkaEventSourceConfig (p. 898)**

Specific configuration settings for an Amazon Managed Streaming for Apache Kafka (Amazon MSK) event source.

Type: AmazonManagedKafkaEventSourceConfig (p. 1124) object

**BatchSize (p. 898)**

The maximum number of records in each batch that Lambda pulls from your stream or queue and sends to your function. Lambda passes all of the records in the batch to the function in a single call, up to the payload limit for synchronous invocation (6 MB).

Default value: Varies by service. For Amazon SQS, the default is 10. For all other services, the default is 100.

Related setting: When you set `BatchSize` to a value greater than 10, you must set `MaximumBatchingWindowInSeconds` to at least 1.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

**BisectBatchOnFunctionError (p. 898)**

(Streams only) If the function returns an error, split the batch in two and retry. The default value is false.

Type: Boolean

**DestinationConfig (p. 898)**

(Streams only) An Amazon SQS queue or Amazon SNS topic destination for discarded records.

Type: DestinationConfig (p. 1132) object

**EventSourceArn (p. 898)**

The Amazon Resource Name (ARN) of the event source.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**FilterCriteria (p. 898)**

(Streams and Amazon SQS) An object that defines the filter criteria that determine whether Lambda should process an event. For more information, see Lambda event filtering.

Type: FilterCriteria (p. 1144) object

**FunctionArn (p. 898)**

The ARN of the Lambda function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**FunctionResponseTypes (p. 898)**

(Streams and Amazon SQS) A list of current response type enums applied to the event source mapping.

Type: Array of strings

Array Members: Minimum number of 0 items. Maximum number of 1 item.

Valid Values: `ReportBatchItemFailures`

**LastModified (p. 898)**

The date that the event source mapping was last updated or that its state changed, in Unix time seconds.

Type: Timestamp

**LastProcessingResult (p. 898)**

The result of the last Lambda invocation of your function.

Type: String

**MaximumBatchingWindowInSeconds (p. 898)**

The maximum amount of time, in seconds, that Lambda spends gathering records before invoking the function. You can configure `MaximumBatchingWindowInSeconds` to any value from 0 seconds to 300 seconds in increments of seconds.

For streams and Amazon SQS event sources, the default batching window is 0 seconds. For Amazon MSK, Self-managed Apache Kafka, and Amazon MQ event sources, the default batching window is 500 ms. Note that because you can only change `MaximumBatchingWindowInSeconds` in increments of seconds, you cannot revert back to the 500 ms default batching window after you have changed it. To restore the default batching window, you must create a new event source mapping.

Related setting: For streams and Amazon SQS event sources, when you set `BatchSize` to a value greater than 10, you must set `MaximumBatchingWindowInSeconds` to at least 1.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 300.

**MaximumRecordAgeInSeconds (p. 898)**

(Streams only) Discard records older than the specified age. The default value is -1, which sets the maximum age to infinite. When the value is set to infinite, Lambda never discards old records.

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 604800.

**MaximumRetryAttempts (p. 898)**

(Streams only) Discard records after the specified number of retries. The default value is -1, which sets the maximum number of retries to infinite. When MaximumRetryAttempts is infinite, Lambda retries failed records until the record expires in the event source.

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 10000.

**ParallelizationFactor (p. 898)**

(Streams only) The number of batches to process concurrently from each shard. The default value is 1.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10.

**Queues (p. 898)**

(Amazon MQ) The name of the Amazon MQ broker destination queue to consume.

Type: Array of strings

Array Members: Fixed number of 1 item.

Length Constraints: Minimum length of 1. Maximum length of 1000.

Pattern: `[\s\S]*`

**SelfManagedEventSource (p. 898)**

The self-managed Apache Kafka cluster for your event source.

Type: SelfManagedEventSource (p. 1171) object

**SelfManagedKafkaEventSourceConfig (p. 898)**

Specific configuration settings for a self-managed Apache Kafka event source.

Type: SelfManagedKafkaEventSourceConfig (p. 1172) object

**SourceAccessConfigurations (p. 898)**

An array of the authentication protocol, VPC components, or virtual host to secure and define your event source.

Type: Array of SourceAccessConfiguration (p. 1173) objects

Array Members: Minimum number of 0 items. Maximum number of 22 items.

**StartingPosition (p. 898)**

The position in a stream from which to start reading. Required for Amazon Kinesis, Amazon DynamoDB, and Amazon MSK stream sources. `AT_TIMESTAMP` is supported only for Amazon Kinesis streams.

Type: String

Valid Values: `TRIM_HORIZON | LATEST | AT_TIMESTAMP`

**StartingPositionTimestamp (p. 898)**

With `StartingPosition` set to `AT_TIMESTAMP`, the time from which to start reading, in Unix time seconds.

Type: Timestamp

**State (p. 898)**

The state of the event source mapping. It can be one of the following: `Creating`, `Enabling`, `Enabled`, `Disabling`, `Disabled`, `Updating`, or `Deleting`.

Type: String

**StateTransitionReason (p. 898)**

Indicates whether a user or Lambda made the last change to the event source mapping.

Type: String

**Topics (p. 898)**

The name of the Kafka topic.

Type: Array of strings

Array Members: Fixed number of 1 item.

Length Constraints: Minimum length of 1. Maximum length of 249.

Pattern: `^[^.]([a-zA-Z0-9\-_.]+)`

**TumblingWindowInSeconds (p. 898)**

(Streams only) The duration in seconds of a processing window. The range is 1–900 seconds.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 900.

**UUID (p. 898)**

The identifier of the event source mapping.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# CreateFunction

Creates a Lambda function. To create a function, you need a deployment package and an execution role. The deployment package is a .zip file archive or container image that contains your function code. The execution role grants the function permission to use AWS services, such as Amazon CloudWatch Logs for log streaming and X-Ray for request tracing.

You set the package type to `Image` if the deployment package is a container image. For a container image, the code property must include the URI of a container image in the Amazon ECR registry. You do not need to specify the handler and runtime properties.

You set the package type to `Zip` if the deployment package is a .zip file archive. For a .zip file archive, the code property specifies the location of the .zip file. You must also specify the handler and runtime properties. The code in the deployment package must be compatible with the target instruction set architecture of the function (`x86-64` or `arm64`). If you do not specify the architecture, the default value is `x86-64`.

When you create a function, Lambda provisions an instance of the function and its supporting resources. If your function connects to a VPC, this process can take a minute or so. During this time, you can't invoke or modify the function. The `State`, `StateReason`, and `StateReasonCode` fields in the response from GetFunctionConfiguration (p. 967) indicate when the function is ready to invoke. For more information, see Function States.

A function has an unpublished version, and can have published versions and aliases. The unpublished version changes when you update your function's code and configuration. A published version is a snapshot of your function code and configuration that can't be changed. An alias is a named resource that maps to a version, and can be changed to map to a different version. Use the `Publish` parameter to create version `1` of your function from its initial configuration.

The other parameters let you configure version-specific and function-level settings. You can modify version-specific settings later with UpdateFunctionConfiguration (p. 1098). Function-level settings apply to both the unpublished and published versions of the function, and include tags (TagResource (p. 1067)) and per-function concurrency limits (PutFunctionConcurrency (p. 1053)).

You can use code signing if your deployment package is a .zip file archive. To enable code signing for this function, specify the ARN of a code-signing configuration. When a user attempts to deploy a code package with UpdateFunctionCode (p. 1088), Lambda checks that the code package has a valid signature from a trusted publisher. The code-signing configuration includes set set of signing profiles, which define the trusted publishers for this function.

If another account or an AWS service invokes your function, use AddPermission (p. 881) to grant permission by creating a resource-based IAM policy. You can grant permissions at the function level, on a version, or on an alias.

To invoke your function directly, use Invoke (p. 993). To invoke your function in response to events in other AWS services, create an event source mapping (CreateEventSourceMapping (p. 893)), or configure a function trigger in the other service. For more information, see Invoking Functions.

## Request Syntax

```
POST /2015-03-31/functions HTTP/1.1
Content-type: application/json

{
   "Architectures": [ "string" ],
   "Code": {
      "ImageUri": "string",
      "S3Bucket": "string",
      "S3Key": "string",
```

```
      "S3ObjectVersion": "string",
      "ZipFile": blob
   },
   "CodeSigningConfigArn": "string",
   "DeadLetterConfig": {
      "TargetArn": "string"
   },
   "Description": "string",
   "Environment": {
      "Variables": {
         "string" : "string"
      }
   },
   "EphemeralStorage": {
      "Size": number
   },
   "FileSystemConfigs": [
      {
         "Arn": "string",
         "LocalMountPath": "string"
      }
   ],
   "FunctionName": "string",
   "Handler": "string",
   "ImageConfig": {
      "Command": [ "string" ],
      "EntryPoint": [ "string" ],
      "WorkingDirectory": "string"
   },
   "KMSKeyArn": "string",
   "Layers": [ "string" ],
   "MemorySize": number,
   "PackageType": "string",
   "Publish": boolean,
   "Role": "string",
   "Runtime": "string",
   "Tags": {
      "string" : "string"
   },
   "Timeout": number,
   "TracingConfig": {
      "Mode": "string"
   },
   "VpcConfig": {
      "SecurityGroupIds": [ "string" ],
      "SubnetIds": [ "string" ]
   }
}
```

## URI Request Parameters

The request does not use any URI parameters.

## Request Body

The request accepts the following data in JSON format.

**Architectures (p. 904)**

The instruction set architecture that the function supports. Enter a string array with one of the valid values (arm64 or x86_64). The default value is `x86_64`.

Type: Array of strings

Array Members: Fixed number of 1 item.

Valid Values: `x86_64 | arm64`

Required: No

**Code (p. 904)**

The code for the function.

Type: FunctionCode (p. 1145) object

Required: Yes

**CodeSigningConfigArn (p. 904)**

To enable code signing for this function, specify the ARN of a code-signing configuration. A code-signing configuration includes a set of signing profiles, which define the trusted publishers for this function.

Type: String

Length Constraints: Maximum length of 200.

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}((-gov)|(-iso(b?)))?-[a-z]+-\d{1}:\d{12}:code-signing-config:csc-[a-z0-9]{17}`

Required: No

**DeadLetterConfig (p. 904)**

A dead letter queue configuration that specifies the queue or topic where Lambda sends asynchronous events when they fail processing. For more information, see Dead Letter Queues.

Type: DeadLetterConfig (p. 1131) object

Required: No

**Description (p. 904)**

A description of the function.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

**Environment (p. 904)**

Environment variables that are accessible from function code during execution.

Type: Environment (p. 1133) object

Required: No

**EphemeralStorage (p. 904)**

The size of the function's /tmp directory in MB. The default value is 512, but can be any whole number between 512 and 10240 MB.

Type: EphemeralStorage (p. 1136) object

Required: No

**FileSystemConfigs (p. 904)**

Connection settings for an Amazon EFS file system.

Type: Array of FileSystemConfig (p. 1142) objects

Array Members: Maximum number of 1 item.

Required: No

**FunctionName (p. 904)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Handler (p. 904)**

The name of the method within your code that Lambda calls to execute your function. Handler is required if the deployment package is a .zip file archive. The format includes the file name. It can also include namespaces and other qualifiers, depending on the runtime. For more information, see Programming Model.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

Required: No

**ImageConfig (p. 904)**

Container image configuration values that override the values in the container image Dockerfile.

Type: ImageConfig (p. 1158) object

Required: No

**KMSKeyArn (p. 904)**

The ARN of the AWS Key Management Service (AWS KMS) key that's used to encrypt your function's environment variables. If it's not provided, AWS Lambda uses a default service key.

Type: String

Pattern: `(arn:(aws[a-zA-Z-]*)?:[a-z0-9-.]+:.*)|()`

Required: No

**Layers (p. 904)**

A list of function layers to add to the function's execution environment. Specify each layer by its ARN, including the version.

Type: Array of strings

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+:[0-9]+`

Required: No

**MemorySize (p. 904)**

The amount of memory available to the function at runtime. Increasing the function memory also increases its CPU allocation. The default value is 128 MB. The value can be any multiple of 1 MB.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 10240.

Required: No

**PackageType (p. 904)**

The type of deployment package. Set to `Image` for container image and set `Zip` for ZIP archive.

Type: String

Valid Values: `Zip | Image`

Required: No

**Publish (p. 904)**

Set to true to publish the first version of the function during creation.

Type: Boolean

Required: No

**Role (p. 904)**

The Amazon Resource Name (ARN) of the function's execution role.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@\-_/]+`

Required: Yes

**Runtime (p. 904)**

The identifier of the function's runtime. Runtime is required if the deployment package is a .zip file archive.

Type: String

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

Required: No

**Tags (p. 904)**

A list of tags to apply to the function.

Type: String to string map

Required: No

**Timeout (p. 904)**

The amount of time (in seconds) that Lambda allows a function to run before stopping it. The default is 3 seconds. The maximum allowed value is 900 seconds. For additional information, see Lambda execution environment.

Type: Integer

Valid Range: Minimum value of 1.

Required: No

**TracingConfig (p. 904)**

Set `Mode` to `Active` to sample and trace a subset of incoming requests with X-Ray.

Type: TracingConfig (p. 1175) object

Required: No

**VpcConfig (p. 904)**

For network connectivity to AWS resources in a VPC, specify a list of security groups and subnets in the VPC. When you connect a function to a VPC, it can only access resources and the internet through that VPC. For more information, see VPC Settings.

Type: VpcConfig (p. 1177) object

Required: No

## Response Syntax

```
HTTP/1.1 201
Content-type: application/json

{
   "Architectures": [ "string" ],
   "CodeSha256": "string",
   "CodeSize": number,
   "DeadLetterConfig": {
      "TargetArn": "string"
   },
   "Description": "string",
   "Environment": {
      "Error": {
         "ErrorCode": "string",
         "Message": "string"
      },
      "Variables": {
         "string" : "string"
      }
   },
   "EphemeralStorage": {
      "Size": number
   },
   "FileSystemConfigs": [
      {
         "Arn": "string",
         "LocalMountPath": "string"
```

```
      }
   ],
   "FunctionArn": "string",
   "FunctionName": "string",
   "Handler": "string",
   "ImageConfigResponse": {
      "Error": {
         "ErrorCode": "string",
         "Message": "string"
      },
      "ImageConfig": {
         "Command": [ "string" ],
         "EntryPoint": [ "string" ],
         "WorkingDirectory": "string"
      }
   },
   "KMSKeyArn": "string",
   "LastModified": "string",
   "LastUpdateStatus": "string",
   "LastUpdateStatusReason": "string",
   "LastUpdateStatusReasonCode": "string",
   "Layers": [
      {
         "Arn": "string",
         "CodeSize": number,
         "SigningJobArn": "string",
         "SigningProfileVersionArn": "string"
      }
   ],
   "MasterArn": "string",
   "MemorySize": number,
   "PackageType": "string",
   "RevisionId": "string",
   "Role": "string",
   "Runtime": "string",
   "SigningJobArn": "string",
   "SigningProfileVersionArn": "string",
   "State": "string",
   "StateReason": "string",
   "StateReasonCode": "string",
   "Timeout": number,
   "TracingConfig": {
      "Mode": "string"
   },
   "Version": "string",
   "VpcConfig": {
      "SecurityGroupIds": [ "string" ],
      "SubnetIds": [ "string" ],
      "VpcId": "string"
   }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 201 response.

The following data is returned in JSON format by the service.

**Architectures (p. 909)**

The instruction set architecture that the function supports. Architecture is a string array with one of the valid values. The default architecture value is `x86_64`.

Type: Array of strings

Array Members: Fixed number of 1 item.

Valid Values: `x86_64 | arm64`

**CodeSha256 (p. 909)**

The SHA256 hash of the function's deployment package.

Type: String

**CodeSize (p. 909)**

The size of the function's deployment package, in bytes.

Type: Long

**DeadLetterConfig (p. 909)**

The function's dead letter queue.

Type: DeadLetterConfig (p. 1131) object

**Description (p. 909)**

The function's description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

**Environment (p. 909)**

The function's environment variables. Omitted from AWS CloudTrail logs.

Type: EnvironmentResponse (p. 1135) object

**EphemeralStorage (p. 909)**

The size of the function's /tmp directory in MB. The default value is 512, but can be any whole number between 512 and 10240 MB.

Type: EphemeralStorage (p. 1136) object

**FileSystemConfigs (p. 909)**

Connection settings for an Amazon EFS file system.

Type: Array of FileSystemConfig (p. 1142) objects

Array Members: Maximum number of 1 item.

**FunctionArn (p. 909)**

The function's Amazon Resource Name (ARN).

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_\.]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**FunctionName (p. 909)**

The name of the function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 170.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**Handler (p. 909)**

The function that Lambda calls to begin executing your function.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

**ImageConfigResponse (p. 909)**

The function's image configuration values.

Type: ImageConfigResponse (p. 1160) object

**KMSKeyArn (p. 909)**

The AWS KMS key that's used to encrypt the function's environment variables. This key is only returned if you've configured a customer managed key.

Type: String

Pattern: `(arn:(aws[a-zA-Z-]*)?:[a-z0-9-.]+:.*)|()`

**LastModified (p. 909)**

The date and time that the function was last updated, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

**LastUpdateStatus (p. 909)**

The status of the last update that was performed on the function. This is first set to `Successful` after function creation completes.

Type: String

Valid Values: `Successful | Failed | InProgress`

**LastUpdateStatusReason (p. 909)**

The reason for the last update that was performed on the function.

Type: String

**LastUpdateStatusReasonCode (p. 909)**

The reason code for the last update that was performed on the function.

Type: String

Valid Values: `EniLimitExceeded | InsufficientRolePermissions | InvalidConfiguration | InternalError | SubnetOutOfIPAddresses | InvalidSubnet | InvalidSecurityGroup | ImageDeleted | ImageAccessDenied | InvalidImage`

**Layers (p. 909)**

The function's layers.

Type: Array of Layer (p. 1161) objects

**MasterArn (p. 909)**

For Lambda@Edge functions, the ARN of the main function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**MemorySize (p. 909)**

The amount of memory available to the function at runtime.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 10240.

**PackageType (p. 909)**

The type of deployment package. Set to `Image` for container image and set `Zip` for .zip file archive.

Type: String

Valid Values: `Zip | Image`

**RevisionId (p. 909)**

The latest updated revision of the function or alias.

Type: String

**Role (p. 909)**

The function's execution role.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@\-_/]+`

**Runtime (p. 909)**

The runtime environment for the Lambda function.

Type: String

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

**SigningJobArn (p. 909)**

The ARN of the signing job.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**SigningProfileVersionArn (p. 909)**

The ARN of the signing profile version.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**State (p. 909)**

The current state of the function. When the state is `Inactive`, you can reactivate the function by invoking it.

Type: String

Valid Values: `Pending | Active | Inactive | Failed`

**StateReason (p. 909)**

The reason for the function's current state.

Type: String

**StateReasonCode (p. 909)**

The reason code for the function's current state. When the code is `Creating`, you can't invoke or modify the function.

Type: String

Valid Values: `Idle | Creating | Restoring | EniLimitExceeded | InsufficientRolePermissions | InvalidConfiguration | InternalError | SubnetOutOfIPAddresses | InvalidSubnet | InvalidSecurityGroup | ImageDeleted | ImageAccessDenied | InvalidImage`

**Timeout (p. 909)**

The amount of time in seconds that Lambda allows a function to run before stopping it.

Type: Integer

Valid Range: Minimum value of 1.

**TracingConfig (p. 909)**

The function's AWS X-Ray tracing configuration.

Type: TracingConfigResponse (p. 1176) object

**Version (p. 909)**

The version of the Lambda function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

**VpcConfig (p. 909)**

The function's networking configuration.

Type: VpcConfigResponse (p. 1178) object

## Errors

**CodeSigningConfigNotFoundException**

The specified code signing configuration does not exist.

HTTP Status Code: 404

**CodeStorageExceededException**

You have exceeded your maximum total code size per account. Learn more

HTTP Status Code: 400

**CodeVerificationFailedException**

The code signature failed one or more of the validation checks for signature mismatch or expiry, and the code signing policy is set to ENFORCE. Lambda blocks the deployment.

HTTP Status Code: 400

**InvalidCodeSignatureException**

The code signature failed the integrity check. Lambda always blocks deployment if the integrity check fails, even if code signing policy is set to WARN.

HTTP Status Code: 400

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3

- AWS SDK for Python
- AWS SDK for Ruby V3

# CreateFunctionUrlConfig

Creates a Lambda function URL with the specified configuration parameters. A function URL is a dedicated HTTP(S) endpoint that you can use to invoke your function.

## Request Syntax

```
POST /2021-10-31/functions/FunctionName/url?Qualifier=Qualifier HTTP/1.1
Content-type: application/json

{
   "AuthType": "string",
   "Cors": {
      "AllowCredentials": boolean,
      "AllowHeaders": [ "string" ],
      "AllowMethods": [ "string" ],
      "AllowOrigins": [ "string" ],
      "ExposeHeaders": [ "string" ],
      "MaxAge": number
   }
}
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 917)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 917)**

The alias name.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(^\$LATEST$)|((?!^[0-9]+$)([a-zA-Z0-9-_]+))`

## Request Body

The request accepts the following data in JSON format.

**AuthType (p. 917)**

The type of authentication that your function URL uses. Set to `AWS_IAM` if you want to restrict access to authenticated `IAM` users only. Set to `NONE` if you want to bypass IAM authentication to create a public endpoint. For more information, see Security and auth model for Lambda function URLs.

Type: String

Valid Values: `NONE | AWS_IAM`

Required: Yes

**Cors (p. 917)**

The cross-origin resource sharing (CORS) settings for your function URL.

Type: Cors (p. 1129) object

Required: No

## Response Syntax

```
HTTP/1.1 201
Content-type: application/json

{
   "AuthType": "string",
   "Cors": {
      "AllowCredentials": boolean,
      "AllowHeaders": [ "string" ],
      "AllowMethods": [ "string" ],
      "AllowOrigins": [ "string" ],
      "ExposeHeaders": [ "string" ],
      "MaxAge": number
   },
   "CreationTime": "string",
   "FunctionArn": "string",
   "FunctionUrl": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 201 response.

The following data is returned in JSON format by the service.

**AuthType (p. 918)**

The type of authentication that your function URL uses. Set to `AWS_IAM` if you want to restrict access to authenticated `IAM` users only. Set to `NONE` if you want to bypass IAM authentication to create a public endpoint. For more information, see Security and auth model for Lambda function URLs.

Type: String

Valid Values: `NONE | AWS_IAM`

**Cors (p. 918)**

The cross-origin resource sharing (CORS) settings for your function URL.

Type: Cors (p. 1129) object

**CreationTime (p. 918)**

When the function URL was created, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

**FunctionArn (p. 918)**

The Amazon Resource Name (ARN) of your function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**FunctionUrl (p. 918)**

The HTTP URL endpoint for your function.

Type: String

Length Constraints: Minimum length of 40. Maximum length of 100.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# DeleteAlias

Deletes a Lambda function alias.

## Request Syntax

```
DELETE /2015-03-31/functions/FunctionName/aliases/Name HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 921)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Name (p. 921)**

The name of the alias.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(?!^[0-9]+$)([a-zA-Z0-9-_]+)`

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 204
```

## Response Elements

If the action is successful, the service sends back an HTTP 204 response with an empty HTTP body.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# DeleteCodeSigningConfig

Deletes the code signing configuration. You can delete the code signing configuration only if no function is using it.

## Request Syntax

```
DELETE /2020-04-22/code-signing-configs/CodeSigningConfigArn HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**CodeSigningConfigArn (p. 923)**

The The Amazon Resource Name (ARN) of the code signing configuration.

Length Constraints: Maximum length of 200.

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}((-gov)|(-iso(b?)))?-[a-z]+-\d{1}:\d{12}:code-signing-config:csc-[a-z0-9]{17}`

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 204
```

## Response Elements

If the action is successful, the service sends back an HTTP 204 response with an empty HTTP body.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# DeleteEventSourceMapping

Deletes an event source mapping. You can get the identifier of a mapping from the output of ListEventSourceMappings (p. 1006).

When you delete an event source mapping, it enters a `Deleting` state and might not be completely deleted for several seconds.

## Request Syntax

```
DELETE /2015-03-31/event-source-mappings/UUID HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**UUID (p. 925)**

The identifier of the event source mapping.

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 202
Content-type: application/json

{
   "AmazonManagedKafkaEventSourceConfig": {
      "ConsumerGroupId": "string"
   },
   "BatchSize": number,
   "BisectBatchOnFunctionError": boolean,
   "DestinationConfig": {
      "OnFailure": {
         "Destination": "string"
      },
      "OnSuccess": {
         "Destination": "string"
      }
   },
   "EventSourceArn": "string",
   "FilterCriteria": {
      "Filters": [
         {
            "Pattern": "string"
         }
      ]
   },
   "FunctionArn": "string",
   "FunctionResponseTypes": [ "string" ],
   "LastModified": number,
   "LastProcessingResult": "string",
```

```
   "MaximumBatchingWindowInSeconds": number,
   "MaximumRecordAgeInSeconds": number,
   "MaximumRetryAttempts": number,
   "ParallelizationFactor": number,
   "Queues": [ "string" ],
   "SelfManagedEventSource": {
      "Endpoints": {
         "string" : [ "string" ]
      }
   },
   "SelfManagedKafkaEventSourceConfig": {
      "ConsumerGroupId": "string"
   },
   "SourceAccessConfigurations": [
      {
         "Type": "string",
         "URI": "string"
      }
   ],
   "StartingPosition": "string",
   "StartingPositionTimestamp": number,
   "State": "string",
   "StateTransitionReason": "string",
   "Topics": [ "string" ],
   "TumblingWindowInSeconds": number,
   "UUID": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 202 response.

