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# AWS Lambda

## Developer Guide



## AWS Lambda: Developer Guide

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# What Is AWS Lambda?

AWS Lambda is a compute service that lets you run code without provisioning or managing servers. AWS Lambda executes your code only when needed and scales automatically, from a few requests per day to thousands per second. You pay only for the compute time you consume - there is no charge when your code is not running. With AWS Lambda, you can run code for virtually any type of application or backend service - all with zero administration. AWS 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, code monitoring and logging. All you need to do is supply your code in one of the languages that AWS Lambda supports (currently Node.js, Java, C#, Go and Python).

You can use AWS Lambda to run your code in response to events, such as changes to data in an Amazon S3 bucket or an Amazon DynamoDB table; to run your code in response to HTTP requests using Amazon API Gateway; or invoke your code using API calls made using AWS SDKs. With these capabilities, you can use Lambda to easily build data processing triggers for AWS services like Amazon S3 and Amazon DynamoDB, process streaming data stored in Kinesis, or create your own back end that operates at AWS scale, performance, and security.

You can also build [serverless](#) applications composed of functions that are triggered by events and automatically deploy them using AWS CodePipeline and AWS CodeBuild. For more information, see [Deploying Lambda-based Applications \(p. 277\)](#).

For more information about the AWS Lambda execution environment, see [Lambda Execution Environment and Available Libraries \(p. 391\)](#). For information about how AWS Lambda determines compute resources required to execute your code, see [Configuring Lambda Functions \(p. 131\)](#).

## When Should I Use AWS Lambda?

AWS Lambda is an ideal compute platform for many application scenarios, provided that you can write your application code in languages supported by AWS Lambda (that is, Node.js, Java, Go and C# and Python), and run within the AWS Lambda standard runtime environment and resources provided by Lambda.

When using AWS Lambda, you are responsible only for your code. AWS Lambda manages the compute fleet that offers a balance of memory, CPU, network, and other resources. This is in exchange for flexibility, which means you cannot log in to compute instances, or customize the operating system or language runtime. These constraints enable AWS Lambda to perform operational and administrative activities on your behalf, including provisioning capacity, monitoring fleet health, applying security patches, deploying your code, and monitoring and logging your Lambda functions.

If you need to manage your own compute resources, Amazon Web Services also offers other compute services to meet your needs.

- Amazon Elastic Compute Cloud (Amazon EC2) service offers flexibility and a wide range of EC2 instance types to choose from. It gives you the option to customize operating systems, network and security settings, and the entire software stack, but you are responsible for provisioning capacity, monitoring fleet health and performance, and using Availability Zones for fault tolerance.
- Elastic Beanstalk offers an easy-to-use service for deploying and scaling applications onto Amazon EC2 in which you retain ownership and full control over the underlying EC2 instances.

# Are You a First-time User of AWS Lambda?

If you are a first-time user of AWS Lambda, we recommend that you read the following sections in order:

1. **Read the product overview and watch the introductory video to understand sample use cases.** These resources are available on the [AWS Lambda webpage](#).
2. **Review the “Lambda Functions” section of this guide.** To understand the programming model and deployment options for a Lambda function there are core concepts you should be familiar with. This section explains these concepts and provides details of how they work in different languages that you can use to author your Lambda function code. For more information, see [Lambda Functions \(p. 15\)](#).
3. **Try the console-based Getting Started exercise.** The exercise provides instructions for you to create and test your first Lambda function using the console. You also learn about the console provided blueprints to quickly create your Lambda functions. For more information, see [Getting Started \(p. 3\)](#).
4. **Read the “Deploying Applications with AWS Lambda” section of this guide.** This section introduces various AWS Lambda components you work with to create an end-to-end experience. For more information, see [Deploying Lambda-based Applications \(p. 277\)](#).

Beyond the Getting Started exercise, you can explore the various use cases, each of which is provided with a tutorial that walks you through an example scenario. Depending on your application needs (for example, whether you want event driven Lambda function invocation or on-demand invocation), you can follow specific tutorials that meet your specific needs. For more information, see [Use Cases \(p. 173\)](#).