The following data is returned in JSON format by the service.

**AmazonManagedKafkaEventSourceConfig (p. 925)**

Specific configuration settings for an Amazon Managed Streaming for Apache Kafka (Amazon MSK) event source.

Type: AmazonManagedKafkaEventSourceConfig (p. 1124) object

**BatchSize (p. 925)**

The maximum number of records in each batch that Lambda pulls from your stream or queue and sends to your function. Lambda passes all of the records in the batch to the function in a single call, up to the payload limit for synchronous invocation (6 MB).

Default value: Varies by service. For Amazon SQS, the default is 10. For all other services, the default is 100.

Related setting: When you set `BatchSize` to a value greater than 10, you must set `MaximumBatchingWindowInSeconds` to at least 1.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

**BisectBatchOnFunctionError (p. 925)**

(Streams only) If the function returns an error, split the batch in two and retry. The default value is false.

Type: Boolean

**DestinationConfig (p. 925)**

(Streams only) An Amazon SQS queue or Amazon SNS topic destination for discarded records.

Type: DestinationConfig (p. 1132) object

**EventSourceArn (p. 925)**

The Amazon Resource Name (ARN) of the event source.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**FilterCriteria (p. 925)**

(Streams and Amazon SQS) An object that defines the filter criteria that determine whether Lambda should process an event. For more information, see Lambda event filtering.

Type: FilterCriteria (p. 1144) object

**FunctionArn (p. 925)**

The ARN of the Lambda function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**FunctionResponseTypes (p. 925)**

(Streams and Amazon SQS) A list of current response type enums applied to the event source mapping.

Type: Array of strings

Array Members: Minimum number of 0 items. Maximum number of 1 item.

Valid Values: `ReportBatchItemFailures`

**LastModified (p. 925)**

The date that the event source mapping was last updated or that its state changed, in Unix time seconds.

Type: Timestamp

**LastProcessingResult (p. 925)**

The result of the last Lambda invocation of your function.

Type: String

**MaximumBatchingWindowInSeconds (p. 925)**

The maximum amount of time, in seconds, that Lambda spends gathering records before invoking the function. You can configure `MaximumBatchingWindowInSeconds` to any value from 0 seconds to 300 seconds in increments of seconds.

For streams and Amazon SQS event sources, the default batching window is 0 seconds. For Amazon MSK, Self-managed Apache Kafka, and Amazon MQ event sources, the default batching window is 500 ms. Note that because you can only change `MaximumBatchingWindowInSeconds` in increments of seconds, you cannot revert back to the 500 ms default batching window after you

have changed it. To restore the default batching window, you must create a new event source mapping.

Related setting: For streams and Amazon SQS event sources, when you set `BatchSize` to a value greater than 10, you must set `MaximumBatchingWindowInSeconds` to at least 1.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 300.

**MaximumRecordAgeInSeconds (p. 925)**

(Streams only) Discard records older than the specified age. The default value is -1, which sets the maximum age to infinite. When the value is set to infinite, Lambda never discards old records.

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 604800.

**MaximumRetryAttempts (p. 925)**

(Streams only) Discard records after the specified number of retries. The default value is -1, which sets the maximum number of retries to infinite. When MaximumRetryAttempts is infinite, Lambda retries failed records until the record expires in the event source.

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 10000.

**ParallelizationFactor (p. 925)**

(Streams only) The number of batches to process concurrently from each shard. The default value is 1.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10.

**Queues (p. 925)**

(Amazon MQ) The name of the Amazon MQ broker destination queue to consume.

Type: Array of strings

Array Members: Fixed number of 1 item.

Length Constraints: Minimum length of 1. Maximum length of 1000.

Pattern: `[\s\S]*`

**SelfManagedEventSource (p. 925)**

The self-managed Apache Kafka cluster for your event source.

Type: SelfManagedEventSource (p. 1171) object

**SelfManagedKafkaEventSourceConfig (p. 925)**

Specific configuration settings for a self-managed Apache Kafka event source.

Type: SelfManagedKafkaEventSourceConfig (p. 1172) object

**SourceAccessConfigurations (p. 925)**

An array of the authentication protocol, VPC components, or virtual host to secure and define your event source.

Type: Array of SourceAccessConfiguration (p. 1173) objects

Array Members: Minimum number of 0 items. Maximum number of 22 items.

**StartingPosition (p. 925)**

The position in a stream from which to start reading. Required for Amazon Kinesis, Amazon DynamoDB, and Amazon MSK stream sources. `AT_TIMESTAMP` is supported only for Amazon Kinesis streams.

Type: String

Valid Values: `TRIM_HORIZON | LATEST | AT_TIMESTAMP`

**StartingPositionTimestamp (p. 925)**

With `StartingPosition` set to `AT_TIMESTAMP`, the time from which to start reading, in Unix time seconds.

Type: Timestamp

**State (p. 925)**

The state of the event source mapping. It can be one of the following: `Creating`, `Enabling`, `Enabled`, `Disabling`, `Disabled`, `Updating`, or `Deleting`.

Type: String

**StateTransitionReason (p. 925)**

Indicates whether a user or Lambda made the last change to the event source mapping.

Type: String

**Topics (p. 925)**

The name of the Kafka topic.

Type: Array of strings

Array Members: Fixed number of 1 item.

Length Constraints: Minimum length of 1. Maximum length of 249.

Pattern: `^[^.]([a-zA-Z0-9\-_.]+)`

**TumblingWindowInSeconds (p. 925)**

(Streams only) The duration in seconds of a processing window. The range is 1–900 seconds.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 900.

**UUID (p. 925)**

The identifier of the event source mapping.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceInUseException**

The operation conflicts with the resource's availability. For example, you attempted to update an EventSource Mapping in CREATING, or tried to delete a EventSource mapping currently in the UPDATING state.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# DeleteFunction

Deletes a Lambda function. To delete a specific function version, use the `Qualifier` parameter. Otherwise, all versions and aliases are deleted.

To delete Lambda event source mappings that invoke a function, use DeleteEventSourceMapping (p. 925). For AWS services and resources that invoke your function directly, delete the trigger in the service where you originally configured it.

## Request Syntax

```
DELETE /2015-03-31/functions/FunctionName?Qualifier=Qualifier HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 931)**

The name of the Lambda function or version.

**Name formats**

- **Function name** - `my-function` (name-only), `my-function:1` (with version).
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

You can append a version number or alias to any of the formats. The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 931)**

Specify a version to delete. You can't delete a version that's referenced by an alias.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 204
```

## Response Elements

If the action is successful, the service sends back an HTTP 204 response with an empty HTTP body.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# DeleteFunctionCodeSigningConfig

Removes the code signing configuration from the function.

## Request Syntax

```
DELETE /2020-06-30/functions/FunctionName/code-signing-config HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 933)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 204
```

## Response Elements

If the action is successful, the service sends back an HTTP 204 response with an empty HTTP body.

## Errors

**CodeSigningConfigNotFoundException**

The specified code signing configuration does not exist.

HTTP Status Code: 404

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# DeleteFunctionConcurrency

Removes a concurrent execution limit from a function.

## Request Syntax

```
DELETE /2017-10-31/functions/FunctionName/concurrency HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 935)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 204
```

## Response Elements

If the action is successful, the service sends back an HTTP 204 response with an empty HTTP body.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# DeleteFunctionEventInvokeConfig

Deletes the configuration for asynchronous invocation for a function, version, or alias.

To configure options for asynchronous invocation, use PutFunctionEventInvokeConfig (p. 1056).

## Request Syntax

```
DELETE /2019-09-25/functions/FunctionName/event-invoke-config?Qualifier=Qualifier HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 937)**

The name of the Lambda function, version, or alias.

**Name formats**

- **Function name** - `my-function` (name-only), `my-function:v1` (with alias).
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

You can append a version number or alias to any of the formats. The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 937)**

A version number or alias name.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 204
```

## Response Elements

If the action is successful, the service sends back an HTTP 204 response with an empty HTTP body.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# DeleteFunctionUrlConfig

Deletes a Lambda function URL. When you delete a function URL, you can't recover it. Creating a new function URL results in a different URL address.

## Request Syntax

```
DELETE /2021-10-31/functions/FunctionName/url?Qualifier=Qualifier HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 939)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 939)**

The alias name.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(^\$LATEST$)|((?!^[0-9]+$)([a-zA-Z0-9-_]+))`

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 204
```

## Response Elements

If the action is successful, the service sends back an HTTP 204 response with an empty HTTP body.

## Errors

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# DeleteLayerVersion

Deletes a version of an AWS Lambda layer. Deleted versions can no longer be viewed or added to functions. To avoid breaking functions, a copy of the version remains in Lambda until no functions refer to it.

## Request Syntax

```
DELETE /2018-10-31/layers/LayerName/versions/VersionNumber HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**LayerName (p. 941)**

The name or Amazon Resource Name (ARN) of the layer.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+)|[a-zA-Z0-9-_]+`

Required: Yes

**VersionNumber (p. 941)**

The version number.

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 204
```

## Response Elements

If the action is successful, the service sends back an HTTP 204 response with an empty HTTP body.

## Errors

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# DeleteProvisionedConcurrencyConfig

Deletes the provisioned concurrency configuration for a function.

## Request Syntax

```
DELETE /2019-09-30/functions/FunctionName/provisioned-concurrency?Qualifier=Qualifier
 HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 943)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 943)**

The version number or alias name.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 204
```

## Response Elements

If the action is successful, the service sends back an HTTP 204 response with an empty HTTP body.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetAccountSettings

Retrieves details about your account's limits and usage in an AWS Region.

## Request Syntax

```
GET /2016-08-19/account-settings/ HTTP/1.1
```

## URI Request Parameters

The request does not use any URI parameters.

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "AccountLimit": {
      "CodeSizeUnzipped": number,
      "CodeSizeZipped": number,
      "ConcurrentExecutions": number,
      "TotalCodeSize": number,
      "UnreservedConcurrentExecutions": number
   },
   "AccountUsage": {
      "FunctionCount": number,
      "TotalCodeSize": number
   }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**AccountLimit (p. 945)**

Limits that are related to concurrency and code storage.

Type: AccountLimit (p. 1118) object

**AccountUsage (p. 945)**

The number of functions and amount of storage in use.

Type: AccountUsage (p. 1119) object

## Errors

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetAlias

Returns details about a Lambda function alias.

## Request Syntax

```
GET /2015-03-31/functions/FunctionName/aliases/Name HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 947)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Name (p. 947)**

The name of the alias.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(?!^[0-9]+$)([a-zA-Z0-9-_]+)`

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "AliasArn": "string",
   "Description": "string",
   "FunctionVersion": "string",
```

```
   "Name": "string",
   "RevisionId": "string",
   "RoutingConfig": {
      "AdditionalVersionWeights": {
         "string" : number
      }
   }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**AliasArn (p. 947)**

The Amazon Resource Name (ARN) of the alias.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**Description (p. 947)**

A description of the alias.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

**FunctionVersion (p. 947)**

The function version that the alias invokes.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

**Name (p. 947)**

The name of the alias.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(?!^[0-9]+$)([a-zA-Z0-9-_]+)`

**RevisionId (p. 947)**

A unique identifier that changes when you update the alias.

Type: String

**RoutingConfig (p. 947)**

The routing configuration of the alias.

Type: AliasRoutingConfiguration (p. 1122) object

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetCodeSigningConfig

Returns information about the specified code signing configuration.

## Request Syntax

```
GET /2020-04-22/code-signing-configs/CodeSigningConfigArn HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**CodeSigningConfigArn (p. 950)**

The The Amazon Resource Name (ARN) of the code signing configuration.

Length Constraints: Maximum length of 200.

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}((-gov)|(-iso(b?)))?-[a-z]+-\d{1}:\d{12}:code-signing-config:csc-[a-z0-9]{17}`

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "CodeSigningConfig": {
      "AllowedPublishers": {
         "SigningProfileVersionArns": [ "string" ]
      },
      "CodeSigningConfigArn": "string",
      "CodeSigningConfigId": "string",
      "CodeSigningPolicies": {
         "UntrustedArtifactOnDeployment": "string"
      },
      "Description": "string",
      "LastModified": "string"
   }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**CodeSigningConfig (p. 950)**

The code signing configuration

Type: CodeSigningConfig (p. 1125) object

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetEventSourceMapping

Returns details about an event source mapping. You can get the identifier of a mapping from the output of ListEventSourceMappings (p. 1006).

## Request Syntax

```
GET /2015-03-31/event-source-mappings/UUID HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**UUID (p. 952)**

The identifier of the event source mapping.

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "AmazonManagedKafkaEventSourceConfig": {
      "ConsumerGroupId": "string"
   },
   "BatchSize": number,
   "BisectBatchOnFunctionError": boolean,
   "DestinationConfig": {
      "OnFailure": {
         "Destination": "string"
      },
      "OnSuccess": {
         "Destination": "string"
      }
   },
   "EventSourceArn": "string",
   "FilterCriteria": {
      "Filters": [
         {
            "Pattern": "string"
         }
      ]
   },
   "FunctionArn": "string",
   "FunctionResponseTypes": [ "string" ],
   "LastModified": number,
   "LastProcessingResult": "string",
   "MaximumBatchingWindowInSeconds": number,
   "MaximumRecordAgeInSeconds": number,
   "MaximumRetryAttempts": number,
   "ParallelizationFactor": number,
```

```
   "Queues": [ "string" ],
   "SelfManagedEventSource": {
      "Endpoints": {
         "string" : [ "string" ]
      }
   },
   "SelfManagedKafkaEventSourceConfig": {
      "ConsumerGroupId": "string"
   },
   "SourceAccessConfigurations": [
      {
         "Type": "string",
         "URI": "string"
      }
   ],
   "StartingPosition": "string",
   "StartingPositionTimestamp": number,
   "State": "string",
   "StateTransitionReason": "string",
   "Topics": [ "string" ],
   "TumblingWindowInSeconds": number,
   "UUID": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**AmazonManagedKafkaEventSourceConfig (p. 952)**

Specific configuration settings for an Amazon Managed Streaming for Apache Kafka (Amazon MSK) event source.

Type: AmazonManagedKafkaEventSourceConfig (p. 1124) object

**BatchSize (p. 952)**

The maximum number of records in each batch that Lambda pulls from your stream or queue and sends to your function. Lambda passes all of the records in the batch to the function in a single call, up to the payload limit for synchronous invocation (6 MB).

Default value: Varies by service. For Amazon SQS, the default is 10. For all other services, the default is 100.

Related setting: When you set `BatchSize` to a value greater than 10, you must set `MaximumBatchingWindowInSeconds` to at least 1.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

**BisectBatchOnFunctionError (p. 952)**

(Streams only) If the function returns an error, split the batch in two and retry. The default value is false.

Type: Boolean

**DestinationConfig (p. 952)**

(Streams only) An Amazon SQS queue or Amazon SNS topic destination for discarded records.

Type: DestinationConfig (p. 1132) object

**EventSourceArn (p. 952)**

The Amazon Resource Name (ARN) of the event source.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**FilterCriteria (p. 952)**

(Streams and Amazon SQS) An object that defines the filter criteria that determine whether Lambda should process an event. For more information, see Lambda event filtering.

Type: FilterCriteria (p. 1144) object

**FunctionArn (p. 952)**

The ARN of the Lambda function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**FunctionResponseTypes (p. 952)**

(Streams and Amazon SQS) A list of current response type enums applied to the event source mapping.

Type: Array of strings

Array Members: Minimum number of 0 items. Maximum number of 1 item.

Valid Values: `ReportBatchItemFailures`

**LastModified (p. 952)**

The date that the event source mapping was last updated or that its state changed, in Unix time seconds.

Type: Timestamp

**LastProcessingResult (p. 952)**

The result of the last Lambda invocation of your function.

Type: String

**MaximumBatchingWindowInSeconds (p. 952)**

The maximum amount of time, in seconds, that Lambda spends gathering records before invoking the function. You can configure `MaximumBatchingWindowInSeconds` to any value from 0 seconds to 300 seconds in increments of seconds.

For streams and Amazon SQS event sources, the default batching window is 0 seconds. For Amazon MSK, Self-managed Apache Kafka, and Amazon MQ event sources, the default batching window is 500 ms. Note that because you can only change `MaximumBatchingWindowInSeconds` in increments of seconds, you cannot revert back to the 500 ms default batching window after you have changed it. To restore the default batching window, you must create a new event source mapping.

Related setting: For streams and Amazon SQS event sources, when you set `BatchSize` to a value greater than 10, you must set `MaximumBatchingWindowInSeconds` to at least 1.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 300.

**MaximumRecordAgeInSeconds (p. 952)**

(Streams only) Discard records older than the specified age. The default value is -1, which sets the maximum age to infinite. When the value is set to infinite, Lambda never discards old records.

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 604800.

**MaximumRetryAttempts (p. 952)**

(Streams only) Discard records after the specified number of retries. The default value is -1, which sets the maximum number of retries to infinite. When MaximumRetryAttempts is infinite, Lambda retries failed records until the record expires in the event source.

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 10000.

**ParallelizationFactor (p. 952)**

(Streams only) The number of batches to process concurrently from each shard. The default value is 1.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10.

**Queues (p. 952)**

(Amazon MQ) The name of the Amazon MQ broker destination queue to consume.

Type: Array of strings

Array Members: Fixed number of 1 item.

Length Constraints: Minimum length of 1. Maximum length of 1000.

Pattern: `[\s\S]*`

**SelfManagedEventSource (p. 952)**

The self-managed Apache Kafka cluster for your event source.

Type: SelfManagedEventSource (p. 1171) object

**SelfManagedKafkaEventSourceConfig (p. 952)**

Specific configuration settings for a self-managed Apache Kafka event source.

Type: SelfManagedKafkaEventSourceConfig (p. 1172) object

**SourceAccessConfigurations (p. 952)**

An array of the authentication protocol, VPC components, or virtual host to secure and define your event source.

Type: Array of SourceAccessConfiguration (p. 1173) objects

Array Members: Minimum number of 0 items. Maximum number of 22 items.

**StartingPosition (p. 952)**

The position in a stream from which to start reading. Required for Amazon Kinesis, Amazon DynamoDB, and Amazon MSK stream sources. `AT_TIMESTAMP` is supported only for Amazon Kinesis streams.

Type: String

Valid Values: `TRIM_HORIZON | LATEST | AT_TIMESTAMP`

**StartingPositionTimestamp (p. 952)**

With `StartingPosition` set to `AT_TIMESTAMP`, the time from which to start reading, in Unix time seconds.

Type: Timestamp

**State (p. 952)**

The state of the event source mapping. It can be one of the following: `Creating`, `Enabling`, `Enabled`, `Disabling`, `Disabled`, `Updating`, or `Deleting`.

Type: String

**StateTransitionReason (p. 952)**

Indicates whether a user or Lambda made the last change to the event source mapping.

Type: String

**Topics (p. 952)**

The name of the Kafka topic.

Type: Array of strings

Array Members: Fixed number of 1 item.

Length Constraints: Minimum length of 1. Maximum length of 249.

Pattern: `^[^.]([a-zA-Z0-9\-_.]+)`

**TumblingWindowInSeconds (p. 952)**

(Streams only) The duration in seconds of a processing window. The range is 1–900 seconds.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 900.

**UUID (p. 952)**

The identifier of the event source mapping.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetFunction

Returns information about the function or function version, with a link to download the deployment package that's valid for 10 minutes. If you specify a function version, only details that are specific to that version are returned.

## Request Syntax

```
GET /2015-03-31/functions/FunctionName?Qualifier=Qualifier HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 958)**

The name of the Lambda function, version, or alias.

**Name formats**

- **Function name** - `my-function` (name-only), `my-function:v1` (with alias).
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

You can append a version number or alias to any of the formats. The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 170.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 958)**

Specify a version or alias to get details about a published version of the function.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "Code": {
      "ImageUri": "string",
      "Location": "string",
      "RepositoryType": "string",
```

```
    "ResolvedImageUri": "string"
  },
  "Concurrency": {
    "ReservedConcurrentExecutions": number
  },
  "Configuration": {
    "Architectures": [ "string" ],
    "CodeSha256": "string",
    "CodeSize": number,
    "DeadLetterConfig": {
      "TargetArn": "string"
    },
    "Description": "string",
    "Environment": {
      "Error": {
        "ErrorCode": "string",
        "Message": "string"
      },
      "Variables": {
        "string" : "string"
      }
    },
    "EphemeralStorage": {
      "Size": number
    },
    "FileSystemConfigs": [
      {
        "Arn": "string",
        "LocalMountPath": "string"
      }
    ],
    "FunctionArn": "string",
    "FunctionName": "string",
    "Handler": "string",
    "ImageConfigResponse": {
      "Error": {
        "ErrorCode": "string",
        "Message": "string"
      },
      "ImageConfig": {
        "Command": [ "string" ],
        "EntryPoint": [ "string" ],
        "WorkingDirectory": "string"
      }
    },
    "KMSKeyArn": "string",
    "LastModified": "string",
    "LastUpdateStatus": "string",
    "LastUpdateStatusReason": "string",
    "LastUpdateStatusReasonCode": "string",
    "Layers": [
      {
        "Arn": "string",
        "CodeSize": number,
        "SigningJobArn": "string",
        "SigningProfileVersionArn": "string"
      }
    ],
    "MasterArn": "string",
    "MemorySize": number,
    "PackageType": "string",
    "RevisionId": "string",
    "Role": "string",
    "Runtime": "string",
    "SigningJobArn": "string",
    "SigningProfileVersionArn": "string",
```

```
      "State": "string",
      "StateReason": "string",
      "StateReasonCode": "string",
      "Timeout": number,
      "TracingConfig": {
         "Mode": "string"
      },
      "Version": "string",
      "VpcConfig": {
         "SecurityGroupIds": [ "string" ],
         "SubnetIds": [ "string" ],
         "VpcId": "string"
      }
   },
   "Tags": {
      "string" : "string"
   }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**Code (p. 958)**

The deployment package of the function or version.

Type: FunctionCodeLocation (p. 1147) object

**Concurrency (p. 958)**

The function's reserved concurrency.

Type: Concurrency (p. 1128) object

**Configuration (p. 958)**

The configuration of the function or version.

Type: FunctionConfiguration (p. 1148) object

**Tags (p. 958)**

The function's tags.

Type: String to string map

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetFunctionCodeSigningConfig

Returns the code signing configuration for the specified function.

## Request Syntax

```
GET /2020-06-30/functions/FunctionName/code-signing-config HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 962)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "CodeSigningConfigArn": "string",
   "FunctionName": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**CodeSigningConfigArn (p. 962)**

The The Amazon Resource Name (ARN) of the code signing configuration.

Type: String

Length Constraints: Maximum length of 200.

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}((-gov)|(-iso(b?)))?-[a-z]+-\d{1}:\d{12}:code-signing-config:csc-[a-z0-9]{17}`

**FunctionName (p. 962)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

# Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

# See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++

- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetFunctionConcurrency

Returns details about the reserved concurrency configuration for a function. To set a concurrency limit for a function, use PutFunctionConcurrency (p. 1053).

## Request Syntax

```
GET /2019-09-30/functions/FunctionName/concurrency HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 965)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "ReservedConcurrentExecutions": number
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**ReservedConcurrentExecutions (p. 965)**

The number of simultaneous executions that are reserved for the function.

Type: Integer

Valid Range: Minimum value of 0.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetFunctionConfiguration

Returns the version-specific settings of a Lambda function or version. The output includes only options that can vary between versions of a function. To modify these settings, use UpdateFunctionConfiguration (p. 1098).

To get all of a function's details, including function-level settings, use GetFunction (p. 958).

## Request Syntax

```
GET /2015-03-31/functions/FunctionName/configuration?Qualifier=Qualifier HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 967)**

The name of the Lambda function, version, or alias.

**Name formats**

- **Function name** - `my-function` (name-only), `my-function:v1` (with alias).
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

You can append a version number or alias to any of the formats. The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 170.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 967)**

Specify a version or alias to get details about a published version of the function.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "Architectures": [ "string" ],
   "CodeSha256": "string",
```

```
"CodeSize": number,
"DeadLetterConfig": {
   "TargetArn": "string"
},
"Description": "string",
"Environment": {
   "Error": {
      "ErrorCode": "string",
      "Message": "string"
   },
   "Variables": {
      "string" : "string"
   }
},
"EphemeralStorage": {
   "Size": number
},
"FileSystemConfigs": [
   {
      "Arn": "string",
      "LocalMountPath": "string"
   }
],
"FunctionArn": "string",
"FunctionName": "string",
"Handler": "string",
"ImageConfigResponse": {
   "Error": {
      "ErrorCode": "string",
      "Message": "string"
   },
   "ImageConfig": {
      "Command": [ "string" ],
      "EntryPoint": [ "string" ],
      "WorkingDirectory": "string"
   }
},
"KMSKeyArn": "string",
"LastModified": "string",
"LastUpdateStatus": "string",
"LastUpdateStatusReason": "string",
"LastUpdateStatusReasonCode": "string",
"Layers": [
   {
      "Arn": "string",
      "CodeSize": number,
      "SigningJobArn": "string",
      "SigningProfileVersionArn": "string"
   }
],
"MasterArn": "string",
"MemorySize": number,
"PackageType": "string",
"RevisionId": "string",
"Role": "string",
"Runtime": "string",
"SigningJobArn": "string",
"SigningProfileVersionArn": "string",
"State": "string",
"StateReason": "string",
"StateReasonCode": "string",
"Timeout": number,
"TracingConfig": {
   "Mode": "string"
},
"Version": "string",
```

```
   "VpcConfig": {
      "SecurityGroupIds": [ "string" ],
      "SubnetIds": [ "string" ],
      "VpcId": "string"
   }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**Architectures (p. 967)**

The instruction set architecture that the function supports. Architecture is a string array with one of the valid values. The default architecture value is `x86_64`.

Type: Array of strings

Array Members: Fixed number of 1 item.

Valid Values: `x86_64 | arm64`

**CodeSha256 (p. 967)**

The SHA256 hash of the function's deployment package.

Type: String

**CodeSize (p. 967)**

The size of the function's deployment package, in bytes.

Type: Long

**DeadLetterConfig (p. 967)**

The function's dead letter queue.

Type: DeadLetterConfig (p. 1131) object

**Description (p. 967)**

The function's description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

**Environment (p. 967)**

The function's environment variables. Omitted from AWS CloudTrail logs.

Type: EnvironmentResponse (p. 1135) object

**EphemeralStorage (p. 967)**

The size of the function's /tmp directory in MB. The default value is 512, but can be any whole number between 512 and 10240 MB.

Type: EphemeralStorage (p. 1136) object

**FileSystemConfigs (p. 967)**

Connection settings for an Amazon EFS file system.

Type: Array of FileSystemConfig (p. 1142) objects

Array Members: Maximum number of 1 item.

**FunctionArn (p. 967)**

The function's Amazon Resource Name (ARN).

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_\.]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**FunctionName (p. 967)**

The name of the function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 170.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**Handler (p. 967)**

The function that Lambda calls to begin executing your function.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

**ImageConfigResponse (p. 967)**

The function's image configuration values.

Type: ImageConfigResponse (p. 1160) object

**KMSKeyArn (p. 967)**

The AWS KMS key that's used to encrypt the function's environment variables. This key is only returned if you've configured a customer managed key.

Type: String

Pattern: `(arn:(aws[a-zA-Z-]*)?:[a-z0-9-.]+:.*)|()`

**LastModified (p. 967)**

The date and time that the function was last updated, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

**LastUpdateStatus (p. 967)**

The status of the last update that was performed on the function. This is first set to `Successful` after function creation completes.

Type: String

Valid Values: `Successful | Failed | InProgress`

**LastUpdateStatusReason (p. 967)**

The reason for the last update that was performed on the function.

Type: String

**LastUpdateStatusReasonCode (p. 967)**

The reason code for the last update that was performed on the function.

Type: String

Valid Values: `EniLimitExceeded | InsufficientRolePermissions | InvalidConfiguration | InternalError | SubnetOutOfIPAddresses | InvalidSubnet | InvalidSecurityGroup | ImageDeleted | ImageAccessDenied | InvalidImage`

**Layers (p. 967)**

The function's layers.

Type: Array of Layer (p. 1161) objects

**MasterArn (p. 967)**

For Lambda@Edge functions, the ARN of the main function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**MemorySize (p. 967)**

The amount of memory available to the function at runtime.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 10240.

**PackageType (p. 967)**

The type of deployment package. Set to `Image` for container image and set `Zip` for .zip file archive.

Type: String

Valid Values: `Zip | Image`

**RevisionId (p. 967)**

The latest updated revision of the function or alias.

Type: String

**Role (p. 967)**

The function's execution role.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@\-_/]+`

**Runtime (p. 967)**

The runtime environment for the Lambda function.

Type: String

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 |`

`dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

**SigningJobArn (p. 967)**

The ARN of the signing job.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**SigningProfileVersionArn (p. 967)**

The ARN of the signing profile version.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**State (p. 967)**

The current state of the function. When the state is `Inactive`, you can reactivate the function by invoking it.

Type: String

Valid Values: `Pending | Active | Inactive | Failed`

**StateReason (p. 967)**

The reason for the function's current state.

Type: String

**StateReasonCode (p. 967)**

The reason code for the function's current state. When the code is `Creating`, you can't invoke or modify the function.

Type: String

Valid Values: `Idle | Creating | Restoring | EniLimitExceeded | InsufficientRolePermissions | InvalidConfiguration | InternalError | SubnetOutOfIPAddresses | InvalidSubnet | InvalidSecurityGroup | ImageDeleted | ImageAccessDenied | InvalidImage`

**Timeout (p. 967)**

The amount of time in seconds that Lambda allows a function to run before stopping it.

Type: Integer

Valid Range: Minimum value of 1.

**TracingConfig (p. 967)**

The function's AWS X-Ray tracing configuration.

Type: TracingConfigResponse (p. 1176) object

**Version (p. 967)**

The version of the Lambda function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

**VpcConfig (p. 967)**

The function's networking configuration.

Type: VpcConfigResponse (p. 1178) object

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetFunctionEventInvokeConfig

Retrieves the configuration for asynchronous invocation for a function, version, or alias.

To configure options for asynchronous invocation, use PutFunctionEventInvokeConfig (p. 1056).

## Request Syntax

```
GET /2019-09-25/functions/FunctionName/event-invoke-config?Qualifier=Qualifier HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 974)**

The name of the Lambda function, version, or alias.

**Name formats**

- **Function name** - `my-function` (name-only), `my-function:v1` (with alias).
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

You can append a version number or alias to any of the formats. The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 974)**

A version number or alias name.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "DestinationConfig": {
      "OnFailure": {
         "Destination": "string"
      },
      "OnSuccess": {
         "Destination": "string"
```

```
      }
   },
   "FunctionArn": "string",
   "LastModified": number,
   "MaximumEventAgeInSeconds": number,
   "MaximumRetryAttempts": number
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**DestinationConfig (p. 974)**

A destination for events after they have been sent to a function for processing.

**Destinations**

- **Function** - The Amazon Resource Name (ARN) of a Lambda function.
- **Queue** - The ARN of an SQS queue.
- **Topic** - The ARN of an SNS topic.
- **Event Bus** - The ARN of an Amazon EventBridge event bus.

Type: DestinationConfig (p. 1132) object

**FunctionArn (p. 974)**

The Amazon Resource Name (ARN) of the function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**LastModified (p. 974)**

The date and time that the configuration was last updated, in Unix time seconds.

Type: Timestamp

**MaximumEventAgeInSeconds (p. 974)**

The maximum age of a request that Lambda sends to a function for processing.

Type: Integer

Valid Range: Minimum value of 60. Maximum value of 21600.

**MaximumRetryAttempts (p. 974)**

The maximum number of times to retry when the function returns an error.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 2.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetFunctionUrlConfig

Returns details about a Lambda function URL.

## Request Syntax

```
GET /2021-10-31/functions/FunctionName/url?Qualifier=Qualifier HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 977)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 977)**

The alias name.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(^\$LATEST$)|((?!^[0-9]+$)([a-zA-Z0-9-_]+))`

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "AuthType": "string",
   "Cors": {
      "AllowCredentials": boolean,
      "AllowHeaders": [ "string" ],
      "AllowMethods": [ "string" ],
```

```
      "AllowOrigins": [ "string" ],
      "ExposeHeaders": [ "string" ],
      "MaxAge": number
   },
   "CreationTime": "string",
   "FunctionArn": "string",
   "FunctionUrl": "string",
   "LastModifiedTime": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**AuthType (p. 977)**

The type of authentication that your function URL uses. Set to `AWS_IAM` if you want to restrict access to authenticated `IAM` users only. Set to `NONE` if you want to bypass IAM authentication to create a public endpoint. For more information, see Security and auth model for Lambda function URLs.

Type: String

Valid Values: `NONE | AWS_IAM`

**Cors (p. 977)**

The cross-origin resource sharing (CORS) settings for your function URL.

Type: Cors (p. 1129) object

**CreationTime (p. 977)**

When the function URL was created, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

**FunctionArn (p. 977)**

The Amazon Resource Name (ARN) of your function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**FunctionUrl (p. 977)**

The HTTP URL endpoint for your function.

Type: String

Length Constraints: Minimum length of 40. Maximum length of 100.

**LastModifiedTime (p. 977)**

When the function URL configuration was last updated, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetLayerVersion

Returns information about a version of an AWS Lambda layer, with a link to download the layer archive that's valid for 10 minutes.

## Request Syntax

```
GET /2018-10-31/layers/LayerName/versions/VersionNumber HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**LayerName (p. 980)**

The name or Amazon Resource Name (ARN) of the layer.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+)|[a-zA-Z0-9-_]+`

Required: Yes

**VersionNumber (p. 980)**

The version number.

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "CompatibleArchitectures": [ "string" ],
   "CompatibleRuntimes": [ "string" ],
   "Content": {
      "CodeSha256": "string",
      "CodeSize": number,
      "Location": "string",
      "SigningJobArn": "string",
      "SigningProfileVersionArn": "string"
   },
   "CreatedDate": "string",
   "Description": "string",
   "LayerArn": "string",
   "LayerVersionArn": "string",
   "LicenseInfo": "string",
   "Version": number
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**CompatibleArchitectures (p. 980)**

A list of compatible instruction set architectures.

Type: Array of strings

Array Members: Maximum number of 2 items.

Valid Values: `x86_64 | arm64`

**CompatibleRuntimes (p. 980)**

The layer's compatible runtimes.

Type: Array of strings

Array Members: Maximum number of 15 items.

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

**Content (p. 980)**

Details about the layer version.

Type: LayerVersionContentOutput (p. 1164) object

**CreatedDate (p. 980)**

The date that the layer version was created, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

**Description (p. 980)**

The description of the version.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

**LayerArn (p. 980)**

The ARN of the layer.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+`

**LayerVersionArn (p. 980)**

The ARN of the layer version.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+:[0-9]+`

**LicenseInfo (p. 980)**

The layer's software license.

Type: String

Length Constraints: Maximum length of 512.

**Version (p. 980)**

The version number.

Type: Long

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetLayerVersionByArn

Returns information about a version of an AWS Lambda layer, with a link to download the layer archive that's valid for 10 minutes.

## Request Syntax

```
GET /2018-10-31/layers?find=LayerVersion&Arn=Arn HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**Arn (p. 983)**

The ARN of the layer version.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+:[0-9]+`

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "CompatibleArchitectures": [ "string" ],
   "CompatibleRuntimes": [ "string" ],
   "Content": {
      "CodeSha256": "string",
      "CodeSize": number,
      "Location": "string",
      "SigningJobArn": "string",
      "SigningProfileVersionArn": "string"
   },
   "CreatedDate": "string",
   "Description": "string",
   "LayerArn": "string",
   "LayerVersionArn": "string",
   "LicenseInfo": "string",
   "Version": number
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**CompatibleArchitectures (p. 983)**

A list of compatible instruction set architectures.

Type: Array of strings

Array Members: Maximum number of 2 items.

Valid Values: `x86_64 | arm64`

**CompatibleRuntimes (p. 983)**

The layer's compatible runtimes.

Type: Array of strings

Array Members: Maximum number of 15 items.

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

**Content (p. 983)**

Details about the layer version.

Type: LayerVersionContentOutput (p. 1164) object

**CreatedDate (p. 983)**

The date that the layer version was created, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

**Description (p. 983)**

The description of the version.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

**LayerArn (p. 983)**

The ARN of the layer.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+`

**LayerVersionArn (p. 983)**

The ARN of the layer version.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+:[0-9]+`

**LicenseInfo (p. 983)**

The layer's software license.

Type: String

Length Constraints: Maximum length of 512.

**Version (p. 983)**

The version number.

Type: Long

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetLayerVersionPolicy

Returns the permission policy for a version of an AWS Lambda layer. For more information, see AddLayerVersionPermission (p. 877).

## Request Syntax

```
GET /2018-10-31/layers/LayerName/versions/VersionNumber/policy HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**LayerName (p. 986)**

The name or Amazon Resource Name (ARN) of the layer.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+)|[a-zA-Z0-9-_]+`

Required: Yes

**VersionNumber (p. 986)**

The version number.

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "Policy": "string",
   "RevisionId": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**Policy (p. 986)**

The policy document.

Type: String

**RevisionId (p. 986)**

A unique identifier for the current revision of the policy.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetPolicy

Returns the resource-based IAM policy for a function, version, or alias.

## Request Syntax

```
GET /2015-03-31/functions/FunctionName/policy?Qualifier=Qualifier HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 988)**

The name of the Lambda function, version, or alias.

**Name formats**

- **Function name** - `my-function` (name-only), `my-function:v1` (with alias).
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

You can append a version number or alias to any of the formats. The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 170.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 988)**

Specify a version or alias to get the policy for that resource.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "Policy": "string",
   "RevisionId": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**Policy (p. 988)**

The resource-based policy.

Type: String

**RevisionId (p. 988)**

A unique identifier for the current revision of the policy.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# GetProvisionedConcurrencyConfig

Retrieves the provisioned concurrency configuration for a function's alias or version.

## Request Syntax

```
GET /2019-09-30/functions/FunctionName/provisioned-concurrency?Qualifier=Qualifier HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 990)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 990)**

The version number or alias name.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "AllocatedProvisionedConcurrentExecutions": number,
   "AvailableProvisionedConcurrentExecutions": number,
   "LastModified": "string",
   "RequestedProvisionedConcurrentExecutions": number,
```

```
   "Status": "string",
   "StatusReason": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**AllocatedProvisionedConcurrentExecutions (p. 990)**

The amount of provisioned concurrency allocated. When a weighted alias is used during linear and canary deployments, this value fluctuates depending on the amount of concurrency that is provisioned for the function versions.

Type: Integer

Valid Range: Minimum value of 0.

**AvailableProvisionedConcurrentExecutions (p. 990)**

The amount of provisioned concurrency available.

Type: Integer

Valid Range: Minimum value of 0.

**LastModified (p. 990)**

The date and time that a user last updated the configuration, in ISO 8601 format.

Type: String

**RequestedProvisionedConcurrentExecutions (p. 990)**

The amount of provisioned concurrency requested.

Type: Integer

Valid Range: Minimum value of 1.

**Status (p. 990)**

The status of the allocation process.

Type: String

Valid Values: `IN_PROGRESS | READY | FAILED`

**StatusReason (p. 990)**

For failed allocations, the reason that provisioned concurrency could not be allocated.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ProvisionedConcurrencyConfigNotFoundException**

The specified configuration does not exist.

HTTP Status Code: 404

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# Invoke

Invokes a Lambda function. You can invoke a function synchronously (and wait for the response), or asynchronously. To invoke a function asynchronously, set `InvocationType` to `Event`.

For synchronous invocation, details about the function response, including errors, are included in the response body and headers. For either invocation type, you can find more information in the execution log and trace.

When an error occurs, your function may be invoked multiple times. Retry behavior varies by error type, client, event source, and invocation type. For example, if you invoke a function asynchronously and it returns an error, Lambda executes the function up to two more times. For more information, see Retry Behavior.

For asynchronous invocation, Lambda adds events to a queue before sending them to your function. If your function does not have enough capacity to keep up with the queue, events may be lost. Occasionally, your function may receive the same event multiple times, even if no error occurs. To retain events that were not processed, configure your function with a dead-letter queue.

The status code in the API response doesn't reflect function errors. Error codes are reserved for errors that prevent your function from executing, such as permissions errors, limit errors, or issues with your function's code and configuration. For example, Lambda returns `TooManyRequestsException` if executing the function would cause you to exceed a concurrency limit at either the account level (`ConcurrentInvocationLimitExceeded`) or function level (`ReservedFunctionConcurrentInvocationLimitExceeded`).

For functions with a long timeout, your client might be disconnected during synchronous invocation while it waits for a response. Configure your HTTP client, SDK, firewall, proxy, or operating system to allow for long connections with timeout or keep-alive settings.

This operation requires permission for the lambda:InvokeFunction action. For details on how to set up permissions for cross-account invocations, see Granting function access to other accounts.

## Request Syntax

```
POST /2015-03-31/functions/FunctionName/invocations?Qualifier=Qualifier HTTP/1.1
X-Amz-Invocation-Type: InvocationType
X-Amz-Log-Type: LogType
X-Amz-Client-Context: ClientContext

Payload
```

## URI Request Parameters

The request uses the following URI parameters.

**ClientContext (p. 993)**

Up to 3583 bytes of base64-encoded data about the invoking client to pass to the function in the context object.

**FunctionName (p. 993)**

The name of the Lambda function, version, or alias.

**Name formats**

- **Function name** - `my-function` (name-only), `my-function:v1` (with alias).
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.

- **Partial ARN** - `123456789012:function:my-function`.

You can append a version number or alias to any of the formats. The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 170.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**InvocationType (p. 993)**

Choose from the following options.

- `RequestResponse` (default) - Invoke the function synchronously. Keep the connection open until the function returns a response or times out. The API response includes the function response and additional data.
- `Event` - Invoke the function asynchronously. Send events that fail multiple times to the function's dead-letter queue (if it's configured). The API response only includes a status code.
- `DryRun` - Validate parameter values and verify that the user or role has permission to invoke the function.

Valid Values: `Event | RequestResponse | DryRun`

**LogType (p. 993)**

Set to `Tail` to include the execution log in the response. Applies to synchronously invoked functions only.

Valid Values: `None | Tail`

**Qualifier (p. 993)**

Specify a version or alias to invoke a published version of the function.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

## Request Body

The request accepts the following binary data.

**Payload (p. 993)**

The JSON that you want to provide to your Lambda function as input.

You can enter the JSON directly. For example, `--payload '{ "key": "value" }'`. You can also specify a file path. For example, `--payload file://payload.json`.

## Response Syntax

```
HTTP/1.1 StatusCode
X-Amz-Function-Error: FunctionError
X-Amz-Log-Result: LogResult
X-Amz-Executed-Version: ExecutedVersion

Payload
```

## Response Elements

If the action is successful, the service sends back the following HTTP response.

**StatusCode (p. 994)**

The HTTP status code is in the 200 range for a successful request. For the `RequestResponse` invocation type, this status code is 200. For the `Event` invocation type, this status code is 202. For the `DryRun` invocation type, the status code is 204.

The response returns the following HTTP headers.

**ExecutedVersion (p. 994)**

The version of the function that executed. When you invoke a function with an alias, this indicates which version the alias resolved to.

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

**FunctionError (p. 994)**

If present, indicates that an error occurred during function execution. Details about the error are included in the response payload.

**LogResult (p. 994)**

The last 4 KB of the execution log, which is base64 encoded.

The response returns the following as the HTTP body.

**Payload (p. 994)**

The response from the function, or an error object.

## Errors

**EC2AccessDeniedException**

Need additional permissions to configure VPC settings.

HTTP Status Code: 502

**EC2ThrottledException**

AWS Lambda was throttled by Amazon EC2 during Lambda function initialization using the execution role provided for the Lambda function.

HTTP Status Code: 502

**EC2UnexpectedException**

AWS Lambda received an unexpected EC2 client exception while setting up for the Lambda function.

HTTP Status Code: 502

**EFSIOException**

An error occurred when reading from or writing to a connected file system.

HTTP Status Code: 410

**EFSMountConnectivityException**

The function couldn't make a network connection to the configured file system.

HTTP Status Code: 408

**EFSMountFailureException**

The function couldn't mount the configured file system due to a permission or configuration issue.

HTTP Status Code: 403

**EFSMountTimeoutException**

The function was able to make a network connection to the configured file system, but the mount operation timed out.

HTTP Status Code: 408

**ENILimitReachedException**

AWS Lambda was not able to create an elastic network interface in the VPC, specified as part of Lambda function configuration, because the limit for network interfaces has been reached.

HTTP Status Code: 502

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**InvalidRequestContentException**

The request body could not be parsed as JSON.

HTTP Status Code: 400

**InvalidRuntimeException**

The runtime or runtime version specified is not supported.

HTTP Status Code: 502

**InvalidSecurityGroupIDException**

The Security Group ID provided in the Lambda function VPC configuration is invalid.

HTTP Status Code: 502

**InvalidSubnetIDException**

The Subnet ID provided in the Lambda function VPC configuration is invalid.

HTTP Status Code: 502

**InvalidZipFileException**

AWS Lambda could not unzip the deployment package.

HTTP Status Code: 502

**KMSAccessDeniedException**

Lambda was unable to decrypt the environment variables because KMS access was denied. Check the Lambda function's KMS permissions.

HTTP Status Code: 502

**KMSDisabledException**

Lambda was unable to decrypt the environment variables because the KMS key used is disabled. Check the Lambda function's KMS key settings.

HTTP Status Code: 502

**KMSInvalidStateException**

Lambda was unable to decrypt the environment variables because the KMS key used is in an invalid state for Decrypt. Check the function's KMS key settings.

HTTP Status Code: 502

**KMSNotFoundException**

Lambda was unable to decrypt the environment variables because the KMS key was not found. Check the function's KMS key settings.

HTTP Status Code: 502

**RequestTooLargeException**

The request payload exceeded the `Invoke` request body JSON input limit. For more information, see Limits.

HTTP Status Code: 413

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ResourceNotReadyException**

The function is inactive and its VPC connection is no longer available. Wait for the VPC connection to reestablish and try again.

HTTP Status Code: 502

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**SubnetIPAddressLimitReachedException**

AWS Lambda was not able to set up VPC access for the Lambda function because one or more configured subnets has no available IP addresses.

HTTP Status Code: 502

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

**UnsupportedMediaTypeException**

The content type of the `Invoke` request body is not JSON.

HTTP Status Code: 415

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# InvokeAsync

*This action has been deprecated.*

**Important**
For asynchronous function invocation, use Invoke (p. 993).

Invokes a function asynchronously.

## Request Syntax

```
POST /2014-11-13/functions/FunctionName/invoke-async/ HTTP/1.1

InvokeArgs
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 999)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 170.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

## Request Body

The request accepts the following binary data.

**InvokeArgs (p. 999)**

The JSON that you want to provide to your Lambda function as input.

Required: Yes

## Response Syntax

```
HTTP/1.1 Status
```

## Response Elements

If the action is successful, the service sends back the following HTTP response.

**Status (p. 999)**

The status code.

## Errors

**InvalidRequestContentException**

The request body could not be parsed as JSON.

HTTP Status Code: 400

**InvalidRuntimeException**

The runtime or runtime version specified is not supported.

HTTP Status Code: 502

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# ListAliases

Returns a list of aliases for a Lambda function.

## Request Syntax

```
GET /2015-03-31/functions/FunctionName/aliases?
FunctionVersion=FunctionVersion&Marker=Marker&MaxItems=MaxItems HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1001)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**FunctionVersion (p. 1001)**

Specify a function version to only list aliases that invoke that version.

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

**Marker (p. 1001)**

Specify the pagination token that's returned by a previous request to retrieve the next page of results.

**MaxItems (p. 1001)**

Limit the number of aliases returned.

Valid Range: Minimum value of 1. Maximum value of 10000.

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
```

```
Content-type: application/json

{
   "Aliases": [
      {
         "AliasArn": "string",
         "Description": "string",
         "FunctionVersion": "string",
         "Name": "string",
         "RevisionId": "string",
         "RoutingConfig": {
            "AdditionalVersionWeights": {
               "string" : number
            }
         }
      }
   ],
   "NextMarker": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**Aliases (p. 1001)**

A list of aliases.

Type: Array of AliasConfiguration (p. 1120) objects

**NextMarker (p. 1001)**

The pagination token that's included if more results are available.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# ListCodeSigningConfigs

Returns a list of code signing configurations. A request returns up to 10,000 configurations per call. You can use the `MaxItems` parameter to return fewer configurations per call.

## Request Syntax

```
GET /2020-04-22/code-signing-configs/?Marker=Marker&MaxItems=MaxItems HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**Marker (p. 1004)**

Specify the pagination token that's returned by a previous request to retrieve the next page of results.

**MaxItems (p. 1004)**

Maximum number of items to return.

Valid Range: Minimum value of 1. Maximum value of 10000.

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "CodeSigningConfigs": [
      {
         "AllowedPublishers": {
            "SigningProfileVersionArns": [ "string" ]
         },
         "CodeSigningConfigArn": "string",
         "CodeSigningConfigId": "string",
         "CodeSigningPolicies": {
            "UntrustedArtifactOnDeployment": "string"
         },
         "Description": "string",
         "LastModified": "string"
      }
   ],
   "NextMarker": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**CodeSigningConfigs (p. 1004)**

The code signing configurations

Type: Array of CodeSigningConfig (p. 1125) objects

**NextMarker (p. 1004)**

The pagination token that's included if more results are available.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# ListEventSourceMappings

Lists event source mappings. Specify an `EventSourceArn` to show only event source mappings for a single event source.

## Request Syntax

```
GET /2015-03-31/event-source-mappings/?
EventSourceArn=EventSourceArn&FunctionName=FunctionName&Marker=Marker&MaxItems=MaxItems
 HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**EventSourceArn (p. 1006)**

The Amazon Resource Name (ARN) of the event source.

- **Amazon Kinesis** - The ARN of the data stream or a stream consumer.
- **Amazon DynamoDB Streams** - The ARN of the stream.
- **Amazon Simple Queue Service** - The ARN of the queue.
- **Amazon Managed Streaming for Apache Kafka** - The ARN of the cluster.

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**FunctionName (p. 1006)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Version or Alias ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction:PROD`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it's limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**Marker (p. 1006)**

A pagination token returned by a previous call.

**MaxItems (p. 1006)**

The maximum number of event source mappings to return. Note that ListEventSourceMappings returns a maximum of 100 items in each response, even if you set the number higher.