The following topics provide additional information about AWS Lambda:

- [AWS Lambda Function Versioning and Aliases \(p. 277\)](#)
- [Using Amazon CloudWatch \(p. 314\)](#)
- [Best Practices for Working with AWS Lambda Functions \(p. 386\)](#)
- [AWS Lambda Limits \(p. 394\)](#)

# Getting Started

In this section, we introduce you to the fundamental concepts of a typical Lambda-based application and the options available to create and test your applications. In addition, you will be provided with instructions on installing the necessary tools to complete the tutorials included in this guide and create your first Lambda function.

## Building Blocks of a Lambda-based Application

- **Lambda function:** The foundation, it is comprised of your custom code and any dependent libraries. For more information, see [Lambda Functions \(p. 15\)](#).
- **Event source:** An AWS service, such as Amazon SNS, or a custom service, that triggers your function and executes its logic. For more information, see [Event Source Mapping \(p. 149\)](#).
- **Downstream resources:** An AWS service, such as DynamoDB tables or Amazon S3 buckets, that your Lambda function calls once it is triggered.
- **Log streams:** While Lambda automatically monitors your function invocations and reports metrics to CloudWatch, you can annotate your function code with custom logging statements that allow you to analyze the execution flow and performance of your Lambda function to ensure it's working properly.
- **AWS SAM:** A model to define [serverless applications](#). AWS SAM is natively supported by AWS CloudFormation and defines simplified syntax for expressing serverless resources. For more information, see [Using the AWS Serverless Application Model \(AWS SAM\) \(p. 297\)](#)

## Tools to Create and Test Lambda-based Applications

There are three key tools that you use to interact with the AWS Lambda service, described below. We will cover tools for building AWS Lambda-based applications in further sections.

- **Lambda Console:** Provides a way for you to graphically design your Lambda-based application, author or update your Lambda function code, and configure event, downstream resources and IAM permissions that your function requires. It also includes advanced configuration options, outlined in [Advanced Topics \(p. 377\)](#).
- **AWS CLI:** A command-line interface you can use to leverage Lambda's API operations, such as creating functions and mapping event sources. For a full list of Lambda's API operations, see [Actions \(p. 396\)](#).
- **SAM CLI:** A command-line interface you can use to develop, test, and analyze your serverless applications locally before uploading them to the Lambda runtime. For more information, see [Test Your Serverless Applications Locally Using SAM CLI \(Public Beta\) \(p. 99\)](#).

## Before you begin

In order to use the tutorials offered at the end of this section, make sure you have done the following:

- [Set Up an AWS Account \(p. 4\)](#)
- [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#)
- Followed the steps to use SAM CLI, including [Docker](#), outlined here: [Install SAM CLI \(p. 7\)](#).

## Next Step

[Set Up an AWS Account \(p. 4\)](#)

# Set Up an AWS Account

If you have not already done so, you need to sign up for an AWS account and create an administrator user in the account. You also need to set up the AWS Command Line Interface (AWS CLI). Many of the tutorials use the AWS CLI.

To complete the setup, follow the instructions in the following topics:

## Set Up an AWS Account and Create an Administrator User

### Sign up for AWS

When you sign up for Amazon Web Services (AWS), your AWS account is automatically signed up for all services in AWS, including AWS Lambda. You are charged only for the services that you use.

With AWS Lambda, you pay only for the resources you use. For more information about AWS Lambda usage rates, see the [AWS Lambda product page](#). If you are a new AWS customer, you can get started with AWS Lambda for free. For more information, see [AWS Free Usage Tier](#).

If you already have an AWS account, skip to the next task. If you don't have an AWS account, use the following procedure to create one.

#### To create an AWS account

1. Open <https://aws.amazon.com/>, and then choose **Create an AWS Account**.

##### Note

This might be unavailable in your browser if you previously signed into the AWS Management Console. In that case, choose **Sign in to a different account**, and then choose **Create a new AWS account**.

2. Follow the online instructions.

Part of the sign-up procedure involves receiving a phone call and entering a PIN using the phone keypad.

Note your AWS account ID, because you'll need it for the next task.