Valid Range: Minimum value of 1. Maximum value of 10000.

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "EventSourceMappings": [
      {
         "AmazonManagedKafkaEventSourceConfig": {
            "ConsumerGroupId": "string"
         },
         "BatchSize": number,
         "BisectBatchOnFunctionError": boolean,
         "DestinationConfig": {
            "OnFailure": {
               "Destination": "string"
            },
            "OnSuccess": {
               "Destination": "string"
            }
         },
         "EventSourceArn": "string",
         "FilterCriteria": {
            "Filters": [
               {
                  "Pattern": "string"
               }
            ]
         },
         "FunctionArn": "string",
         "FunctionResponseTypes": [ "string" ],
         "LastModified": number,
         "LastProcessingResult": "string",
         "MaximumBatchingWindowInSeconds": number,
         "MaximumRecordAgeInSeconds": number,
         "MaximumRetryAttempts": number,
         "ParallelizationFactor": number,
         "Queues": [ "string" ],
         "SelfManagedEventSource": {
            "Endpoints": {
               "string" : [ "string" ]
            }
         },
         "SelfManagedKafkaEventSourceConfig": {
            "ConsumerGroupId": "string"
         },
         "SourceAccessConfigurations": [
            {
               "Type": "string",
               "URI": "string"
            }
         ],
         "StartingPosition": "string",
         "StartingPositionTimestamp": number,
         "State": "string",
         "StateTransitionReason": "string",
         "Topics": [ "string" ],
         "TumblingWindowInSeconds": number,
         "UUID": "string"
      }
```

```
    ],
    "NextMarker": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**EventSourceMappings (p. 1007)**

A list of event source mappings.

Type: Array of EventSourceMappingConfiguration (p. 1137) objects

**NextMarker (p. 1007)**

A pagination token that's returned when the response doesn't contain all event source mappings.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3

- AWS SDK for Python
- AWS SDK for Ruby V3

# ListFunctionEventInvokeConfigs

Retrieves a list of configurations for asynchronous invocation for a function.

To configure options for asynchronous invocation, use PutFunctionEventInvokeConfig (p. 1056).

## Request Syntax

```
GET /2019-09-25/functions/FunctionName/event-invoke-config/list?
Marker=Marker&MaxItems=MaxItems HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1010)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Marker (p. 1010)**

Specify the pagination token that's returned by a previous request to retrieve the next page of results.

**MaxItems (p. 1010)**

The maximum number of configurations to return.

Valid Range: Minimum value of 1. Maximum value of 50.

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
```

```
   "FunctionEventInvokeConfigs": [
      {
         "DestinationConfig": {
            "OnFailure": {
               "Destination": "string"
            },
            "OnSuccess": {
               "Destination": "string"
            }
         },
         "FunctionArn": "string",
         "LastModified": number,
         "MaximumEventAgeInSeconds": number,
         "MaximumRetryAttempts": number
      }
   ],
   "NextMarker": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**FunctionEventInvokeConfigs (p. 1010)**

A list of configurations.

Type: Array of FunctionEventInvokeConfig (p. 1154) objects

**NextMarker (p. 1010)**

The pagination token that's included if more results are available.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# ListFunctions

Returns a list of Lambda functions, with the version-specific configuration of each. Lambda returns up to 50 functions per call.

Set `FunctionVersion` to `ALL` to include all published versions of each function in addition to the unpublished version.

> **Note**
> The `ListFunctions` action returns a subset of the FunctionConfiguration (p. 1148) fields. To get the additional fields (State, StateReasonCode, StateReason, LastUpdateStatus, LastUpdateStatusReason, LastUpdateStatusReasonCode) for a function or version, use GetFunction (p. 958).

## Request Syntax

```
GET /2015-03-31/functions/?
FunctionVersion=FunctionVersion&Marker=Marker&MasterRegion=MasterRegion&MaxItems=MaxItems
 HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionVersion (p. 1013)**

Set to `ALL` to include entries for all published versions of each function.

Valid Values: `ALL`

**Marker (p. 1013)**

Specify the pagination token that's returned by a previous request to retrieve the next page of results.

**MasterRegion (p. 1013)**

For Lambda@Edge functions, the AWS Region of the master function. For example, `us-east-1` filters the list of functions to only include Lambda@Edge functions replicated from a master function in US East (N. Virginia). If specified, you must set `FunctionVersion` to `ALL`.

Pattern: `ALL|[a-z]{2}(-gov)?-[a-z]+-\d{1}`

**MaxItems (p. 1013)**

The maximum number of functions to return in the response. Note that `ListFunctions` returns a maximum of 50 items in each response, even if you set the number higher.

Valid Range: Minimum value of 1. Maximum value of 10000.

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json
```

```
{
   "Functions": [
      {
         "Architectures": [ "string" ],
         "CodeSha256": "string",
         "CodeSize": number,
         "DeadLetterConfig": {
            "TargetArn": "string"
         },
         "Description": "string",
         "Environment": {
            "Error": {
               "ErrorCode": "string",
               "Message": "string"
            },
            "Variables": {
               "string" : "string"
            }
         },
         "EphemeralStorage": {
            "Size": number
         },
         "FileSystemConfigs": [
            {
               "Arn": "string",
               "LocalMountPath": "string"
            }
         ],
         "FunctionArn": "string",
         "FunctionName": "string",
         "Handler": "string",
         "ImageConfigResponse": {
            "Error": {
               "ErrorCode": "string",
               "Message": "string"
            },
            "ImageConfig": {
               "Command": [ "string" ],
               "EntryPoint": [ "string" ],
               "WorkingDirectory": "string"
            }
         },
         "KMSKeyArn": "string",
         "LastModified": "string",
         "LastUpdateStatus": "string",
         "LastUpdateStatusReason": "string",
         "LastUpdateStatusReasonCode": "string",
         "Layers": [
            {
               "Arn": "string",
               "CodeSize": number,
               "SigningJobArn": "string",
               "SigningProfileVersionArn": "string"
            }
         ],
         "MasterArn": "string",
         "MemorySize": number,
         "PackageType": "string",
         "RevisionId": "string",
         "Role": "string",
         "Runtime": "string",
         "SigningJobArn": "string",
         "SigningProfileVersionArn": "string",
         "State": "string",
         "StateReason": "string",
```

```
            "StateReasonCode": "string",
            "Timeout": number,
            "TracingConfig": {
               "Mode": "string"
            },
            "Version": "string",
            "VpcConfig": {
               "SecurityGroupIds": [ "string" ],
               "SubnetIds": [ "string" ],
               "VpcId": "string"
            }
         }
      ],
      "NextMarker": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**Functions (p. 1013)**

A list of Lambda functions.

Type: Array of FunctionConfiguration (p. 1148) objects

**NextMarker (p. 1013)**

The pagination token that's included if more results are available.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# ListFunctionsByCodeSigningConfig

List the functions that use the specified code signing configuration. You can use this method prior to deleting a code signing configuration, to verify that no functions are using it.

## Request Syntax

```
GET /2020-04-22/code-signing-configs/CodeSigningConfigArn/functions?
Marker=Marker&MaxItems=MaxItems HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**CodeSigningConfigArn (p. 1017)**

The The Amazon Resource Name (ARN) of the code signing configuration.

Length Constraints: Maximum length of 200.

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}((-gov)|(-iso(b?)))?-[a-z]+-\d{1}:\d{12}:code-signing-config:csc-[a-z0-9]{17}`

Required: Yes

**Marker (p. 1017)**

Specify the pagination token that's returned by a previous request to retrieve the next page of results.

**MaxItems (p. 1017)**

Maximum number of items to return.

Valid Range: Minimum value of 1. Maximum value of 10000.

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "FunctionArns": [ "string" ],
   "NextMarker": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**FunctionArns (p. 1017)**

The function ARNs.

Type: Array of strings

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**NextMarker (p. 1017)**

The pagination token that's included if more results are available.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# ListFunctionUrlConfigs

Returns a list of Lambda function URLs for the specified function.

## Request Syntax

```
GET /2021-10-31/functions/FunctionName/urls?Marker=Marker&MaxItems=MaxItems HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1019)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Marker (p. 1019)**

Specify the pagination token that's returned by a previous request to retrieve the next page of results.

**MaxItems (p. 1019)**

The maximum number of function URLs to return in the response. Note that `ListFunctionUrlConfigs` returns a maximum of 50 items in each response, even if you set the number higher.

Valid Range: Minimum value of 1. Maximum value of 50.

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "FunctionUrlConfigs": [
```

```
      {
         "AuthType": "string",
         "Cors": {
            "AllowCredentials": boolean,
            "AllowHeaders": [ "string" ],
            "AllowMethods": [ "string" ],
            "AllowOrigins": [ "string" ],
            "ExposeHeaders": [ "string" ],
            "MaxAge": number
         },
         "CreationTime": "string",
         "FunctionArn": "string",
         "FunctionUrl": "string",
         "LastModifiedTime": "string"
      }
   ],
   "NextMarker": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**FunctionUrlConfigs (p. 1019)**

A list of function URL configurations.

Type: Array of FunctionUrlConfig (p. 1156) objects

**NextMarker (p. 1019)**

The pagination token that's included if more results are available.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# ListLayers

Lists AWS Lambda layers and shows information about the latest version of each. Specify a runtime identifier to list only layers that indicate that they're compatible with that runtime. Specify a compatible architecture to include only layers that are compatible with that instruction set architecture.

## Request Syntax

```
GET /2018-10-31/layers?
CompatibleArchitecture=CompatibleArchitecture&CompatibleRuntime=CompatibleRuntime&Marker=Marker&MaxItem
 HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**CompatibleArchitecture (p. 1022)**

The compatible instruction set architecture.

Valid Values: `x86_64 | arm64`

**CompatibleRuntime (p. 1022)**

A runtime identifier. For example, `go1.x`.

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

**Marker (p. 1022)**

A pagination token returned by a previous call.

**MaxItems (p. 1022)**

The maximum number of layers to return.

Valid Range: Minimum value of 1. Maximum value of 50.

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "Layers": [
      {
         "LatestMatchingVersion": {
            "CompatibleArchitectures": [ "string" ],
            "CompatibleRuntimes": [ "string" ],
            "CreatedDate": "string",
```

```
            "Description": "string",
            "LayerVersionArn": "string",
            "LicenseInfo": "string",
            "Version": number
         },
         "LayerArn": "string",
         "LayerName": "string"
      }
   ],
   "NextMarker": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**Layers (p. 1022)**

A list of function layers.

Type: Array of LayersListItem (p. 1162) objects

**NextMarker (p. 1022)**

A pagination token returned when the response doesn't contain all layers.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2

- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# ListLayerVersions

Lists the versions of an AWS Lambda layer. Versions that have been deleted aren't listed. Specify a runtime identifier to list only versions that indicate that they're compatible with that runtime. Specify a compatible architecture to include only layer versions that are compatible with that architecture.

## Request Syntax

```
GET /2018-10-31/layers/LayerName/versions?
CompatibleArchitecture=CompatibleArchitecture&CompatibleRuntime=CompatibleRuntime&Marker=Marker&MaxItem
 HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**CompatibleArchitecture (p. 1025)**

The compatible instruction set architecture.

Valid Values: `x86_64 | arm64`

**CompatibleRuntime (p. 1025)**

A runtime identifier. For example, `go1.x`.

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

**LayerName (p. 1025)**

The name or Amazon Resource Name (ARN) of the layer.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+)|[a-zA-Z0-9-_]+`

Required: Yes

**Marker (p. 1025)**

A pagination token returned by a previous call.

**MaxItems (p. 1025)**

The maximum number of versions to return.

Valid Range: Minimum value of 1. Maximum value of 50.

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json
```

```
{
   "LayerVersions": [
      {
         "CompatibleArchitectures": [ "string" ],
         "CompatibleRuntimes": [ "string" ],
         "CreatedDate": "string",
         "Description": "string",
         "LayerVersionArn": "string",
         "LicenseInfo": "string",
         "Version": number
      }
   ],
   "NextMarker": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**LayerVersions (p. 1025)**

A list of versions.

Type: Array of LayerVersionsListItem (p. 1165) objects

**NextMarker (p. 1025)**

A pagination token returned when the response doesn't contain all versions.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# ListProvisionedConcurrencyConfigs

Retrieves a list of provisioned concurrency configurations for a function.

## Request Syntax

```
GET /2019-09-30/functions/FunctionName/provisioned-concurrency?
List=ALL&Marker=Marker&MaxItems=MaxItems HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1028)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Marker (p. 1028)**

Specify the pagination token that's returned by a previous request to retrieve the next page of results.

**MaxItems (p. 1028)**

Specify a number to limit the number of configurations returned.

Valid Range: Minimum value of 1. Maximum value of 50.

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "NextMarker": "string",
   "ProvisionedConcurrencyConfigs": [
      {
```

```
            "AllocatedProvisionedConcurrentExecutions": number,
            "AvailableProvisionedConcurrentExecutions": number,
            "FunctionArn": "string",
            "LastModified": "string",
            "RequestedProvisionedConcurrentExecutions": number,
            "Status": "string",
            "StatusReason": "string"
        }
    ]
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**NextMarker (p. 1028)**

The pagination token that's included if more results are available.

Type: String

**ProvisionedConcurrencyConfigs (p. 1028)**

A list of provisioned concurrency configurations.

Type: Array of ProvisionedConcurrencyConfigListItem (p. 1169) objects

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# ListTags

Returns a function's tags. You can also view tags with GetFunction (p. 958).

## Request Syntax

```
GET /2017-03-31/tags/ARN HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**ARN (p. 1031)**

The function's Amazon Resource Name (ARN). Note: Lambda does not support adding tags to aliases or versions.

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "Tags": {
      "string" : "string"
   }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**Tags (p. 1031)**

The function's tags.

Type: String to string map

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# ListVersionsByFunction

Returns a list of versions, with the version-specific configuration of each. Lambda returns up to 50 versions per call.

## Request Syntax

```
GET /2015-03-31/functions/FunctionName/versions?Marker=Marker&MaxItems=MaxItems HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1033)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 170.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Marker (p. 1033)**

Specify the pagination token that's returned by a previous request to retrieve the next page of results.

**MaxItems (p. 1033)**

The maximum number of versions to return. Note that `ListVersionsByFunction` returns a maximum of 50 items in each response, even if you set the number higher.

Valid Range: Minimum value of 1. Maximum value of 10000.

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "NextMarker": "string",
   "Versions": [
```

```
{
   "Architectures": [ "string" ],
   "CodeSha256": "string",
   "CodeSize": number,
   "DeadLetterConfig": {
      "TargetArn": "string"
   },
   "Description": "string",
   "Environment": {
      "Error": {
         "ErrorCode": "string",
         "Message": "string"
      },
      "Variables": {
         "string" : "string"
      }
   },
   "EphemeralStorage": {
      "Size": number
   },
   "FileSystemConfigs": [
      {
         "Arn": "string",
         "LocalMountPath": "string"
      }
   ],
   "FunctionArn": "string",
   "FunctionName": "string",
   "Handler": "string",
   "ImageConfigResponse": {
      "Error": {
         "ErrorCode": "string",
         "Message": "string"
      },
      "ImageConfig": {
         "Command": [ "string" ],
         "EntryPoint": [ "string" ],
         "WorkingDirectory": "string"
      }
   },
   "KMSKeyArn": "string",
   "LastModified": "string",
   "LastUpdateStatus": "string",
   "LastUpdateStatusReason": "string",
   "LastUpdateStatusReasonCode": "string",
   "Layers": [
      {
         "Arn": "string",
         "CodeSize": number,
         "SigningJobArn": "string",
         "SigningProfileVersionArn": "string"
      }
   ],
   "MasterArn": "string",
   "MemorySize": number,
   "PackageType": "string",
   "RevisionId": "string",
   "Role": "string",
   "Runtime": "string",
   "SigningJobArn": "string",
   "SigningProfileVersionArn": "string",
   "State": "string",
   "StateReason": "string",
   "StateReasonCode": "string",
   "Timeout": number,
   "TracingConfig": {
```

```
            "Mode": "string"
         },
         "Version": "string",
         "VpcConfig": {
            "SecurityGroupIds": [ "string" ],
            "SubnetIds": [ "string" ],
            "VpcId": "string"
         }
      }
   ]
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**NextMarker (p. 1033)**

The pagination token that's included if more results are available.

Type: String

**Versions (p. 1033)**

A list of Lambda function versions.

Type: Array of FunctionConfiguration (p. 1148) objects

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface

- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# PublishLayerVersion

Creates an AWS Lambda layer from a ZIP archive. Each time you call `PublishLayerVersion` with the same layer name, a new version is created.

Add layers to your function with CreateFunction (p. 904) or UpdateFunctionConfiguration (p. 1098).

## Request Syntax

```
POST /2018-10-31/layers/LayerName/versions HTTP/1.1
Content-type: application/json

{
   "CompatibleArchitectures": [ "string" ],
   "CompatibleRuntimes": [ "string" ],
   "Content": {
      "S3Bucket": "string",
      "S3Key": "string",
      "S3ObjectVersion": "string",
      "ZipFile": blob
   },
   "Description": "string",
   "LicenseInfo": "string"
}
```

## URI Request Parameters

The request uses the following URI parameters.

**LayerName (p. 1037)**

The name or Amazon Resource Name (ARN) of the layer.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+)|[a-zA-Z0-9-_]+`

Required: Yes

## Request Body

The request accepts the following data in JSON format.

**CompatibleArchitectures (p. 1037)**

A list of compatible instruction set architectures.

Type: Array of strings

Array Members: Maximum number of 2 items.

Valid Values: `x86_64 | arm64`

Required: No

**CompatibleRuntimes (p. 1037)**

A list of compatible function runtimes. Used for filtering with ListLayers (p. 1022) and ListLayerVersions (p. 1025).

Type: Array of strings

Array Members: Maximum number of 15 items.

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

Required: No

**Content (p. 1037)**

The function layer archive.

Type: LayerVersionContentInput (p. 1163) object

Required: Yes

**Description (p. 1037)**

The description of the version.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

**LicenseInfo (p. 1037)**

The layer's software license. It can be any of the following:

- An SPDX license identifier. For example, `MIT`.
- The URL of a license hosted on the internet. For example, `https://opensource.org/licenses/MIT`.
- The full text of the license.

Type: String

Length Constraints: Maximum length of 512.

Required: No

## Response Syntax

```
HTTP/1.1 201
Content-type: application/json

{
   "CompatibleArchitectures": [ "string" ],
   "CompatibleRuntimes": [ "string" ],
   "Content": {
      "CodeSha256": "string",
      "CodeSize": number,
      "Location": "string",
      "SigningJobArn": "string",
      "SigningProfileVersionArn": "string"
   },
   "CreatedDate": "string",
   "Description": "string",
   "LayerArn": "string",
```

```
   "LayerVersionArn": "string",
   "LicenseInfo": "string",
   "Version": number
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 201 response.

The following data is returned in JSON format by the service.

**CompatibleArchitectures (p. 1038)**

A list of compatible instruction set architectures.

Type: Array of strings

Array Members: Maximum number of 2 items.

Valid Values: `x86_64 | arm64`

**CompatibleRuntimes (p. 1038)**

The layer's compatible runtimes.

Type: Array of strings

Array Members: Maximum number of 15 items.

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

**Content (p. 1038)**

Details about the layer version.

Type: LayerVersionContentOutput (p. 1164) object

**CreatedDate (p. 1038)**

The date that the layer version was created, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

**Description (p. 1038)**

The description of the version.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

**LayerArn (p. 1038)**

The ARN of the layer.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+`

**LayerVersionArn (p. 1038)**

The ARN of the layer version.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+:[0-9]+`

**LicenseInfo (p. 1038)**

The layer's software license.

Type: String

Length Constraints: Maximum length of 512.

**Version (p. 1038)**

The version number.

Type: Long

## Errors

**CodeStorageExceededException**

You have exceeded your maximum total code size per account. Learn more

HTTP Status Code: 400

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# PublishVersion

Creates a version from the current code and configuration of a function. Use versions to create a snapshot of your function code and configuration that doesn't change.

AWS Lambda doesn't publish a version if the function's configuration and code haven't changed since the last version. Use UpdateFunctionCode (p. 1088) or UpdateFunctionConfiguration (p. 1098) to update the function before publishing a version.

Clients can invoke versions directly or with an alias. To create an alias, use CreateAlias (p. 886).

## Request Syntax

```
POST /2015-03-31/functions/FunctionName/versions HTTP/1.1
Content-type: application/json

{
   "CodeSha256": "string",
   "Description": "string",
   "RevisionId": "string"
}
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1042)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

## Request Body

The request accepts the following data in JSON format.

**CodeSha256 (p. 1042)**

Only publish a version if the hash value matches the value that's specified. Use this option to avoid publishing a version if the function code has changed since you last updated it. You can get the hash for the version that you uploaded from the output of UpdateFunctionCode (p. 1088).

Type: String

Required: No

**Description (p. 1042)**

A description for the version to override the description in the function configuration.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

**RevisionId (p. 1042)**

Only update the function if the revision ID matches the ID that's specified. Use this option to avoid publishing a version if the function configuration has changed since you last updated it.

Type: String

Required: No

## Response Syntax

```
HTTP/1.1 201
Content-type: application/json

{
   "Architectures": [ "string" ],
   "CodeSha256": "string",
   "CodeSize": number,
   "DeadLetterConfig": {
      "TargetArn": "string"
   },
   "Description": "string",
   "Environment": {
      "Error": {
         "ErrorCode": "string",
         "Message": "string"
      },
      "Variables": {
         "string" : "string"
      }
   },
   "EphemeralStorage": {
      "Size": number
   },
   "FileSystemConfigs": [
      {
         "Arn": "string",
         "LocalMountPath": "string"
      }
   ],
   "FunctionArn": "string",
   "FunctionName": "string",
   "Handler": "string",
   "ImageConfigResponse": {
      "Error": {
         "ErrorCode": "string",
         "Message": "string"
      },
      "ImageConfig": {
         "Command": [ "string" ],
         "EntryPoint": [ "string" ],
         "WorkingDirectory": "string"
```

```
      }
   },
   "KMSKeyArn": "string",
   "LastModified": "string",
   "LastUpdateStatus": "string",
   "LastUpdateStatusReason": "string",
   "LastUpdateStatusReasonCode": "string",
   "Layers": [
      {
         "Arn": "string",
         "CodeSize": number,
         "SigningJobArn": "string",
         "SigningProfileVersionArn": "string"
      }
   ],
   "MasterArn": "string",
   "MemorySize": number,
   "PackageType": "string",
   "RevisionId": "string",
   "Role": "string",
   "Runtime": "string",
   "SigningJobArn": "string",
   "SigningProfileVersionArn": "string",
   "State": "string",
   "StateReason": "string",
   "StateReasonCode": "string",
   "Timeout": number,
   "TracingConfig": {
      "Mode": "string"
   },
   "Version": "string",
   "VpcConfig": {
      "SecurityGroupIds": [ "string" ],
      "SubnetIds": [ "string" ],
      "VpcId": "string"
   }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 201 response.

The following data is returned in JSON format by the service.

**Architectures (p. 1043)**

The instruction set architecture that the function supports. Architecture is a string array with one of the valid values. The default architecture value is `x86_64`.

Type: Array of strings

Array Members: Fixed number of 1 item.

Valid Values: `x86_64 | arm64`

**CodeSha256 (p. 1043)**

The SHA256 hash of the function's deployment package.

Type: String

**CodeSize (p. 1043)**

The size of the function's deployment package, in bytes.

Type: Long

**DeadLetterConfig (p. 1043)**

The function's dead letter queue.

Type: DeadLetterConfig (p. 1131) object

**Description (p. 1043)**

The function's description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

**Environment (p. 1043)**

The function's environment variables. Omitted from AWS CloudTrail logs.

Type: EnvironmentResponse (p. 1135) object

**EphemeralStorage (p. 1043)**

The size of the function's /tmp directory in MB. The default value is 512, but can be any whole number between 512 and 10240 MB.

Type: EphemeralStorage (p. 1136) object

**FileSystemConfigs (p. 1043)**

Connection settings for an Amazon EFS file system.

Type: Array of FileSystemConfig (p. 1142) objects

Array Members: Maximum number of 1 item.

**FunctionArn (p. 1043)**

The function's Amazon Resource Name (ARN).

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_\.]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**FunctionName (p. 1043)**

The name of the function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 170.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**Handler (p. 1043)**

The function that Lambda calls to begin executing your function.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

**ImageConfigResponse (p. 1043)**

The function's image configuration values.

Type: ImageConfigResponse (p. 1160) object

**KMSKeyArn (p. 1043)**

The AWS KMS key that's used to encrypt the function's environment variables. This key is only returned if you've configured a customer managed key.

Type: String

Pattern: `(arn:(aws[a-zA-Z-]*)?:[a-z0-9-.]+:.*)|()`

**LastModified (p. 1043)**

The date and time that the function was last updated, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

**LastUpdateStatus (p. 1043)**

The status of the last update that was performed on the function. This is first set to `Successful` after function creation completes.

Type: String

Valid Values: `Successful | Failed | InProgress`

**LastUpdateStatusReason (p. 1043)**

The reason for the last update that was performed on the function.

Type: String

**LastUpdateStatusReasonCode (p. 1043)**

The reason code for the last update that was performed on the function.

Type: String

Valid Values: `EniLimitExceeded | InsufficientRolePermissions | InvalidConfiguration | InternalError | SubnetOutOfIPAddresses | InvalidSubnet | InvalidSecurityGroup | ImageDeleted | ImageAccessDenied | InvalidImage`

**Layers (p. 1043)**

The function's layers.

Type: Array of Layer (p. 1161) objects

**MasterArn (p. 1043)**

For Lambda@Edge functions, the ARN of the main function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**MemorySize (p. 1043)**

The amount of memory available to the function at runtime.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 10240.

**PackageType (p. 1043)**

The type of deployment package. Set to `Image` for container image and set `Zip` for .zip file archive.

Type: String

Valid Values: `Zip | Image`

**RevisionId (p. 1043)**

The latest updated revision of the function or alias.

Type: String

**Role (p. 1043)**

The function's execution role.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@\-_/]+`

**Runtime (p. 1043)**

The runtime environment for the Lambda function.

Type: String

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

**SigningJobArn (p. 1043)**

The ARN of the signing job.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**SigningProfileVersionArn (p. 1043)**

The ARN of the signing profile version.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**State (p. 1043)**

The current state of the function. When the state is `Inactive`, you can reactivate the function by invoking it.

Type: String

Valid Values: `Pending | Active | Inactive | Failed`

**StateReason (p. 1043)**

The reason for the function's current state.

Type: String

**StateReasonCode (p. 1043)**

The reason code for the function's current state. When the code is `Creating`, you can't invoke or modify the function.

Type: String

Valid Values: `Idle | Creating | Restoring | EniLimitExceeded | InsufficientRolePermissions | InvalidConfiguration | InternalError | SubnetOutOfIPAddresses | InvalidSubnet | InvalidSecurityGroup | ImageDeleted | ImageAccessDenied | InvalidImage`

**Timeout (p. 1043)**

The amount of time in seconds that Lambda allows a function to run before stopping it.

Type: Integer

Valid Range: Minimum value of 1.

**TracingConfig (p. 1043)**

The function's AWS X-Ray tracing configuration.

Type: TracingConfigResponse (p. 1176) object

**Version (p. 1043)**

The version of the Lambda function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

**VpcConfig (p. 1043)**

The function's networking configuration.

Type: VpcConfigResponse (p. 1178) object

## Errors

**CodeStorageExceededException**

You have exceeded your maximum total code size per account. Learn more

HTTP Status Code: 400

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**PreconditionFailedException**

The RevisionId provided does not match the latest RevisionId for the Lambda function or alias. Call the `GetFunction` or the `GetAlias` API to retrieve the latest RevisionId for your resource.

HTTP Status Code: 412

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# PutFunctionCodeSigningConfig

Update the code signing configuration for the function. Changes to the code signing configuration take effect the next time a user tries to deploy a code package to the function.

## Request Syntax

```
PUT /2020-06-30/functions/FunctionName/code-signing-config HTTP/1.1
Content-type: application/json

{
   "CodeSigningConfigArn": "string"
}
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1050)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

## Request Body

The request accepts the following data in JSON format.

**CodeSigningConfigArn (p. 1050)**

The The Amazon Resource Name (ARN) of the code signing configuration.

Type: String

Length Constraints: Maximum length of 200.

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}((-gov)|(-iso(b?)))?-[a-z]+-\d{1}:\d{12}:code-signing-config:csc-[a-z0-9]{17}`

Required: Yes

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "CodeSigningConfigArn": "string",
   "FunctionName": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**CodeSigningConfigArn (p. 1051)**

The The Amazon Resource Name (ARN) of the code signing configuration.

Type: String

Length Constraints: Maximum length of 200.

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}((-gov)|(-iso(b?)))?-[a-z]+-\d{1}:\d{12}:code-signing-config:csc-[a-z0-9]{17}`

**FunctionName (p. 1051)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

## Errors

**CodeSigningConfigNotFoundException**

The specified code signing configuration does not exist.

HTTP Status Code: 404

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# PutFunctionConcurrency

Sets the maximum number of simultaneous executions for a function, and reserves capacity for that concurrency level.

Concurrency settings apply to the function as a whole, including all published versions and the unpublished version. Reserving concurrency both ensures that your function has capacity to process the specified number of events simultaneously, and prevents it from scaling beyond that level. Use GetFunction (p. 958) to see the current setting for a function.

Use GetAccountSettings (p. 945) to see your Regional concurrency limit. You can reserve concurrency for as many functions as you like, as long as you leave at least 100 simultaneous executions unreserved for functions that aren't configured with a per-function limit. For more information, see Managing Concurrency.

## Request Syntax

```
PUT /2017-10-31/functions/FunctionName/concurrency HTTP/1.1
Content-type: application/json

{
   "ReservedConcurrentExecutions": number
}
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1053)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

## Request Body

The request accepts the following data in JSON format.

**ReservedConcurrentExecutions (p. 1053)**

The number of simultaneous executions to reserve for the function.

Type: Integer

Valid Range: Minimum value of 0.

Required: Yes

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "ReservedConcurrentExecutions": number
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**ReservedConcurrentExecutions (p. 1054)**

The number of concurrent executions that are reserved for this function. For more information, see Managing Concurrency.

Type: Integer

Valid Range: Minimum value of 0.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# PutFunctionEventInvokeConfig

Configures options for asynchronous invocation on a function, version, or alias. If a configuration already exists for a function, version, or alias, this operation overwrites it. If you exclude any settings, they are removed. To set one option without affecting existing settings for other options, use UpdateFunctionEventInvokeConfig (p. 1109).

By default, Lambda retries an asynchronous invocation twice if the function returns an error. It retains events in a queue for up to six hours. When an event fails all processing attempts or stays in the asynchronous invocation queue for too long, Lambda discards it. To retain discarded events, configure a dead-letter queue with UpdateFunctionConfiguration (p. 1098).

To send an invocation record to a queue, topic, function, or event bus, specify a destination. You can configure separate destinations for successful invocations (on-success) and events that fail all processing attempts (on-failure). You can configure destinations in addition to or instead of a dead-letter queue.

## Request Syntax

```
PUT /2019-09-25/functions/FunctionName/event-invoke-config?Qualifier=Qualifier HTTP/1.1
Content-type: application/json

{
   "DestinationConfig": {
      "OnFailure": {
         "Destination": "string"
      },
      "OnSuccess": {
         "Destination": "string"
      }
   },
   "MaximumEventAgeInSeconds": number,
   "MaximumRetryAttempts": number
}
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1056)**

The name of the Lambda function, version, or alias.

**Name formats**

- **Function name** - `my-function` (name-only), `my-function:v1` (with alias).
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

You can append a version number or alias to any of the formats. The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 1056)**

A version number or alias name.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

## Request Body

The request accepts the following data in JSON format.

**DestinationConfig (p. 1056)**

A destination for events after they have been sent to a function for processing.

**Destinations**

- **Function** - The Amazon Resource Name (ARN) of a Lambda function.
- **Queue** - The ARN of an SQS queue.
- **Topic** - The ARN of an SNS topic.
- **Event Bus** - The ARN of an Amazon EventBridge event bus.

Type: DestinationConfig (p. 1132) object

Required: No

**MaximumEventAgeInSeconds (p. 1056)**

The maximum age of a request that Lambda sends to a function for processing.

Type: Integer

Valid Range: Minimum value of 60. Maximum value of 21600.

Required: No

**MaximumRetryAttempts (p. 1056)**

The maximum number of times to retry when the function returns an error.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 2.

Required: No

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "DestinationConfig": {
      "OnFailure": {
         "Destination": "string"
      },
      "OnSuccess": {
         "Destination": "string"
      }
```

```
   },
   "FunctionArn": "string",
   "LastModified": number,
   "MaximumEventAgeInSeconds": number,
   "MaximumRetryAttempts": number
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**DestinationConfig (p. 1057)**

A destination for events after they have been sent to a function for processing.

**Destinations**

- **Function** - The Amazon Resource Name (ARN) of a Lambda function.
- **Queue** - The ARN of an SQS queue.
- **Topic** - The ARN of an SNS topic.
- **Event Bus** - The ARN of an Amazon EventBridge event bus.

Type: DestinationConfig (p. 1132) object

**FunctionArn (p. 1057)**

The Amazon Resource Name (ARN) of the function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**LastModified (p. 1057)**

The date and time that the configuration was last updated, in Unix time seconds.

Type: Timestamp

**MaximumEventAgeInSeconds (p. 1057)**

The maximum age of a request that Lambda sends to a function for processing.

Type: Integer

Valid Range: Minimum value of 60. Maximum value of 21600.

**MaximumRetryAttempts (p. 1057)**

The maximum number of times to retry when the function returns an error.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 2.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# PutProvisionedConcurrencyConfig

Adds a provisioned concurrency configuration to a function's alias or version.

## Request Syntax

```
PUT /2019-09-30/functions/FunctionName/provisioned-concurrency?Qualifier=Qualifier HTTP/1.1
Content-type: application/json

{
   "ProvisionedConcurrentExecutions": number
}
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1060)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 1060)**

The version number or alias name.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

Required: Yes

## Request Body

The request accepts the following data in JSON format.

**ProvisionedConcurrentExecutions (p. 1060)**

The amount of provisioned concurrency to allocate for the version or alias.

Type: Integer

Valid Range: Minimum value of 1.

Required: Yes

## Response Syntax

```
HTTP/1.1 202
Content-type: application/json

{
   "AllocatedProvisionedConcurrentExecutions": number,
   "AvailableProvisionedConcurrentExecutions": number,
   "LastModified": "string",
   "RequestedProvisionedConcurrentExecutions": number,
   "Status": "string",
   "StatusReason": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 202 response.

The following data is returned in JSON format by the service.

**AllocatedProvisionedConcurrentExecutions (p. 1061)**

The amount of provisioned concurrency allocated. When a weighted alias is used during linear and canary deployments, this value fluctuates depending on the amount of concurrency that is provisioned for the function versions.

Type: Integer

Valid Range: Minimum value of 0.

**AvailableProvisionedConcurrentExecutions (p. 1061)**

The amount of provisioned concurrency available.

Type: Integer

Valid Range: Minimum value of 0.

**LastModified (p. 1061)**

The date and time that a user last updated the configuration, in ISO 8601 format.

Type: String

**RequestedProvisionedConcurrentExecutions (p. 1061)**

The amount of provisioned concurrency requested.

Type: Integer

Valid Range: Minimum value of 1.

**Status (p. 1061)**

The status of the allocation process.

Type: String

Valid Values: `IN_PROGRESS | READY | FAILED`

**StatusReason (p. 1061)**

For failed allocations, the reason that provisioned concurrency could not be allocated.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# RemoveLayerVersionPermission

Removes a statement from the permissions policy for a version of an AWS Lambda layer. For more information, see AddLayerVersionPermission (p. 877).

## Request Syntax

```
DELETE /2018-10-31/layers/LayerName/versions/VersionNumber/policy/StatementId?
RevisionId=RevisionId HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**LayerName (p. 1063)**

The name or Amazon Resource Name (ARN) of the layer.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+)|[a-zA-Z0-9-_]+`

Required: Yes

**RevisionId (p. 1063)**

Only update the policy if the revision ID matches the ID specified. Use this option to avoid modifying a policy that has changed since you last read it.

**StatementId (p. 1063)**

The identifier that was specified when the statement was added.

Length Constraints: Minimum length of 1. Maximum length of 100.

Pattern: `([a-zA-Z0-9-_]+)`

Required: Yes

**VersionNumber (p. 1063)**

The version number.

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 204
```

## Response Elements

If the action is successful, the service sends back an HTTP 204 response with an empty HTTP body.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**PreconditionFailedException**

The RevisionId provided does not match the latest RevisionId for the Lambda function or alias. Call the `GetFunction` or the `GetAlias` API to retrieve the latest RevisionId for your resource.

HTTP Status Code: 412

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# RemovePermission

Revokes function-use permission from an AWS service or another account. You can get the ID of the statement from the output of GetPolicy (p. 988).

## Request Syntax

```
DELETE /2015-03-31/functions/FunctionName/policy/StatementId?
Qualifier=Qualifier&RevisionId=RevisionId HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1065)**

The name of the Lambda function, version, or alias.

**Name formats**

- **Function name** - `my-function` (name-only), `my-function:v1` (with alias).
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

You can append a version number or alias to any of the formats. The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 1065)**

Specify a version or alias to remove permissions from a published version of the function.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

**RevisionId (p. 1065)**

Only update the policy if the revision ID matches the ID that's specified. Use this option to avoid modifying a policy that has changed since you last read it.

**StatementId (p. 1065)**

Statement ID of the permission to remove.

Length Constraints: Minimum length of 1. Maximum length of 100.

Pattern: `([a-zA-Z0-9-_.]+)`

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 204
```

## Response Elements

If the action is successful, the service sends back an HTTP 204 response with an empty HTTP body.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**PreconditionFailedException**

The RevisionId provided does not match the latest RevisionId for the Lambda function or alias. Call the `GetFunction` or the `GetAlias` API to retrieve the latest RevisionId for your resource.

HTTP Status Code: 412

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# TagResource

Adds tags to a function.

## Request Syntax

```
POST /2017-03-31/tags/ARN HTTP/1.1
Content-type: application/json

{
   "Tags": {
      "string" : "string"
   }
}
```

## URI Request Parameters

The request uses the following URI parameters.

**ARN (p. 1067)**

The function's Amazon Resource Name (ARN).

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

## Request Body

The request accepts the following data in JSON format.

**Tags (p. 1067)**

A list of tags to apply to the function.

Type: String to string map

Required: Yes

## Response Syntax

```
HTTP/1.1 204
```

## Response Elements

If the action is successful, the service sends back an HTTP 204 response with an empty HTTP body.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# UntagResource

Removes tags from a function.

## Request Syntax

```
DELETE /2017-03-31/tags/ARN?tagKeys=TagKeys HTTP/1.1
```

## URI Request Parameters

The request uses the following URI parameters.

**ARN (p. 1069)**

The function's Amazon Resource Name (ARN).

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**TagKeys (p. 1069)**

A list of tag keys to remove from the function.

Required: Yes

## Request Body

The request does not have a request body.

## Response Syntax

```
HTTP/1.1 204
```

## Response Elements

If the action is successful, the service sends back an HTTP 204 response with an empty HTTP body.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# UpdateAlias

Updates the configuration of a Lambda function alias.

## Request Syntax

```
PUT /2015-03-31/functions/FunctionName/aliases/Name HTTP/1.1
Content-type: application/json

{
   "Description": "string",
   "FunctionVersion": "string",
   "RevisionId": "string",
   "RoutingConfig": {
      "AdditionalVersionWeights": {
         "string" : number
      }
   }
}
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1071)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Name (p. 1071)**

The name of the alias.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(?!^[0-9]+$)([a-zA-Z0-9-_]+)`

Required: Yes

## Request Body

The request accepts the following data in JSON format.

**Description (p. 1071)**

A description of the alias.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

**FunctionVersion (p. 1071)**

The function version that the alias invokes.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

Required: No

**RevisionId (p. 1071)**

Only update the alias if the revision ID matches the ID that's specified. Use this option to avoid modifying an alias that has changed since you last read it.

Type: String

Required: No

**RoutingConfig (p. 1071)**

The routing configuration of the alias.

Type: AliasRoutingConfiguration (p. 1122) object

Required: No

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "AliasArn": "string",
   "Description": "string",
   "FunctionVersion": "string",
   "Name": "string",
   "RevisionId": "string",
   "RoutingConfig": {
      "AdditionalVersionWeights": {
         "string" : number
      }
   }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**AliasArn (p. 1072)**

The Amazon Resource Name (ARN) of the alias.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**Description (p. 1072)**

A description of the alias.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

**FunctionVersion (p. 1072)**

The function version that the alias invokes.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

**Name (p. 1072)**

The name of the alias.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(?!^[0-9]+$)([a-zA-Z0-9-_]+)`

**RevisionId (p. 1072)**

A unique identifier that changes when you update the alias.

Type: String

**RoutingConfig (p. 1072)**

The routing configuration of the alias.

Type: AliasRoutingConfiguration (p. 1122) object

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**PreconditionFailedException**

The RevisionId provided does not match the latest RevisionId for the Lambda function or alias. Call the `GetFunction` or the `GetAlias` API to retrieve the latest RevisionId for your resource.

HTTP Status Code: 412

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# UpdateCodeSigningConfig

Update the code signing configuration. Changes to the code signing configuration take effect the next time a user tries to deploy a code package to the function.

## Request Syntax

```
PUT /2020-04-22/code-signing-configs/CodeSigningConfigArn HTTP/1.1
Content-type: application/json

{
   "AllowedPublishers": {
      "SigningProfileVersionArns": [ "string" ]
   },
   "CodeSigningPolicies": {
      "UntrustedArtifactOnDeployment": "string"
   },
   "Description": "string"
}
```

## URI Request Parameters

The request uses the following URI parameters.

**CodeSigningConfigArn (p. 1075)**

The The Amazon Resource Name (ARN) of the code signing configuration.

Length Constraints: Maximum length of 200.

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}((-gov)|(-iso(b?)))?-[a-z]+-\d{1}:\d{12}:code-signing-config:csc-[a-z0-9]{17}`

Required: Yes

## Request Body

The request accepts the following data in JSON format.

**AllowedPublishers (p. 1075)**

Signing profiles for this code signing configuration.

Type: AllowedPublishers (p. 1123) object

Required: No

**CodeSigningPolicies (p. 1075)**

The code signing policy.

Type: CodeSigningPolicies (p. 1127) object

Required: No

**Description (p. 1075)**

Descriptive name for this code signing configuration.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "CodeSigningConfig": {
      "AllowedPublishers": {
         "SigningProfileVersionArns": [ "string" ]
      },
      "CodeSigningConfigArn": "string",
      "CodeSigningConfigId": "string",
      "CodeSigningPolicies": {
         "UntrustedArtifactOnDeployment": "string"
      },
      "Description": "string",
      "LastModified": "string"
   }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**CodeSigningConfig (p. 1076)**

The code signing configuration

Type: CodeSigningConfig (p. 1125) object

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# UpdateEventSourceMapping

Updates an event source mapping. You can change the function that AWS Lambda invokes, or pause invocation and resume later from the same location.

For details about how to configure different event sources, see the following topics.

- Amazon DynamoDB Streams
- Amazon Kinesis
- Amazon SQS
- Amazon MQ and RabbitMQ
- Amazon MSK
- Apache Kafka

The following error handling options are available only for stream sources (DynamoDB and Kinesis):

- `BisectBatchOnFunctionError` - If the function returns an error, split the batch in two and retry.
- `DestinationConfig` - Send discarded records to an Amazon SQS queue or Amazon SNS topic.
- `MaximumRecordAgeInSeconds` - Discard records older than the specified age. The default value is infinite (-1). When set to infinite (-1), failed records are retried until the record expires
- `MaximumRetryAttempts` - Discard records after the specified number of retries. The default value is infinite (-1). When set to infinite (-1), failed records are retried until the record expires.
- `ParallelizationFactor` - Process multiple batches from each shard concurrently.

For information about which configuration parameters apply to each event source, see the following topics.

- Amazon DynamoDB Streams
- Amazon Kinesis
- Amazon SQS
- Amazon MQ and RabbitMQ
- Amazon MSK
- Apache Kafka

## Request Syntax

```
PUT /2015-03-31/event-source-mappings/UUID HTTP/1.1
Content-type: application/json

{
   "BatchSize": number,
   "BisectBatchOnFunctionError": boolean,
   "DestinationConfig": {
      "OnFailure": {
         "Destination": "string"
      },
      "OnSuccess": {
         "Destination": "string"
      }
   },
   "Enabled": boolean,
   "FilterCriteria": {
      "Filters": [
```

```
            {
               "Pattern": "string"
            }
         ]
      },
      "FunctionName": "string",
      "FunctionResponseTypes": [ "string" ],
      "MaximumBatchingWindowInSeconds": number,
      "MaximumRecordAgeInSeconds": number,
      "MaximumRetryAttempts": number,
      "ParallelizationFactor": number,
      "SourceAccessConfigurations": [
         {
            "Type": "string",
            "URI": "string"
         }
      ],
      "TumblingWindowInSeconds": number
}
```

## URI Request Parameters

The request uses the following URI parameters.

**UUID (p. 1078)**

The identifier of the event source mapping.

Required: Yes

## Request Body

The request accepts the following data in JSON format.

**BatchSize (p. 1078)**

The maximum number of records in each batch that Lambda pulls from your stream or queue and sends to your function. Lambda passes all of the records in the batch to the function in a single call, up to the payload limit for synchronous invocation (6 MB).

- **Amazon Kinesis** - Default 100. Max 10,000.
- **Amazon DynamoDB Streams** - Default 100. Max 10,000.
- **Amazon Simple Queue Service** - Default 10. For standard queues the max is 10,000. For FIFO queues the max is 10.
- **Amazon Managed Streaming for Apache Kafka** - Default 100. Max 10,000.
- **Self-managed Apache Kafka** - Default 100. Max 10,000.
- **Amazon MQ (ActiveMQ and RabbitMQ)** - Default 100. Max 10,000.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

Required: No

**BisectBatchOnFunctionError (p. 1078)**

(Streams only) If the function returns an error, split the batch in two and retry.

Type: Boolean

Required: No

**DestinationConfig (p. 1078)**

(Streams only) An Amazon SQS queue or Amazon SNS topic destination for discarded records.

Type: DestinationConfig (p. 1132) object

Required: No

**Enabled (p. 1078)**

When true, the event source mapping is active. When false, Lambda pauses polling and invocation.

Default: True

Type: Boolean

Required: No

**FilterCriteria (p. 1078)**

(Streams and Amazon SQS) An object that defines the filter criteria that determine whether Lambda should process an event. For more information, see Lambda event filtering.

Type: FilterCriteria (p. 1144) object

Required: No

**FunctionName (p. 1078)**

The name of the Lambda function.

**Name formats**

- **Function name** - `MyFunction`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction`.
- **Version or Alias ARN** - `arn:aws:lambda:us-west-2:123456789012:function:MyFunction:PROD`.
- **Partial ARN** - `123456789012:function:MyFunction`.

The length constraint applies only to the full ARN. If you specify only the function name, it's limited to 64 characters in length.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: No

**FunctionResponseTypes (p. 1078)**

(Streams and Amazon SQS) A list of current response type enums applied to the event source mapping.

Type: Array of strings

Array Members: Minimum number of 0 items. Maximum number of 1 item.

Valid Values: `ReportBatchItemFailures`

Required: No

**MaximumBatchingWindowInSeconds (p. 1078)**

The maximum amount of time, in seconds, that Lambda spends gathering records before invoking the function. You can configure `MaximumBatchingWindowInSeconds` to any value from 0 seconds to 300 seconds in increments of seconds.

For streams and Amazon SQS event sources, the default batching window is 0 seconds. For Amazon MSK, Self-managed Apache Kafka, and Amazon MQ event sources, the default batching window is 500 ms. Note that because you can only change `MaximumBatchingWindowInSeconds` in increments of seconds, you cannot revert back to the 500 ms default batching window after you have changed it. To restore the default batching window, you must create a new event source mapping.

Related setting: For streams and Amazon SQS event sources, when you set `BatchSize` to a value greater than 10, you must set `MaximumBatchingWindowInSeconds` to at least 1.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 300.

Required: No

**MaximumRecordAgeInSeconds (p. 1078)**

(Streams only) Discard records older than the specified age. The default value is infinite (-1).

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 604800.

Required: No

**MaximumRetryAttempts (p. 1078)**

(Streams only) Discard records after the specified number of retries. The default value is infinite (-1). When set to infinite (-1), failed records are retried until the record expires.

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 10000.

Required: No

**ParallelizationFactor (p. 1078)**

(Streams only) The number of batches to process from each shard concurrently.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10.

Required: No

**SourceAccessConfigurations (p. 1078)**

An array of authentication protocols or VPC components required to secure your event source.

Type: Array of SourceAccessConfiguration (p. 1173) objects

Array Members: Minimum number of 0 items. Maximum number of 22 items.

Required: No

**TumblingWindowInSeconds (p. 1078)**

(Streams only) The duration in seconds of a processing window. The range is between 1 second and 900 seconds.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 900.

Required: No

## Response Syntax

```
HTTP/1.1 202
Content-type: application/json

{
   "AmazonManagedKafkaEventSourceConfig": {
      "ConsumerGroupId": "string"
   },
   "BatchSize": number,
   "BisectBatchOnFunctionError": boolean,
   "DestinationConfig": {
      "OnFailure": {
         "Destination": "string"
      },
      "OnSuccess": {
         "Destination": "string"
      }
   },
   "EventSourceArn": "string",
   "FilterCriteria": {
      "Filters": [
         {
            "Pattern": "string"
         }
      ]
   },
   "FunctionArn": "string",
   "FunctionResponseTypes": [ "string" ],
   "LastModified": number,
   "LastProcessingResult": "string",
   "MaximumBatchingWindowInSeconds": number,
   "MaximumRecordAgeInSeconds": number,
   "MaximumRetryAttempts": number,
   "ParallelizationFactor": number,
   "Queues": [ "string" ],
   "SelfManagedEventSource": {
      "Endpoints": {
         "string" : [ "string" ]
      }
   },
   "SelfManagedKafkaEventSourceConfig": {
      "ConsumerGroupId": "string"
   },
   "SourceAccessConfigurations": [
      {
         "Type": "string",
         "URI": "string"
      }
   ],
   "StartingPosition": "string",
   "StartingPositionTimestamp": number,
```

```
   "State": "string",
   "StateTransitionReason": "string",
   "Topics": [ "string" ],
   "TumblingWindowInSeconds": number,
   "UUID": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 202 response.

The following data is returned in JSON format by the service.

**AmazonManagedKafkaEventSourceConfig (p. 1082)**

Specific configuration settings for an Amazon Managed Streaming for Apache Kafka (Amazon MSK) event source.

Type: AmazonManagedKafkaEventSourceConfig (p. 1124) object

**BatchSize (p. 1082)**

The maximum number of records in each batch that Lambda pulls from your stream or queue and sends to your function. Lambda passes all of the records in the batch to the function in a single call, up to the payload limit for synchronous invocation (6 MB).

Default value: Varies by service. For Amazon SQS, the default is 10. For all other services, the default is 100.

Related setting: When you set `BatchSize` to a value greater than 10, you must set `MaximumBatchingWindowInSeconds` to at least 1.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

**BisectBatchOnFunctionError (p. 1082)**

(Streams only) If the function returns an error, split the batch in two and retry. The default value is false.

Type: Boolean

**DestinationConfig (p. 1082)**

(Streams only) An Amazon SQS queue or Amazon SNS topic destination for discarded records.

Type: DestinationConfig (p. 1132) object

**EventSourceArn (p. 1082)**

The Amazon Resource Name (ARN) of the event source.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**FilterCriteria (p. 1082)**

(Streams and Amazon SQS) An object that defines the filter criteria that determine whether Lambda should process an event. For more information, see Lambda event filtering.

Type: FilterCriteria (p. 1144) object

**FunctionArn (p. 1082)**

The ARN of the Lambda function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**FunctionResponseTypes (p. 1082)**

(Streams and Amazon SQS) A list of current response type enums applied to the event source mapping.

Type: Array of strings

Array Members: Minimum number of 0 items. Maximum number of 1 item.

Valid Values: `ReportBatchItemFailures`

**LastModified (p. 1082)**

The date that the event source mapping was last updated or that its state changed, in Unix time seconds.

Type: Timestamp

**LastProcessingResult (p. 1082)**

The result of the last Lambda invocation of your function.

Type: String

**MaximumBatchingWindowInSeconds (p. 1082)**

The maximum amount of time, in seconds, that Lambda spends gathering records before invoking the function. You can configure `MaximumBatchingWindowInSeconds` to any value from 0 seconds to 300 seconds in increments of seconds.

For streams and Amazon SQS event sources, the default batching window is 0 seconds. For Amazon MSK, Self-managed Apache Kafka, and Amazon MQ event sources, the default batching window is 500 ms. Note that because you can only change `MaximumBatchingWindowInSeconds` in increments of seconds, you cannot revert back to the 500 ms default batching window after you have changed it. To restore the default batching window, you must create a new event source mapping.

Related setting: For streams and Amazon SQS event sources, when you set `BatchSize` to a value greater than 10, you must set `MaximumBatchingWindowInSeconds` to at least 1.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 300.

**MaximumRecordAgeInSeconds (p. 1082)**

(Streams only) Discard records older than the specified age. The default value is -1, which sets the maximum age to infinite. When the value is set to infinite, Lambda never discards old records.

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 604800.

**MaximumRetryAttempts (p. 1082)**

(Streams only) Discard records after the specified number of retries. The default value is -1, which sets the maximum number of retries to infinite. When MaximumRetryAttempts is infinite, Lambda retries failed records until the record expires in the event source.

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 10000.

**ParallelizationFactor (p. 1082)**

(Streams only) The number of batches to process concurrently from each shard. The default value is 1.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10.

**Queues (p. 1082)**

(Amazon MQ) The name of the Amazon MQ broker destination queue to consume.

Type: Array of strings

Array Members: Fixed number of 1 item.

Length Constraints: Minimum length of 1. Maximum length of 1000.

Pattern: `[\s\S]*`

**SelfManagedEventSource (p. 1082)**

The self-managed Apache Kafka cluster for your event source.

Type: SelfManagedEventSource (p. 1171) object

**SelfManagedKafkaEventSourceConfig (p. 1082)**

Specific configuration settings for a self-managed Apache Kafka event source.

Type: SelfManagedKafkaEventSourceConfig (p. 1172) object

**SourceAccessConfigurations (p. 1082)**

An array of the authentication protocol, VPC components, or virtual host to secure and define your event source.

Type: Array of SourceAccessConfiguration (p. 1173) objects

Array Members: Minimum number of 0 items. Maximum number of 22 items.

**StartingPosition (p. 1082)**

The position in a stream from which to start reading. Required for Amazon Kinesis, Amazon DynamoDB, and Amazon MSK stream sources. `AT_TIMESTAMP` is supported only for Amazon Kinesis streams.

Type: String

Valid Values: `TRIM_HORIZON | LATEST | AT_TIMESTAMP`

**StartingPositionTimestamp (p. 1082)**

With `StartingPosition` set to `AT_TIMESTAMP`, the time from which to start reading, in Unix time seconds.

Type: Timestamp

**State (p. 1082)**

The state of the event source mapping. It can be one of the following: `Creating`, `Enabling`, `Enabled`, `Disabling`, `Disabled`, `Updating`, or `Deleting`.

Type: String

**StateTransitionReason (p. 1082)**

Indicates whether a user or Lambda made the last change to the event source mapping.

Type: String

**Topics (p. 1082)**

The name of the Kafka topic.

Type: Array of strings

Array Members: Fixed number of 1 item.

Length Constraints: Minimum length of 1. Maximum length of 249.

Pattern: `^[^.]([a-zA-Z0-9\-_.]+)`

**TumblingWindowInSeconds (p. 1082)**

(Streams only) The duration in seconds of a processing window. The range is 1–900 seconds.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 900.

**UUID (p. 1082)**

The identifier of the event source mapping.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceInUseException**

The operation conflicts with the resource's availability. For example, you attempted to update an EventSource Mapping in CREATING, or tried to delete a EventSource mapping currently in the UPDATING state.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# UpdateFunctionCode

Updates a Lambda function's code. If code signing is enabled for the function, the code package must be signed by a trusted publisher. For more information, see Configuring code signing.

If the function's package type is `Image`, you must specify the code package in `ImageUri` as the URI of a container image in the Amazon ECR registry.

If the function's package type is `Zip`, you must specify the deployment package as a .zip file archive. Enter the Amazon S3 bucket and key of the code .zip file location. You can also provide the function code inline using the `ZipFile` field.

The code in the deployment package must be compatible with the target instruction set architecture of the function (`x86-64` or `arm64`).

The function's code is locked when you publish a version. You can't modify the code of a published version, only the unpublished version.

> **Note**
> For a function defined as a container image, Lambda resolves the image tag to an image digest. In Amazon ECR, if you update the image tag to a new image, Lambda does not automatically update the function.

## Request Syntax

```
PUT /2015-03-31/functions/FunctionName/code HTTP/1.1
Content-type: application/json

{
   "Architectures": [ "string" ],
   "DryRun": boolean,
   "ImageUri": "string",
   "Publish": boolean,
   "RevisionId": "string",
   "S3Bucket": "string",
   "S3Key": "string",
   "S3ObjectVersion": "string",
   "ZipFile": blob
}
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1088)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

## Request Body

The request accepts the following data in JSON format.

**Architectures (p. 1088)**

The instruction set architecture that the function supports. Enter a string array with one of the valid values (arm64 or x86_64). The default value is `x86_64`.

Type: Array of strings

Array Members: Fixed number of 1 item.

Valid Values: `x86_64 | arm64`

Required: No

**DryRun (p. 1088)**

Set to true to validate the request parameters and access permissions without modifying the function code.

Type: Boolean

Required: No

**ImageUri (p. 1088)**

URI of a container image in the Amazon ECR registry. Do not use for a function defined with a .zip file archive.

Type: String

Required: No

**Publish (p. 1088)**

Set to true to publish a new version of the function after updating the code. This has the same effect as calling PublishVersion (p. 1042) separately.

Type: Boolean

Required: No

**RevisionId (p. 1088)**

Only update the function if the revision ID matches the ID that's specified. Use this option to avoid modifying a function that has changed since you last read it.

Type: String

Required: No

**S3Bucket (p. 1088)**

An Amazon S3 bucket in the same AWS Region as your function. The bucket can be in a different AWS account. Use only with a function defined with a .zip file archive deployment package.

Type: String

Length Constraints: Minimum length of 3. Maximum length of 63.

Pattern: `^[0-9A-Za-z\.\-_]*(?<!\.)$`

Required: No

**S3Key (p. 1088)**

The Amazon S3 key of the deployment package. Use only with a function defined with a .zip file archive deployment package.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Required: No

**S3ObjectVersion (p. 1088)**

For versioned objects, the version of the deployment package object to use.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Required: No

**ZipFile (p. 1088)**

The base64-encoded contents of the deployment package. AWS SDK and AWS CLI clients handle the encoding for you. Use only with a function defined with a .zip file archive deployment package.

Type: Base64-encoded binary data object

Required: No

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "Architectures": [ "string" ],
   "CodeSha256": "string",
   "CodeSize": number,
   "DeadLetterConfig": {
      "TargetArn": "string"
   },
   "Description": "string",
   "Environment": {
      "Error": {
         "ErrorCode": "string",
         "Message": "string"
      },
      "Variables": {
         "string" : "string"
      }
   },
   "EphemeralStorage": {
      "Size": number
   },
   "FileSystemConfigs": [
      {
```

```
            "Arn": "string",
            "LocalMountPath": "string"
         }
      ],
      "FunctionArn": "string",
      "FunctionName": "string",
      "Handler": "string",
      "ImageConfigResponse": {
         "Error": {
            "ErrorCode": "string",
            "Message": "string"
         },
         "ImageConfig": {
            "Command": [ "string" ],
            "EntryPoint": [ "string" ],
            "WorkingDirectory": "string"
         }
      },
      "KMSKeyArn": "string",
      "LastModified": "string",
      "LastUpdateStatus": "string",
      "LastUpdateStatusReason": "string",
      "LastUpdateStatusReasonCode": "string",
      "Layers": [
         {
            "Arn": "string",
            "CodeSize": number,
            "SigningJobArn": "string",
            "SigningProfileVersionArn": "string"
         }
      ],
      "MasterArn": "string",
      "MemorySize": number,
      "PackageType": "string",
      "RevisionId": "string",
      "Role": "string",
      "Runtime": "string",
      "SigningJobArn": "string",
      "SigningProfileVersionArn": "string",
      "State": "string",
      "StateReason": "string",
      "StateReasonCode": "string",
      "Timeout": number,
      "TracingConfig": {
         "Mode": "string"
      },
      "Version": "string",
      "VpcConfig": {
         "SecurityGroupIds": [ "string" ],
         "SubnetIds": [ "string" ],
         "VpcId": "string"
      }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**Architectures (p. 1090)**

The instruction set architecture that the function supports. Architecture is a string array with one of the valid values. The default architecture value is `x86_64`.

Type: Array of strings

Array Members: Fixed number of 1 item.

Valid Values: `x86_64 | arm64`

**CodeSha256 (p. 1090)**

The SHA256 hash of the function's deployment package.

Type: String

**CodeSize (p. 1090)**

The size of the function's deployment package, in bytes.

Type: Long

**DeadLetterConfig (p. 1090)**

The function's dead letter queue.

Type: DeadLetterConfig (p. 1131) object

**Description (p. 1090)**

The function's description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

**Environment (p. 1090)**

The function's environment variables. Omitted from AWS CloudTrail logs.

Type: EnvironmentResponse (p. 1135) object

**EphemeralStorage (p. 1090)**

The size of the function's /tmp directory in MB. The default value is 512, but can be any whole number between 512 and 10240 MB.

Type: EphemeralStorage (p. 1136) object

**FileSystemConfigs (p. 1090)**

Connection settings for an Amazon EFS file system.

Type: Array of FileSystemConfig (p. 1142) objects

Array Members: Maximum number of 1 item.

**FunctionArn (p. 1090)**

The function's Amazon Resource Name (ARN).

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_\.]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**FunctionName (p. 1090)**

The name of the function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 170.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**Handler (p. 1090)**

The function that Lambda calls to begin executing your function.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

**ImageConfigResponse (p. 1090)**

The function's image configuration values.

Type: ImageConfigResponse (p. 1160) object

**KMSKeyArn (p. 1090)**

The AWS KMS key that's used to encrypt the function's environment variables. This key is only returned if you've configured a customer managed key.

Type: String

Pattern: `(arn:(aws[a-zA-Z-]*)?:[a-z0-9-.]+:.*)|()`

**LastModified (p. 1090)**

The date and time that the function was last updated, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

**LastUpdateStatus (p. 1090)**

The status of the last update that was performed on the function. This is first set to `Successful` after function creation completes.

Type: String

Valid Values: `Successful | Failed | InProgress`

**LastUpdateStatusReason (p. 1090)**

The reason for the last update that was performed on the function.

Type: String

**LastUpdateStatusReasonCode (p. 1090)**

The reason code for the last update that was performed on the function.

Type: String

Valid Values: `EniLimitExceeded | InsufficientRolePermissions | InvalidConfiguration | InternalError | SubnetOutOfIPAddresses | InvalidSubnet | InvalidSecurityGroup | ImageDeleted | ImageAccessDenied | InvalidImage`

**Layers (p. 1090)**

The function's layers.

Type: Array of Layer (p. 1161) objects

**MasterArn (p. 1090)**

For Lambda@Edge functions, the ARN of the main function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**MemorySize (p. 1090)**

The amount of memory available to the function at runtime.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 10240.

**PackageType (p. 1090)**

The type of deployment package. Set to `Image` for container image and set `Zip` for .zip file archive.

Type: String

Valid Values: `Zip | Image`

**RevisionId (p. 1090)**

The latest updated revision of the function or alias.

Type: String

**Role (p. 1090)**

The function's execution role.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@\-_/]+`

**Runtime (p. 1090)**

The runtime environment for the Lambda function.

Type: String

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

**SigningJobArn (p. 1090)**

The ARN of the signing job.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**SigningProfileVersionArn (p. 1090)**

The ARN of the signing profile version.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**State (p. 1090)**

The current state of the function. When the state is `Inactive`, you can reactivate the function by invoking it.

Type: String

Valid Values: `Pending | Active | Inactive | Failed`

**StateReason (p. 1090)**

The reason for the function's current state.

Type: String

**StateReasonCode (p. 1090)**

The reason code for the function's current state. When the code is `Creating`, you can't invoke or modify the function.

Type: String

Valid Values: `Idle | Creating | Restoring | EniLimitExceeded | InsufficientRolePermissions | InvalidConfiguration | InternalError | SubnetOutOfIPAddresses | InvalidSubnet | InvalidSecurityGroup | ImageDeleted | ImageAccessDenied | InvalidImage`

**Timeout (p. 1090)**

The amount of time in seconds that Lambda allows a function to run before stopping it.

Type: Integer

Valid Range: Minimum value of 1.

**TracingConfig (p. 1090)**

The function's AWS X-Ray tracing configuration.

Type: TracingConfigResponse (p. 1176) object

**Version (p. 1090)**

The version of the Lambda function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

**VpcConfig (p. 1090)**

The function's networking configuration.

Type: VpcConfigResponse (p. 1178) object

## Errors

**CodeSigningConfigNotFoundException**

The specified code signing configuration does not exist.

HTTP Status Code: 404

**CodeStorageExceededException**

You have exceeded your maximum total code size per account. Learn more

HTTP Status Code: 400

**CodeVerificationFailedException**

The code signature failed one or more of the validation checks for signature mismatch or expiry, and the code signing policy is set to ENFORCE. Lambda blocks the deployment.

HTTP Status Code: 400

**InvalidCodeSignatureException**

The code signature failed the integrity check. Lambda always blocks deployment if the integrity check fails, even if code signing policy is set to WARN.

HTTP Status Code: 400

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**PreconditionFailedException**

The RevisionId provided does not match the latest RevisionId for the Lambda function or alias. Call the `GetFunction` or the `GetAlias` API to retrieve the latest RevisionId for your resource.

HTTP Status Code: 412

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++

- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# UpdateFunctionConfiguration

Modify the version-specific settings of a Lambda function.

When you update a function, Lambda provisions an instance of the function and its supporting resources. If your function connects to a VPC, this process can take a minute. During this time, you can't modify the function, but you can still invoke it. The `LastUpdateStatus`, `LastUpdateStatusReason`, and `LastUpdateStatusReasonCode` fields in the response from GetFunctionConfiguration (p. 967) indicate when the update is complete and the function is processing events with the new configuration. For more information, see Function States.

These settings can vary between versions of a function and are locked when you publish a version. You can't modify the configuration of a published version, only the unpublished version.

To configure function concurrency, use PutFunctionConcurrency (p. 1053). To grant invoke permissions to an account or AWS service, use AddPermission (p. 881).

## Request Syntax

```
PUT /2015-03-31/functions/FunctionName/configuration HTTP/1.1
Content-type: application/json

{
   "DeadLetterConfig": {
      "TargetArn": "string"
   },
   "Description": "string",
   "Environment": {
      "Variables": {
         "string" : "string"
      }
   },
   "EphemeralStorage": {
      "Size": number
   },
   "FileSystemConfigs": [
      {
         "Arn": "string",
         "LocalMountPath": "string"
      }
   ],
   "Handler": "string",
   "ImageConfig": {
      "Command": [ "string" ],
      "EntryPoint": [ "string" ],
      "WorkingDirectory": "string"
   },
   "KMSKeyArn": "string",
   "Layers": [ "string" ],
   "MemorySize": number,
   "RevisionId": "string",
   "Role": "string",
   "Runtime": "string",
   "Timeout": number,
   "TracingConfig": {
      "Mode": "string"
   },
   "VpcConfig": {
      "SecurityGroupIds": [ "string" ],
      "SubnetIds": [ "string" ]
   }
}
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1098)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

## Request Body

The request accepts the following data in JSON format.

**DeadLetterConfig (p. 1098)**

A dead letter queue configuration that specifies the queue or topic where Lambda sends asynchronous events when they fail processing. For more information, see Dead Letter Queues.

Type: DeadLetterConfig (p. 1131) object

Required: No

**Description (p. 1098)**

A description of the function.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

**Environment (p. 1098)**

Environment variables that are accessible from function code during execution.

Type: Environment (p. 1133) object

Required: No

**EphemeralStorage (p. 1098)**

The size of the function's /tmp directory in MB. The default value is 512, but can be any whole number between 512 and 10240 MB.

Type: EphemeralStorage (p. 1136) object

Required: No

**FileSystemConfigs (p. 1098)**

Connection settings for an Amazon EFS file system.

Type: Array of FileSystemConfig (p. 1142) objects

Array Members: Maximum number of 1 item.

Required: No

**Handler (p. 1098)**

The name of the method within your code that Lambda calls to execute your function. Handler is required if the deployment package is a .zip file archive. The format includes the file name. It can also include namespaces and other qualifiers, depending on the runtime. For more information, see Programming Model.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

Required: No

**ImageConfig (p. 1098)**

Container image configuration values that override the values in the container image Docker file.

Type: ImageConfig (p. 1158) object

Required: No

**KMSKeyArn (p. 1098)**

The ARN of the AWS Key Management Service (AWS KMS) key that's used to encrypt your function's environment variables. If it's not provided, AWS Lambda uses a default service key.

Type: String

Pattern: `(arn:(aws[a-zA-Z-]*)?:[a-z0-9-.]+:.*)|()`

Required: No

**Layers (p. 1098)**

A list of function layers to add to the function's execution environment. Specify each layer by its ARN, including the version.

Type: Array of strings

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+:[0-9]+`

Required: No

**MemorySize (p. 1098)**

The amount of memory available to the function at runtime. Increasing the function memory also increases its CPU allocation. The default value is 128 MB. The value can be any multiple of 1 MB.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 10240.

Required: No

**RevisionId (p. 1098)**

Only update the function if the revision ID matches the ID that's specified. Use this option to avoid modifying a function that has changed since you last read it.

Type: String

Required: No

**Role (p. 1098)**

The Amazon Resource Name (ARN) of the function's execution role.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@\-_/]+`

Required: No

**Runtime (p. 1098)**

The identifier of the function's runtime. Runtime is required if the deployment package is a .zip file archive.

Type: String

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

Required: No

**Timeout (p. 1098)**

The amount of time (in seconds) that Lambda allows a function to run before stopping it. The default is 3 seconds. The maximum allowed value is 900 seconds. For additional information, see Lambda execution environment.

Type: Integer

Valid Range: Minimum value of 1.

Required: No

**TracingConfig (p. 1098)**

Set `Mode` to `Active` to sample and trace a subset of incoming requests with X-Ray.

Type: TracingConfig (p. 1175) object

Required: No

**VpcConfig (p. 1098)**

For network connectivity to AWS resources in a VPC, specify a list of security groups and subnets in the VPC. When you connect a function to a VPC, it can only access resources and the internet through that VPC. For more information, see VPC Settings.

Type: VpcConfig (p. 1177) object

Required: No

# Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "Architectures": [ "string" ],
   "CodeSha256": "string",
   "CodeSize": number,
   "DeadLetterConfig": {
      "TargetArn": "string"
   },
   "Description": "string",
   "Environment": {
      "Error": {
         "ErrorCode": "string",
         "Message": "string"
      },
      "Variables": {
         "string" : "string"
      }
   },
   "EphemeralStorage": {
      "Size": number
   },
   "FileSystemConfigs": [
      {
         "Arn": "string",
         "LocalMountPath": "string"
      }
   ],
   "FunctionArn": "string",
   "FunctionName": "string",
   "Handler": "string",
   "ImageConfigResponse": {
      "Error": {
         "ErrorCode": "string",
         "Message": "string"
      },
      "ImageConfig": {
         "Command": [ "string" ],
         "EntryPoint": [ "string" ],
         "WorkingDirectory": "string"
      }
   },
   "KMSKeyArn": "string",
   "LastModified": "string",
   "LastUpdateStatus": "string",
   "LastUpdateStatusReason": "string",
   "LastUpdateStatusReasonCode": "string",
   "Layers": [
      {
         "Arn": "string",
```

```
         "CodeSize": number,
         "SigningJobArn": "string",
         "SigningProfileVersionArn": "string"
      }
   ],
   "MasterArn": "string",
   "MemorySize": number,
   "PackageType": "string",
   "RevisionId": "string",
   "Role": "string",
   "Runtime": "string",
   "SigningJobArn": "string",
   "SigningProfileVersionArn": "string",
   "State": "string",
   "StateReason": "string",
   "StateReasonCode": "string",
   "Timeout": number,
   "TracingConfig": {
      "Mode": "string"
   },
   "Version": "string",
   "VpcConfig": {
      "SecurityGroupIds": [ "string" ],
      "SubnetIds": [ "string" ],
      "VpcId": "string"
   }
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**Architectures (p. 1102)**

The instruction set architecture that the function supports. Architecture is a string array with one of the valid values. The default architecture value is `x86_64`.

Type: Array of strings

Array Members: Fixed number of 1 item.

Valid Values: `x86_64 | arm64`

**CodeSha256 (p. 1102)**

The SHA256 hash of the function's deployment package.

Type: String

**CodeSize (p. 1102)**

The size of the function's deployment package, in bytes.

Type: Long

**DeadLetterConfig (p. 1102)**

The function's dead letter queue.

Type: DeadLetterConfig (p. 1131) object

**Description (p. 1102)**

The function's description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

**Environment (p. 1102)**

The function's environment variables. Omitted from AWS CloudTrail logs.

Type: EnvironmentResponse (p. 1135) object

**EphemeralStorage (p. 1102)**

The size of the function's /tmp directory in MB. The default value is 512, but can be any whole number between 512 and 10240 MB.

Type: EphemeralStorage (p. 1136) object

**FileSystemConfigs (p. 1102)**

Connection settings for an Amazon EFS file system.

Type: Array of FileSystemConfig (p. 1142) objects

Array Members: Maximum number of 1 item.

**FunctionArn (p. 1102)**

The function's Amazon Resource Name (ARN).

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_\.]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**FunctionName (p. 1102)**

The name of the function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 170.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**Handler (p. 1102)**

The function that Lambda calls to begin executing your function.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

**ImageConfigResponse (p. 1102)**

The function's image configuration values.

Type: ImageConfigResponse (p. 1160) object

**KMSKeyArn (p. 1102)**

The AWS KMS key that's used to encrypt the function's environment variables. This key is only returned if you've configured a customer managed key.

Type: String

Pattern: `(arn:(aws[a-zA-Z-]*)?:[a-z0-9-.]+:.*)|()`

**LastModified (p. 1102)**

The date and time that the function was last updated, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

**LastUpdateStatus (p. 1102)**

The status of the last update that was performed on the function. This is first set to `Successful` after function creation completes.

Type: String

Valid Values: `Successful | Failed | InProgress`

**LastUpdateStatusReason (p. 1102)**

The reason for the last update that was performed on the function.

Type: String

**LastUpdateStatusReasonCode (p. 1102)**

The reason code for the last update that was performed on the function.

Type: String

Valid Values: `EniLimitExceeded | InsufficientRolePermissions | InvalidConfiguration | InternalError | SubnetOutOfIPAddresses | InvalidSubnet | InvalidSecurityGroup | ImageDeleted | ImageAccessDenied | InvalidImage`

**Layers (p. 1102)**

The function's layers.

Type: Array of Layer (p. 1161) objects

**MasterArn (p. 1102)**

For Lambda@Edge functions, the ARN of the main function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**MemorySize (p. 1102)**

The amount of memory available to the function at runtime.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 10240.

**PackageType (p. 1102)**

The type of deployment package. Set to `Image` for container image and set `Zip` for .zip file archive.

Type: String

Valid Values: `Zip | Image`

**RevisionId (p. 1102)**

The latest updated revision of the function or alias.

Type: String

**Role (p. 1102)**

The function's execution role.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@\-_/]+`

**Runtime (p. 1102)**

The runtime environment for the Lambda function.

Type: String

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

**SigningJobArn (p. 1102)**

The ARN of the signing job.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**SigningProfileVersionArn (p. 1102)**

The ARN of the signing profile version.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

**State (p. 1102)**

The current state of the function. When the state is `Inactive`, you can reactivate the function by invoking it.

Type: String

Valid Values: `Pending | Active | Inactive | Failed`

**StateReason (p. 1102)**

The reason for the function's current state.

Type: String

**StateReasonCode (p. 1102)**

The reason code for the function's current state. When the code is `Creating`, you can't invoke or modify the function.

Type: String

Valid Values: `Idle | Creating | Restoring | EniLimitExceeded | InsufficientRolePermissions | InvalidConfiguration | InternalError | SubnetOutOfIPAddresses | InvalidSubnet | InvalidSecurityGroup | ImageDeleted | ImageAccessDenied | InvalidImage`

**Timeout (p. 1102)**

The amount of time in seconds that Lambda allows a function to run before stopping it.

Type: Integer

Valid Range: Minimum value of 1.

**TracingConfig (p. 1102)**

The function's AWS X-Ray tracing configuration.

Type: TracingConfigResponse (p. 1176) object

**Version (p. 1102)**

The version of the Lambda function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

**VpcConfig (p. 1102)**

The function's networking configuration.

Type: VpcConfigResponse (p. 1178) object

## Errors

**CodeSigningConfigNotFoundException**

The specified code signing configuration does not exist.

HTTP Status Code: 404

**CodeVerificationFailedException**

The code signature failed one or more of the validation checks for signature mismatch or expiry, and the code signing policy is set to ENFORCE. Lambda blocks the deployment.

HTTP Status Code: 400

**InvalidCodeSignatureException**

The code signature failed the integrity check. Lambda always blocks deployment if the integrity check fails, even if code signing policy is set to WARN.

HTTP Status Code: 400

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**PreconditionFailedException**

The RevisionId provided does not match the latest RevisionId for the Lambda function or alias. Call the `GetFunction` or the `GetAlias` API to retrieve the latest RevisionId for your resource.

HTTP Status Code: 412

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# UpdateFunctionEventInvokeConfig

Updates the configuration for asynchronous invocation for a function, version, or alias.

To configure options for asynchronous invocation, use PutFunctionEventInvokeConfig (p. 1056).

## Request Syntax

```
POST /2019-09-25/functions/FunctionName/event-invoke-config?Qualifier=Qualifier HTTP/1.1
Content-type: application/json

{
   "DestinationConfig": {
      "OnFailure": {
         "Destination": "string"
      },
      "OnSuccess": {
         "Destination": "string"
      }
   },
   "MaximumEventAgeInSeconds": number,
   "MaximumRetryAttempts": number
}
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1109)**

The name of the Lambda function, version, or alias.

**Name formats**

- **Function name** - `my-function` (name-only), `my-function:v1` (with alias).
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

You can append a version number or alias to any of the formats. The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 1109)**

A version number or alias name.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(|[a-zA-Z0-9$_-]+)`

## Request Body

The request accepts the following data in JSON format.

**DestinationConfig (p. 1109)**

A destination for events after they have been sent to a function for processing.

**Destinations**

- **Function** - The Amazon Resource Name (ARN) of a Lambda function.
- **Queue** - The ARN of an SQS queue.
- **Topic** - The ARN of an SNS topic.
- **Event Bus** - The ARN of an Amazon EventBridge event bus.

Type: DestinationConfig (p. 1132) object

Required: No

**MaximumEventAgeInSeconds (p. 1109)**

The maximum age of a request that Lambda sends to a function for processing.

Type: Integer

Valid Range: Minimum value of 60. Maximum value of 21600.

Required: No

**MaximumRetryAttempts (p. 1109)**

The maximum number of times to retry when the function returns an error.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 2.

Required: No

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "DestinationConfig": {
      "OnFailure": {
         "Destination": "string"
      },
      "OnSuccess": {
         "Destination": "string"
      }
   },
   "FunctionArn": "string",
   "LastModified": number,
   "MaximumEventAgeInSeconds": number,
   "MaximumRetryAttempts": number
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**DestinationConfig (p. 1110)**

A destination for events after they have been sent to a function for processing.

**Destinations**

- **Function** - The Amazon Resource Name (ARN) of a Lambda function.
- **Queue** - The ARN of an SQS queue.
- **Topic** - The ARN of an SNS topic.
- **Event Bus** - The ARN of an Amazon EventBridge event bus.

Type: DestinationConfig (p. 1132) object

**FunctionArn (p. 1110)**

The Amazon Resource Name (ARN) of the function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**LastModified (p. 1110)**

The date and time that the configuration was last updated, in Unix time seconds.

Type: Timestamp

**MaximumEventAgeInSeconds (p. 1110)**

The maximum age of a request that Lambda sends to a function for processing.

Type: Integer

Valid Range: Minimum value of 60. Maximum value of 21600.

**MaximumRetryAttempts (p. 1110)**

The maximum number of times to retry when the function returns an error.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 2.

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# UpdateFunctionUrlConfig

Updates the configuration for a Lambda function URL.

## Request Syntax

```
PUT /2021-10-31/functions/FunctionName/url?Qualifier=Qualifier HTTP/1.1
Content-type: application/json

{
   "AuthType": "string",
   "Cors": {
      "AllowCredentials": boolean,
      "AllowHeaders": [ "string" ],
      "AllowMethods": [ "string" ],
      "AllowOrigins": [ "string" ],
      "ExposeHeaders": [ "string" ],
      "MaxAge": number
   }
}
```

## URI Request Parameters

The request uses the following URI parameters.

**FunctionName (p. 1113)**

The name of the Lambda function.

**Name formats**

- **Function name** - `my-function`.
- **Function ARN** - `arn:aws:lambda:us-west-2:123456789012:function:my-function`.
- **Partial ARN** - `123456789012:function:my-function`.

The length constraint applies only to the full ARN. If you specify only the function name, it is limited to 64 characters in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**Qualifier (p. 1113)**

The alias name.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(^\$LATEST$)|((?!^[0-9]+$)([a-zA-Z0-9-_]+))`

## Request Body

The request accepts the following data in JSON format.

**AuthType (p. 1113)**

The type of authentication that your function URL uses. Set to `AWS_IAM` if you want to restrict access to authenticated `IAM` users only. Set to `NONE` if you want to bypass IAM authentication to create a public endpoint. For more information, see Security and auth model for Lambda function URLs.

Type: String

Valid Values: `NONE | AWS_IAM`

Required: No

**Cors (p. 1113)**

The cross-origin resource sharing (CORS) settings for your function URL.

Type: Cors (p. 1129) object

Required: No

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
   "AuthType": "string",
   "Cors": {
      "AllowCredentials": boolean,
      "AllowHeaders": [ "string" ],
      "AllowMethods": [ "string" ],
      "AllowOrigins": [ "string" ],
      "ExposeHeaders": [ "string" ],
      "MaxAge": number
   },
   "CreationTime": "string",
   "FunctionArn": "string",
   "FunctionUrl": "string",
   "LastModifiedTime": "string"
}
```

## Response Elements

If the action is successful, the service sends back an HTTP 200 response.

The following data is returned in JSON format by the service.

**AuthType (p. 1114)**

The type of authentication that your function URL uses. Set to `AWS_IAM` if you want to restrict access to authenticated `IAM` users only. Set to `NONE` if you want to bypass IAM authentication to create a public endpoint. For more information, see Security and auth model for Lambda function URLs.

Type: String

Valid Values: `NONE | AWS_IAM`

**Cors (p. 1114)**

The cross-origin resource sharing (CORS) settings for your function URL.

Type: Cors (p. 1129) object

**CreationTime (p. 1114)**

When the function URL was created, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

**FunctionArn (p. 1114)**

The Amazon Resource Name (ARN) of your function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**FunctionUrl (p. 1114)**

The HTTP URL endpoint for your function.

Type: String

Length Constraints: Minimum length of 40. Maximum length of 100.

**LastModifiedTime (p. 1114)**

When the function URL configuration was last updated, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists, or another operation is in progress.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource specified in the request does not exist.

HTTP Status Code: 404

**ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

**TooManyRequestsException**

The request throughput limit was exceeded.

HTTP Status Code: 429

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS Command Line Interface
- AWS SDK for .NET
- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for JavaScript
- AWS SDK for PHP V3
- AWS SDK for Python
- AWS SDK for Ruby V3

# Data Types

The following data types are supported:

- AccountLimit (p. 1118)
- AccountUsage (p. 1119)
- AliasConfiguration (p. 1120)
- AliasRoutingConfiguration (p. 1122)
- AllowedPublishers (p. 1123)
- AmazonManagedKafkaEventSourceConfig (p. 1124)
- CodeSigningConfig (p. 1125)
- CodeSigningPolicies (p. 1127)
- Concurrency (p. 1128)
- Cors (p. 1129)
- DeadLetterConfig (p. 1131)
- DestinationConfig (p. 1132)
- Environment (p. 1133)
- EnvironmentError (p. 1134)
- EnvironmentResponse (p. 1135)
- EphemeralStorage (p. 1136)
- EventSourceMappingConfiguration (p. 1137)
- FileSystemConfig (p. 1142)
- Filter (p. 1143)
- FilterCriteria (p. 1144)
- FunctionCode (p. 1145)
- FunctionCodeLocation (p. 1147)
- FunctionConfiguration (p. 1148)
- FunctionEventInvokeConfig (p. 1154)
- FunctionUrlConfig (p. 1156)
- ImageConfig (p. 1158)
- ImageConfigError (p. 1159)
- ImageConfigResponse (p. 1160)

- Layer (p. 1161)
- LayersListItem (p. 1162)
- LayerVersionContentInput (p. 1163)
- LayerVersionContentOutput (p. 1164)
- LayerVersionsListItem (p. 1165)
- OnFailure (p. 1167)
- OnSuccess (p. 1168)
- ProvisionedConcurrencyConfigListItem (p. 1169)
- SelfManagedEventSource (p. 1171)
- SelfManagedKafkaEventSourceConfig (p. 1172)
- SourceAccessConfiguration (p. 1173)
- TracingConfig (p. 1175)
- TracingConfigResponse (p. 1176)
- VpcConfig (p. 1177)
- VpcConfigResponse (p. 1178)

# AccountLimit

Limits that are related to concurrency and storage. All file and storage sizes are in bytes.

## Contents

**CodeSizeUnzipped**

The maximum size of a function's deployment package and layers when they're extracted.

Type: Long

Required: No

**CodeSizeZipped**

The maximum size of a deployment package when it's uploaded directly to Lambda. Use Amazon S3 for larger files.

Type: Long

Required: No

**ConcurrentExecutions**

The maximum number of simultaneous function executions.

Type: Integer

Required: No

**TotalCodeSize**

The amount of storage space that you can use for all deployment packages and layer archives.

Type: Long

Required: No

**UnreservedConcurrentExecutions**

The maximum number of simultaneous function executions, minus the capacity that's reserved for individual functions with PutFunctionConcurrency (p. 1053).

Type: Integer

Valid Range: Minimum value of 0.

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# AccountUsage

The number of functions and amount of storage in use.

## Contents

**FunctionCount**

The number of Lambda functions.

Type: Long

Required: No

**TotalCodeSize**

The amount of storage space, in bytes, that's being used by deployment packages and layer archives.

Type: Long

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# AliasConfiguration

Provides configuration information about a Lambda function alias.

## Contents

**AliasArn**

The Amazon Resource Name (ARN) of the alias.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: No

**Description**

A description of the alias.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

**FunctionVersion**

The function version that the alias invokes.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

Required: No

**Name**

The name of the alias.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(?!^[0-9]+$)([a-zA-Z0-9-_]+)`

Required: No

**RevisionId**

A unique identifier that changes when you update the alias.

Type: String

Required: No

**RoutingConfig**

The routing configuration of the alias.

Type: AliasRoutingConfiguration (p. 1122) object

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# AliasRoutingConfiguration

The traffic-shifting configuration of a Lambda function alias.

## Contents

**AdditionalVersionWeights**

The second version, and the percentage of traffic that's routed to it.

Type: String to double map

Key Length Constraints: Minimum length of 1. Maximum length of 1024.

Key Pattern: `[0-9]+`

Valid Range: Minimum value of 0.0. Maximum value of 1.0.

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# AllowedPublishers

List of signing profiles that can sign a code package.

## Contents

**SigningProfileVersionArns**

The Amazon Resource Name (ARN) for each of the signing profiles. A signing profile defines a trusted user who can sign a code package.

Type: Array of strings

Array Members: Minimum number of 1 item. Maximum number of 20 items.

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

Required: Yes

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# AmazonManagedKafkaEventSourceConfig

Specific configuration settings for an Amazon Managed Streaming for Apache Kafka (Amazon MSK) event source.

## Contents

**ConsumerGroupId**

The identifier for the Kafka consumer group to join. The consumer group ID must be unique among all your Kafka event sources. After creating a Kafka event source mapping with the consumer group ID specified, you cannot update this value. For more information, see Customizable consumer group ID.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 200.

Pattern: `[a-zA-Z0-9-\/*:_+=.@-]*`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# CodeSigningConfig

Details about a Code signing configuration.

## Contents

**AllowedPublishers**

List of allowed publishers.

Type: AllowedPublishers (p. 1123) object

Required: Yes

**CodeSigningConfigArn**

The Amazon Resource Name (ARN) of the Code signing configuration.

Type: String

Length Constraints: Maximum length of 200.

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}((-gov)|(-iso(b?)))?-[a-z]+-\d{1}:\d{12}:code-signing-config:csc-[a-z0-9]{17}`

Required: Yes

**CodeSigningConfigId**

Unique identifer for the Code signing configuration.

Type: String

Pattern: `csc-[a-zA-Z0-9-_\.]{17}`

Required: Yes

**CodeSigningPolicies**

The code signing policy controls the validation failure action for signature mismatch or expiry.

Type: CodeSigningPolicies (p. 1127) object

Required: Yes

**Description**

Code signing configuration description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

**LastModified**

The date and time that the Code signing configuration was last modified, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

Required: Yes

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# CodeSigningPolicies

Code signing configuration policies specify the validation failure action for signature mismatch or expiry.

## Contents

**UntrustedArtifactOnDeployment**

Code signing configuration policy for deployment validation failure. If you set the policy to `Enforce`, Lambda blocks the deployment request if signature validation checks fail. If you set the policy to `Warn`, Lambda allows the deployment and creates a CloudWatch log.

Default value: `Warn`

Type: String

Valid Values: `Warn | Enforce`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# Concurrency

## Contents

**ReservedConcurrentExecutions**

The number of concurrent executions that are reserved for this function. For more information, see Managing Concurrency.

Type: Integer

Valid Range: Minimum value of 0.

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# Cors

The cross-origin resource sharing (CORS) settings for your Lambda function URL. Use CORS to grant access to your function URL from any origin. You can also use CORS to control access for specific HTTP headers and methods in requests to your function URL.

## Contents

**AllowCredentials**

Whether to allow cookies or other credentials in requests to your function URL. The default is `false`.

Type: Boolean

Required: No

**AllowHeaders**

The HTTP headers that origins can include in requests to your function URL. For example: `Date`, `Keep-Alive`, `X-Custom-Header`.

Type: Array of strings

Array Members: Maximum number of 100 items.

Length Constraints: Maximum length of 1024.

Pattern: `.*`

Required: No

**AllowMethods**

The HTTP methods that are allowed when calling your function URL. For example: `GET`, `POST`, `DELETE`, or the wildcard character (`*`).

Type: Array of strings

Array Members: Maximum number of 6 items.

Length Constraints: Maximum length of 6.

Pattern: `.*`

Required: No

**AllowOrigins**

The origins that can access your function URL. You can list any number of specific origins, separated by a comma. For example: `https://www.example.com`, `http://localhost:60905`.

Alternatively, you can grant access to all origins using the wildcard character (`*`).

Type: Array of strings

Array Members: Maximum number of 100 items.

Length Constraints: Minimum length of 1. Maximum length of 253.

Pattern: `.*`

Required: No

**ExposeHeaders**

The HTTP headers in your function response that you want to expose to origins that call your function URL. For example: `Date`, `Keep-Alive`, `X-Custom-Header`.

Type: Array of strings

Array Members: Maximum number of 100 items.

Length Constraints: Maximum length of 1024.

Pattern: `.*`

Required: No

**MaxAge**

The maximum amount of time, in seconds, that web browsers can cache results of a preflight request. By default, this is set to `0`, which means that the browser doesn't cache results.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 86400.

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# DeadLetterConfig

The dead-letter queue for failed asynchronous invocations.

## Contents

**TargetArn**

The Amazon Resource Name (ARN) of an Amazon SQS queue or Amazon SNS topic.

Type: String

Pattern: `(arn:(aws[a-zA-Z-]*)?:[a-z0-9-.]+:.*)|()`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# DestinationConfig

A configuration object that specifies the destination of an event after Lambda processes it.

## Contents

**OnFailure**

The destination configuration for failed invocations.

Type: OnFailure (p. 1167) object

Required: No

**OnSuccess**

The destination configuration for successful invocations.

Type: OnSuccess (p. 1168) object

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# Environment

A function's environment variable settings. You can use environment variables to adjust your function's behavior without updating code. An environment variable is a pair of strings that are stored in a function's version-specific configuration.

## Contents

**Variables**

Environment variable key-value pairs. For more information, see Using Lambda environment variables.

Type: String to string map

Key Pattern: `[a-zA-Z]([a-zA-Z0-9_])+`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# EnvironmentError

Error messages for environment variables that couldn't be applied.

## Contents

**ErrorCode**

The error code.

Type: String

Required: No

**Message**

The error message.

Type: String

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# EnvironmentResponse

The results of an operation to update or read environment variables. If the operation is successful, the response contains the environment variables. If it failed, the response contains details about the error.

## Contents

**Error**

Error messages for environment variables that couldn't be applied.

Type: EnvironmentError (p. 1134) object

Required: No

**Variables**

Environment variable key-value pairs. Omitted from AWS CloudTrail logs.

Type: String to string map

Key Pattern: `[a-zA-Z]([a-zA-Z0-9_])+`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# EphemeralStorage

The size of the function's /tmp directory in MB. The default value is 512, but can be any whole number between 512 and 10240 MB.

## Contents

**Size**

The size of the function's /tmp directory.

Type: Integer

Valid Range: Minimum value of 512. Maximum value of 10240.

Required: Yes

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# EventSourceMappingConfiguration

A mapping between an AWS resource and a Lambda function. For details, see CreateEventSourceMapping (p. 893).

## Contents

**AmazonManagedKafkaEventSourceConfig**

Specific configuration settings for an Amazon Managed Streaming for Apache Kafka (Amazon MSK) event source.

Type: AmazonManagedKafkaEventSourceConfig (p. 1124) object

Required: No

**BatchSize**

The maximum number of records in each batch that Lambda pulls from your stream or queue and sends to your function. Lambda passes all of the records in the batch to the function in a single call, up to the payload limit for synchronous invocation (6 MB).

Default value: Varies by service. For Amazon SQS, the default is 10. For all other services, the default is 100.

Related setting: When you set `BatchSize` to a value greater than 10, you must set `MaximumBatchingWindowInSeconds` to at least 1.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

Required: No

**BisectBatchOnFunctionError**

(Streams only) If the function returns an error, split the batch in two and retry. The default value is false.

Type: Boolean

Required: No

**DestinationConfig**

(Streams only) An Amazon SQS queue or Amazon SNS topic destination for discarded records.

Type: DestinationConfig (p. 1132) object

Required: No

**EventSourceArn**

The Amazon Resource Name (ARN) of the event source.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

Required: No

**FilterCriteria**

(Streams and Amazon SQS) An object that defines the filter criteria that determine whether Lambda should process an event. For more information, see Lambda event filtering.

Type: FilterCriteria (p. 1144) object

Required: No

**FunctionArn**

The ARN of the Lambda function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: No

**FunctionResponseTypes**

(Streams and Amazon SQS) A list of current response type enums applied to the event source mapping.

Type: Array of strings

Array Members: Minimum number of 0 items. Maximum number of 1 item.

Valid Values: `ReportBatchItemFailures`

Required: No

**LastModified**

The date that the event source mapping was last updated or that its state changed, in Unix time seconds.

Type: Timestamp

Required: No

**LastProcessingResult**

The result of the last Lambda invocation of your function.

Type: String

Required: No

**MaximumBatchingWindowInSeconds**

The maximum amount of time, in seconds, that Lambda spends gathering records before invoking the function. You can configure `MaximumBatchingWindowInSeconds` to any value from 0 seconds to 300 seconds in increments of seconds.

For streams and Amazon SQS event sources, the default batching window is 0 seconds. For Amazon MSK, Self-managed Apache Kafka, and Amazon MQ event sources, the default batching window is 500 ms. Note that because you can only change `MaximumBatchingWindowInSeconds` in increments of seconds, you cannot revert back to the 500 ms default batching window after you have changed it. To restore the default batching window, you must create a new event source mapping.

Related setting: For streams and Amazon SQS event sources, when you set `BatchSize` to a value greater than 10, you must set `MaximumBatchingWindowInSeconds` to at least 1.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 300.

Required: No

**MaximumRecordAgeInSeconds**

(Streams only) Discard records older than the specified age. The default value is -1, which sets the maximum age to infinite. When the value is set to infinite, Lambda never discards old records.

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 604800.

Required: No

**MaximumRetryAttempts**

(Streams only) Discard records after the specified number of retries. The default value is -1, which sets the maximum number of retries to infinite. When MaximumRetryAttempts is infinite, Lambda retries failed records until the record expires in the event source.

Type: Integer

Valid Range: Minimum value of -1. Maximum value of 10000.

Required: No

**ParallelizationFactor**

(Streams only) The number of batches to process concurrently from each shard. The default value is 1.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10.

Required: No

**Queues**

(Amazon MQ) The name of the Amazon MQ broker destination queue to consume.

Type: Array of strings

Array Members: Fixed number of 1 item.

Length Constraints: Minimum length of 1. Maximum length of 1000.

Pattern: `[\s\S]*`

Required: No

**SelfManagedEventSource**

The self-managed Apache Kafka cluster for your event source.

Type: SelfManagedEventSource (p. 1171) object

Required: No

**SelfManagedKafkaEventSourceConfig**

Specific configuration settings for a self-managed Apache Kafka event source.

Type: SelfManagedKafkaEventSourceConfig (p. 1172) object

Required: No

**SourceAccessConfigurations**

An array of the authentication protocol, VPC components, or virtual host to secure and define your event source.

Type: Array of SourceAccessConfiguration (p. 1173) objects

Array Members: Minimum number of 0 items. Maximum number of 22 items.

Required: No

**StartingPosition**

The position in a stream from which to start reading. Required for Amazon Kinesis, Amazon DynamoDB, and Amazon MSK stream sources. `AT_TIMESTAMP` is supported only for Amazon Kinesis streams.

Type: String

Valid Values: `TRIM_HORIZON | LATEST | AT_TIMESTAMP`

Required: No

**StartingPositionTimestamp**

With `StartingPosition` set to `AT_TIMESTAMP`, the time from which to start reading, in Unix time seconds.

Type: Timestamp

Required: No

**State**

The state of the event source mapping. It can be one of the following: `Creating`, `Enabling`, `Enabled`, `Disabling`, `Disabled`, `Updating`, or `Deleting`.

Type: String

Required: No

**StateTransitionReason**

Indicates whether a user or Lambda made the last change to the event source mapping.

Type: String

Required: No

**Topics**

The name of the Kafka topic.

Type: Array of strings

Array Members: Fixed number of 1 item.

Length Constraints: Minimum length of 1. Maximum length of 249.

Pattern: `^[^.]([a-zA-Z0-9\-_.]+)`

Required: No

**TumblingWindowInSeconds**

(Streams only) The duration in seconds of a processing window. The range is 1–900 seconds.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 900.

Required: No

**UUID**

The identifier of the event source mapping.

Type: String

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# FileSystemConfig

Details about the connection between a Lambda function and an Amazon EFS file system.

## Contents

**Arn**

The Amazon Resource Name (ARN) of the Amazon EFS access point that provides access to the file system.

Type: String

Length Constraints: Maximum length of 200.

Pattern: `arn:aws[a-zA-Z-]*:elasticfilesystem:[a-z]{2}((-gov)|(-iso(b?)))?-[a-z]+-\d{1}:\d{12}:access-point/fsap-[a-f0-9]{17}`

Required: Yes

**LocalMountPath**

The path where the function can access the file system, starting with `/mnt/`.

Type: String

Length Constraints: Maximum length of 160.

Pattern: `^/mnt/[a-zA-Z0-9-_.]+$`

Required: Yes

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# Filter

A structure within a `FilterCriteria` object that defines an event filtering pattern.

## Contents

**Pattern**

A filter pattern. For more information on the syntax of a filter pattern, see Filter rule syntax.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 4096.

Pattern: `.*`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# FilterCriteria

An object that contains the filters for an event source.

## Contents

**Filters**

A list of filters.

Type: Array of Filter (p. 1143) objects

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# FunctionCode

The code for the Lambda function. You can specify either an object in Amazon S3, upload a .zip file archive deployment package directly, or specify the URI of a container image.

## Contents

**ImageUri**

URI of a container image in the Amazon ECR registry.

Type: String

Required: No

**S3Bucket**

An Amazon S3 bucket in the same AWS Region as your function. The bucket can be in a different AWS account.

Type: String

Length Constraints: Minimum length of 3. Maximum length of 63.

Pattern: `^[0-9A-Za-z\.\-_]*(?<!\.)$`

Required: No

**S3Key**

The Amazon S3 key of the deployment package.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Required: No

**S3ObjectVersion**

For versioned objects, the version of the deployment package object to use.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Required: No

**ZipFile**

The base64-encoded contents of the deployment package. AWS SDK and AWS CLI clients handle the encoding for you.

Type: Base64-encoded binary data object

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++

- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# FunctionCodeLocation

Details about a function's deployment package.

## Contents

**ImageUri**

URI of a container image in the Amazon ECR registry.

Type: String

Required: No

**Location**

A presigned URL that you can use to download the deployment package.

Type: String

Required: No

**RepositoryType**

The service that's hosting the file.

Type: String

Required: No

**ResolvedImageUri**

The resolved URI for the image.

Type: String

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# FunctionConfiguration

Details about a function's configuration.

## Contents

**Architectures**

The instruction set architecture that the function supports. Architecture is a string array with one of the valid values. The default architecture value is `x86_64`.

Type: Array of strings

Array Members: Fixed number of 1 item.

Valid Values: `x86_64 | arm64`

Required: No

**CodeSha256**

The SHA256 hash of the function's deployment package.

Type: String

Required: No

**CodeSize**

The size of the function's deployment package, in bytes.

Type: Long

Required: No

**DeadLetterConfig**

The function's dead letter queue.

Type: DeadLetterConfig (p. 1131) object

Required: No

**Description**

The function's description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

**Environment**

The function's environment variables. Omitted from AWS CloudTrail logs.

Type: EnvironmentResponse (p. 1135) object

Required: No

**EphemeralStorage**

The size of the function's /tmp directory in MB. The default value is 512, but can be any whole number between 512 and 10240 MB.

Type: EphemeralStorage (p. 1136) object

Required: No

**FileSystemConfigs**

Connection settings for an Amazon EFS file system.

Type: Array of FileSystemConfig (p. 1142) objects

Array Members: Maximum number of 1 item.

Required: No

**FunctionArn**

The function's Amazon Resource Name (ARN).

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_\.]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: No

**FunctionName**

The name of the function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 170.

Pattern: `(arn:(aws[a-zA-Z-]*)?:lambda:)?([a-z]{2}(-gov)?-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: No

**Handler**

The function that Lambda calls to begin executing your function.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

Required: No

**ImageConfigResponse**

The function's image configuration values.

Type: ImageConfigResponse (p. 1160) object

Required: No

**KMSKeyArn**

The AWS KMS key that's used to encrypt the function's environment variables. This key is only returned if you've configured a customer managed key.

Type: String

Pattern: `(arn:(aws[a-zA-Z-]*)?:[a-z0-9-.]+:.*)|()`

Required: No

**LastModified**

The date and time that the function was last updated, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

Required: No

**LastUpdateStatus**

The status of the last update that was performed on the function. This is first set to `Successful` after function creation completes.

Type: String

Valid Values: `Successful | Failed | InProgress`

Required: No

**LastUpdateStatusReason**

The reason for the last update that was performed on the function.

Type: String

Required: No

**LastUpdateStatusReasonCode**

The reason code for the last update that was performed on the function.

Type: String

Valid Values: `EniLimitExceeded | InsufficientRolePermissions | InvalidConfiguration | InternalError | SubnetOutOfIPAddresses | InvalidSubnet | InvalidSecurityGroup | ImageDeleted | ImageAccessDenied | InvalidImage`

Required: No

**Layers**

The function's layers.

Type: Array of Layer (p. 1161) objects

Required: No

**MasterArn**

For Lambda@Edge functions, the ARN of the main function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: No

**MemorySize**

The amount of memory available to the function at runtime.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 10240.

Required: No

**PackageType**

The type of deployment package. Set to `Image` for container image and set `Zip` for .zip file archive.

Type: String

Valid Values: `Zip | Image`

Required: No

**RevisionId**

The latest updated revision of the function or alias.

Type: String

Required: No

**Role**

The function's execution role.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@\-_/]+`

Required: No

**Runtime**

The runtime environment for the Lambda function.

Type: String

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

Required: No

**SigningJobArn**

The ARN of the signing job.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

Required: No

**SigningProfileVersionArn**

The ARN of the signing profile version.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

Required: No

**State**

The current state of the function. When the state is `Inactive`, you can reactivate the function by invoking it.

Type: String

Valid Values: `Pending | Active | Inactive | Failed`

Required: No

**StateReason**

The reason for the function's current state.

Type: String

Required: No

**StateReasonCode**

The reason code for the function's current state. When the code is `Creating`, you can't invoke or modify the function.

Type: String

Valid Values: `Idle | Creating | Restoring | EniLimitExceeded | InsufficientRolePermissions | InvalidConfiguration | InternalError | SubnetOutOfIPAddresses | InvalidSubnet | InvalidSecurityGroup | ImageDeleted | ImageAccessDenied | InvalidImage`

Required: No

**Timeout**

The amount of time in seconds that Lambda allows a function to run before stopping it.

Type: Integer

Valid Range: Minimum value of 1.

Required: No

**TracingConfig**

The function's AWS X-Ray tracing configuration.

Type: TracingConfigResponse (p. 1176) object

Required: No

**Version**

The version of the Lambda function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

Required: No

**VpcConfig**

The function's networking configuration.

Type: VpcConfigResponse (p. 1178) object

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# FunctionEventInvokeConfig

## Contents

**DestinationConfig**

A destination for events after they have been sent to a function for processing.

**Destinations**

- **Function** - The Amazon Resource Name (ARN) of a Lambda function.
- **Queue** - The ARN of an SQS queue.
- **Topic** - The ARN of an SNS topic.
- **Event Bus** - The ARN of an Amazon EventBridge event bus.

Type: DestinationConfig (p. 1132) object

Required: No

**FunctionArn**

The Amazon Resource Name (ARN) of the function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: No

**LastModified**

The date and time that the configuration was last updated, in Unix time seconds.

Type: Timestamp

Required: No

**MaximumEventAgeInSeconds**

The maximum age of a request that Lambda sends to a function for processing.

Type: Integer

Valid Range: Minimum value of 60. Maximum value of 21600.

Required: No

**MaximumRetryAttempts**

The maximum number of times to retry when the function returns an error.

Type: Integer

Valid Range: Minimum value of 0. Maximum value of 2.

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# FunctionUrlConfig

Details about a Lambda function URL.

## Contents

**AuthType**

The type of authentication that your function URL uses. Set to `AWS_IAM` if you want to restrict access to authenticated `IAM` users only. Set to `NONE` if you want to bypass IAM authentication to create a public endpoint. For more information, see Security and auth model for Lambda function URLs.

Type: String

Valid Values: `NONE | AWS_IAM`

Required: Yes

**Cors**

The cross-origin resource sharing (CORS) settings for your function URL.

Type: Cors (p. 1129) object

Required: No

**CreationTime**

When the function URL was created, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

Required: Yes

**FunctionArn**

The Amazon Resource Name (ARN) of your function.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

**FunctionUrl**

The HTTP URL endpoint for your function.

Type: String

Length Constraints: Minimum length of 40. Maximum length of 100.

Required: Yes

**LastModifiedTime**

When the function URL configuration was last updated, in ISO-8601 format (YYYY-MM-DDThh:mm:ss.sTZD).

Type: String

Required: Yes

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# ImageConfig

Configuration values that override the container image Dockerfile settings. See Container settings.

## Contents

**Command**

Specifies parameters that you want to pass in with ENTRYPOINT.

Type: Array of strings

Array Members: Maximum number of 1500 items.

Required: No

**EntryPoint**

Specifies the entry point to their application, which is typically the location of the runtime executable.

Type: Array of strings

Array Members: Maximum number of 1500 items.

Required: No

**WorkingDirectory**

Specifies the working directory.

Type: String

Length Constraints: Maximum length of 1000.

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# ImageConfigError

Error response to GetFunctionConfiguration.

## Contents

**ErrorCode**

Error code.

Type: String

Required: No

**Message**

Error message.

Type: String

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# ImageConfigResponse

Response to GetFunctionConfiguration request.

## Contents

**Error**

Error response to GetFunctionConfiguration.

Type: ImageConfigError (p. 1159) object

Required: No

**ImageConfig**

Configuration values that override the container image Dockerfile.

Type: ImageConfig (p. 1158) object

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# Layer

An AWS Lambda layer.

## Contents

**Arn**

The Amazon Resource Name (ARN) of the function layer.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+:[0-9]+`

Required: No

**CodeSize**

The size of the layer archive in bytes.

Type: Long

Required: No

**SigningJobArn**

The Amazon Resource Name (ARN) of a signing job.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

Required: No

**SigningProfileVersionArn**

The Amazon Resource Name (ARN) for a signing profile version.

Type: String

Pattern: `arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# LayersListItem

Details about an AWS Lambda layer.

## Contents

**LatestMatchingVersion**

The newest version of the layer.

Type: LayerVersionsListItem (p. 1165) object

Required: No

**LayerArn**

The Amazon Resource Name (ARN) of the function layer.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+`

Required: No

**LayerName**

The name of the layer.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+)|[a-zA-Z0-9-_]+`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# LayerVersionContentInput

A ZIP archive that contains the contents of an AWS Lambda layer. You can specify either an Amazon S3 location, or upload a layer archive directly.

## Contents

**S3Bucket**

The Amazon S3 bucket of the layer archive.

Type: String

Length Constraints: Minimum length of 3. Maximum length of 63.

Pattern: `^[0-9A-Za-z\.\-_]*(?<!\.)$`

Required: No

**S3Key**

The Amazon S3 key of the layer archive.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Required: No

**S3ObjectVersion**

For versioned objects, the version of the layer archive object to use.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Required: No

**ZipFile**

The base64-encoded contents of the layer archive. AWS SDK and AWS CLI clients handle the encoding for you.

Type: Base64-encoded binary data object

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# LayerVersionContentOutput

Details about a version of an AWS Lambda layer.

## Contents

**CodeSha256**

The SHA-256 hash of the layer archive.

Type: String

Required: No

**CodeSize**

The size of the layer archive in bytes.

Type: Long

Required: No

**Location**

A link to the layer archive in Amazon S3 that is valid for 10 minutes.

Type: String

Required: No

**SigningJobArn**

The Amazon Resource Name (ARN) of a signing job.

Type: String

Required: No

**SigningProfileVersionArn**

The Amazon Resource Name (ARN) for a signing profile version.

Type: String

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# LayerVersionsListItem

Details about a version of an AWS Lambda layer.

## Contents

**CompatibleArchitectures**

A list of compatible instruction set architectures.

Type: Array of strings

Array Members: Maximum number of 2 items.

Valid Values: `x86_64 | arm64`

Required: No

**CompatibleRuntimes**

The layer's compatible runtimes.

Type: Array of strings

Array Members: Maximum number of 15 items.

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | nodejs10.x | nodejs12.x | nodejs14.x | nodejs16.x | java8 | java8.al2 | java11 | python2.7 | python3.6 | python3.7 | python3.8 | python3.9 | dotnetcore1.0 | dotnetcore2.0 | dotnetcore2.1 | dotnetcore3.1 | dotnet6 | nodejs4.3-edge | go1.x | ruby2.5 | ruby2.7 | provided | provided.al2`

Required: No

**CreatedDate**

The date that the version was created, in ISO 8601 format. For example, `2018-11-27T15:10:45.123+0000`.

Type: String

Required: No

**Description**

The description of the version.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

**LayerVersionArn**

The ARN of the layer version.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `arn:[a-zA-Z0-9-]+:lambda:[a-zA-Z0-9-]+:\d{12}:layer:[a-zA-Z0-9-_]+:[0-9]+`

Required: No

**LicenseInfo**

The layer's open-source license.

Type: String

Length Constraints: Maximum length of 512.

Required: No

**Version**

The version number.

Type: Long

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# OnFailure

A destination for events that failed processing.

## Contents

**Destination**

The Amazon Resource Name (ARN) of the destination resource.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 350.

Pattern: `^$|arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# OnSuccess

A destination for events that were processed successfully.

## Contents

**Destination**

The Amazon Resource Name (ARN) of the destination resource.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 350.

Pattern: `^$|arn:(aws[a-zA-Z0-9-]*):([a-zA-Z0-9\-])+:([a-z]{2}(-gov)?-[a-z]+-\d{1})?:(\d{12})?:(.*)`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# ProvisionedConcurrencyConfigListItem

Details about the provisioned concurrency configuration for a function alias or version.

## Contents

**AllocatedProvisionedConcurrentExecutions**

The amount of provisioned concurrency allocated. When a weighted alias is used during linear and canary deployments, this value fluctuates depending on the amount of concurrency that is provisioned for the function versions.

Type: Integer

Valid Range: Minimum value of 0.

Required: No

**AvailableProvisionedConcurrentExecutions**

The amount of provisioned concurrency available.

Type: Integer

Valid Range: Minimum value of 0.

Required: No

**FunctionArn**

The Amazon Resource Name (ARN) of the alias or version.

Type: String

Pattern: `arn:(aws[a-zA-Z-]*)?:lambda:[a-z]{2}(-gov)?-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: No

**LastModified**

The date and time that a user last updated the configuration, in ISO 8601 format.

Type: String

Required: No

**RequestedProvisionedConcurrentExecutions**

The amount of provisioned concurrency requested.

Type: Integer

Valid Range: Minimum value of 1.

Required: No

**Status**

The status of the allocation process.

Type: String

Valid Values: `IN_PROGRESS | READY | FAILED`

Required: No

**StatusReason**

For failed allocations, the reason that provisioned concurrency could not be allocated.

Type: String

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# SelfManagedEventSource

The self-managed Apache Kafka cluster for your event source.

## Contents

**Endpoints**

The list of bootstrap servers for your Kafka brokers in the following format: `"KAFKA_BOOTSTRAP_SERVERS": ["abc.xyz.com:xxxx","abc2.xyz.com:xxxx"]`.

Type: String to array of strings map

Map Entries: Maximum number of 2 items.

Valid Keys: `KAFKA_BOOTSTRAP_SERVERS`

Array Members: Minimum number of 1 item. Maximum number of 10 items.

Length Constraints: Minimum length of 1. Maximum length of 300.

Pattern: `^(([a-zA-Z0-9]|[a-zA-Z0-9][a-zA-Z0-9\-]*[a-zA-Z0-9])\.)*([A-Za-z0-9]|[A-Za-z0-9][A-Za-z0-9\-]*[A-Za-z0-9]):[0-9]{1,5}`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# SelfManagedKafkaEventSourceConfig

Specific configuration settings for a self-managed Apache Kafka event source.

## Contents

**ConsumerGroupId**

The identifier for the Kafka consumer group to join. The consumer group ID must be unique among all your Kafka event sources. After creating a Kafka event source mapping with the consumer group ID specified, you cannot update this value. For more information, see Customizable consumer group ID.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 200.

Pattern: `[a-zA-Z0-9-\/*:_+=.@-]*`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# SourceAccessConfiguration

To secure and define access to your event source, you can specify the authentication protocol, VPC components, or virtual host.

## Contents

**Type**

The type of authentication protocol, VPC components, or virtual host for your event source. For example: `"Type":"SASL_SCRAM_512_AUTH"`.

- `BASIC_AUTH` - (Amazon MQ) The AWS Secrets Manager secret that stores your broker credentials.
- `BASIC_AUTH` - (Self-managed Apache Kafka) The Secrets Manager ARN of your secret key used for SASL/PLAIN authentication of your Apache Kafka brokers.
- `VPC_SUBNET` - (Self-managed Apache Kafka) The subnets associated with your VPC. Lambda connects to these subnets to fetch data from your self-managed Apache Kafka cluster.
- `VPC_SECURITY_GROUP` - (Self-managed Apache Kafka) The VPC security group used to manage access to your self-managed Apache Kafka brokers.
- `SASL_SCRAM_256_AUTH` - (Self-managed Apache Kafka) The Secrets Manager ARN of your secret key used for SASL SCRAM-256 authentication of your self-managed Apache Kafka brokers.
- `SASL_SCRAM_512_AUTH` - (Amazon MSK, Self-managed Apache Kafka) The Secrets Manager ARN of your secret key used for SASL SCRAM-512 authentication of your self-managed Apache Kafka brokers.
- `VIRTUAL_HOST` - (RabbitMQ) The name of the virtual host in your RabbitMQ broker. Lambda uses this RabbitMQ host as the event source. This property cannot be specified in an UpdateEventSourceMapping API call.
- `CLIENT_CERTIFICATE_TLS_AUTH` - (Amazon MSK, self-managed Apache Kafka) The Secrets Manager ARN of your secret key containing the certificate chain (X.509 PEM), private key (PKCS#8 PEM), and private key password (optional) used for mutual TLS authentication of your MSK/ Apache Kafka brokers.
- `SERVER_ROOT_CA_CERTIFICATE` - (Self-managed Apache Kafka) The Secrets Manager ARN of your secret key containing the root CA certificate (X.509 PEM) used for TLS encryption of your Apache Kafka brokers.

Type: String

Valid Values: `BASIC_AUTH | VPC_SUBNET | VPC_SECURITY_GROUP | SASL_SCRAM_512_AUTH | SASL_SCRAM_256_AUTH | VIRTUAL_HOST | CLIENT_CERTIFICATE_TLS_AUTH | SERVER_ROOT_CA_CERTIFICATE`

Required: No

**URI**

The value for your chosen configuration in `Type`. For example: `"URI": "arn:aws:secretsmanager:us-east-1:01234567890:secret:MyBrokerSecretName"`.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 200.

Pattern: `[a-zA-Z0-9-\/*:_+=.@-]*`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# TracingConfig

The function's AWS X-Ray tracing configuration. To sample and record incoming requests, set `Mode` to `Active`.

## Contents

**Mode**

The tracing mode.

Type: String

Valid Values: `Active | PassThrough`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# TracingConfigResponse

The function's AWS X-Ray tracing configuration.

## Contents

**Mode**

The tracing mode.

Type: String

Valid Values: `Active | PassThrough`

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# VpcConfig

The VPC security groups and subnets that are attached to a Lambda function. For more information, see VPC Settings.

## Contents

**SecurityGroupIds**

A list of VPC security groups IDs.

Type: Array of strings

Array Members: Maximum number of 5 items.

Required: No

**SubnetIds**

A list of VPC subnet IDs.

Type: Array of strings

Array Members: Maximum number of 16 items.

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# VpcConfigResponse

The VPC security groups and subnets that are attached to a Lambda function.

## Contents

**SecurityGroupIds**

A list of VPC security groups IDs.

Type: Array of strings

Array Members: Maximum number of 5 items.

Required: No

**SubnetIds**

A list of VPC subnet IDs.

Type: Array of strings

Array Members: Maximum number of 16 items.

Required: No

**VpcId**

The ID of the VPC.

Type: String

Required: No

## See Also

For more information about using this API in one of the language-specific AWS SDKs, see the following:

- AWS SDK for C++
- AWS SDK for Go
- AWS SDK for Java V2
- AWS SDK for Ruby V3

# Certificate errors when using an SDK

Because AWS SDKs use the CA certificates from your computer, changes to the certificates on the AWS servers can cause connection failures when you attempt to use an SDK. You can prevent these failures by keeping your computer's CA certificates and operating system up-to-date. If you encounter this issue in a corporate environment and do not manage your own computer, you might need to ask an administrator to assist with the update process. The following list shows minimum operating system and Java versions:

- Microsoft Windows versions that have updates from January 2005 or later installed contain at least one of the required CAs in their trust list.
- Mac OS X 10.4 with Java for Mac OS X 10.4 Release 5 (February 2007), Mac OS X 10.5 (October 2007), and later versions contain at least one of the required CAs in their trust list.

- Red Hat Enterprise Linux 5 (March 2007), 6, and 7 and CentOS 5, 6, and 7 all contain at least one of the required CAs in their default trusted CA list.
- Java 1.4.2_12 (May 2006), 5 Update 2 (March 2005), and all later versions, including Java 6 (December 2006), 7, and 8, contain at least one of the required CAs in their default trusted CA list.

When accessing the AWS Lambda management console or AWS Lambda API endpoints, whether through browsers or programmatically, you will need to ensure your client machines support any of the following CAs:

- Amazon Root CA 1
- Starfield Services Root Certificate Authority - G2
- Starfield Class 2 Certification Authority

Root certificates from the first two authorities are available from Amazon trust services, but keeping your computer up-to-date is the more straightforward solution. To learn more about ACM-provided certificates, see AWS Certificate Manager FAQs.

# Common Errors

This section lists the errors common to the API actions of all AWS services. For errors specific to an API action for this service, see the topic for that API action.

**AccessDeniedException**

You do not have sufficient access to perform this action.

HTTP Status Code: 400

**IncompleteSignature**

The request signature does not conform to AWS standards.

HTTP Status Code: 400

**InternalFailure**

The request processing has failed because of an unknown error, exception or failure.

HTTP Status Code: 500

**InvalidAction**

The action or operation requested is invalid. Verify that the action is typed correctly.

HTTP Status Code: 400

**InvalidClientTokenId**

The X.509 certificate or AWS access key ID provided does not exist in our records.

HTTP Status Code: 403

**InvalidParameterCombination**

Parameters that must not be used together were used together.

HTTP Status Code: 400

**InvalidParameterValue**

An invalid or out-of-range value was supplied for the input parameter.

HTTP Status Code: 400

**InvalidQueryParameter**

The AWS query string is malformed or does not adhere to AWS standards.

HTTP Status Code: 400

**MalformedQueryString**

The query string contains a syntax error.

HTTP Status Code: 404

**MissingAction**

The request is missing an action or a required parameter.

HTTP Status Code: 400

**MissingAuthenticationToken**

The request must contain either a valid (registered) AWS access key ID or X.509 certificate.

HTTP Status Code: 403

**MissingParameter**

A required parameter for the specified action is not supplied.

HTTP Status Code: 400

**NotAuthorized**

You do not have permission to perform this action.

HTTP Status Code: 400

**OptInRequired**

The AWS access key ID needs a subscription for the service.

HTTP Status Code: 403

**RequestExpired**

The request reached the service more than 15 minutes after the date stamp on the request or more than 15 minutes after the request expiration date (such as for pre-signed URLs), or the date stamp on the request is more than 15 minutes in the future.

HTTP Status Code: 400

**ServiceUnavailable**

The request has failed due to a temporary failure of the server.

HTTP Status Code: 503

**ThrottlingException**

The request was denied due to request throttling.

HTTP Status Code: 400

**ValidationError**

The input fails to satisfy the constraints specified by an AWS service.

HTTP Status Code: 400

# Common Parameters

The following list contains the parameters that all actions use for signing Signature Version 4 requests with a query string. Any action-specific parameters are listed in the topic for that action. For more information about Signature Version 4, see Signature Version 4 Signing Process in the *Amazon Web Services General Reference*.

**Action**

The action to be performed.

Type: string

Required: Yes

**Version**

The API version that the request is written for, expressed in the format YYYY-MM-DD.

Type: string

Required: Yes

**X-Amz-Algorithm**

The hash algorithm that you used to create the request signature.

Condition: Specify this parameter when you include authentication information in a query string instead of in the HTTP authorization header.

Type: string

Valid Values: `AWS4-HMAC-SHA256`

Required: Conditional

**X-Amz-Credential**

The credential scope value, which is a string that includes your access key, the date, the region you are targeting, the service you are requesting, and a termination string ("aws4_request"). The value is expressed in the following format: *access_key*/*YYYYMMDD*/*region*/*service*/aws4_request.

For more information, see Task 2: Create a String to Sign for Signature Version 4 in the *Amazon Web Services General Reference*.

Condition: Specify this parameter when you include authentication information in a query string instead of in the HTTP authorization header.

Type: string

Required: Conditional

**X-Amz-Date**

The date that is used to create the signature. The format must be ISO 8601 basic format (YYYYMMDD'T'HHMMSS'Z'). For example, the following date time is a valid X-Amz-Date value: `20120325T120000Z`.

Condition: X-Amz-Date is optional for all requests; it can be used to override the date used for signing requests. If the Date header is specified in the ISO 8601 basic format, X-Amz-Date is not required. When X-Amz-Date is used, it always overrides the value of the Date header. For more information, see Handling Dates in Signature Version 4 in the *Amazon Web Services General Reference*.

Type: string

Required: Conditional

**X-Amz-Security-Token**

The temporary security token that was obtained through a call to AWS Security Token Service (AWS STS). For a list of services that support temporary security credentials from AWS Security Token Service, go to AWS Services That Work with IAM in the *IAM User Guide*.

Condition: If you're using temporary security credentials from the AWS Security Token Service, you must include the security token.

Type: string

Required: Conditional

**X-Amz-Signature**

Specifies the hex-encoded signature that was calculated from the string to sign and the derived signing key.

Condition: Specify this parameter when you include authentication information in a query string instead of in the HTTP authorization header.

Type: string

Required: Conditional

**X-Amz-SignedHeaders**

Specifies all the HTTP headers that were included as part of the canonical request. For more information about specifying signed headers, see Task 1: Create a Canonical Request For Signature Version 4 in the *Amazon Web Services General Reference*.

Condition: Specify this parameter when you include authentication information in a query string instead of in the HTTP authorization header.

Type: string

Required: Conditional

# AWS glossary

For the latest AWS terminology, see the AWS glossary in the *AWS General Reference*.