### Create an IAM User

Services in AWS, such as AWS Lambda, require that you provide credentials when you access them, so that the service can determine whether you have permissions to access the resources owned by

that service. The console requires your password. You can create access keys for your AWS account to access the AWS CLI or API. However, we don't recommend that you access AWS using the credentials for your AWS account. Instead, we recommend that you use AWS Identity and Access Management (IAM). Create an IAM user, add the user to an IAM group with administrative permissions, and then grant administrative permissions to the IAM user that you created. You can then access AWS using a special URL and that IAM user's credentials.

If you signed up for AWS, but you haven't created an IAM user for yourself, you can create one using the IAM console.

The Getting Started exercises and tutorials in this guide assume you have a user (`adminuser`) with administrator privileges. When you follow the procedure, create a user with name `adminuser`.

### To create an IAM user for yourself and add the user to an Administrators group

1. Use your AWS account email address and password to sign in as the *AWS account root user* to the IAM console at <https://console.aws.amazon.com/iam/>.

#### Note

We strongly recommend that you adhere to the best practice of using the **Administrator** IAM user below and securely lock away the root user credentials. Sign in as the root user only to perform a few [account and service management tasks](#).

2. In the navigation pane of the console, choose **Users**, and then choose **Add user**.
3. For **User name**, type **Administrator**.
4. Select the check box next to **AWS Management Console access**, select **Custom password**, and then type the new user's password in the text box. You can optionally select **Require password reset** to force the user to create a new password the next time the user signs in.
5. Choose **Next: Permissions**.
6. On the **Set permissions for user** page, choose **Add user to group**.
7. Choose **Create group**.
8. In the **Create group** dialog box, type **Administrators**.
9. For **Filter**, choose **Job function**.
10. In the policy list, select the check box for **AdministratorAccess**. Then choose **Create group**.
11. Back in the list of groups, select the check box for your new group. Choose **Refresh** if necessary to see the group in the list.
12. Choose **Next: Review** to see the list of group memberships to be added to the new user. When you are ready to proceed, choose **Create user**.

You can use this same process to create more groups and users, and to give your users access to your AWS account resources. To learn about using policies to restrict users' permissions to specific AWS resources, go to [Access Management](#) and [Example Policies](#).

### To sign in as the new IAM user

1. Sign out of the AWS Management Console.
2. Use the following URL format to log in to the console:

```
https://aws_account_number.signin.aws.amazon.com/console/
```

The `aws_account_number` is your AWS account ID without hyphen. For example, if your AWS account ID is 1234-5678-9012, your AWS account number is 123456789012. For information about how to find your account number, see [Your AWS Account ID and Its Alias](#) in the *IAM User Guide*.

3. Enter the IAM user name and password that you just created. When you're signed in, the navigation bar displays *your\_user\_name @ your aws account id*.

If you don't want the URL for your sign-in page to contain your AWS account ID, you can create an account alias.

#### To create or remove an account alias

1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
2. On the navigation pane, choose **Dashboard**.
3. Find the IAM users sign-in link.
4. To create the alias, click **Customize**, enter the name you want to use for your alias, and then choose **Yes, Create**.
5. To remove the alias, choose **Customize**, and then choose **Yes, Delete**. The sign-in URL reverts to using your AWS account ID.

To sign in after you create an account alias, use the following URL:

```
https://your_account_alias.signin.aws.amazon.com/console/
```

To verify the sign-in link for IAM users for your account, open the IAM console and check under **IAM users sign-in link**: on the dashboard.

For more information about IAM, see the following:

- [AWS Identity and Access Management \(IAM\)](#)
- [Getting Started](#)
- [IAM User Guide](#)

## Next Step

[Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#)

# Set Up the AWS Command Line Interface (AWS CLI)

All the exercises in this guide assume that you are using administrator user credentials (`adminuser`) in your account to perform the operations. For instructions on creating an administrator user in your AWS account, see [Set Up an AWS Account and Create an Administrator User \(p. 4\)](#), and then follow the steps to download and configure the AWS Command Line Interface (AWS CLI).

#### To set up the AWS CLI

1. Download and configure the AWS CLI. For instructions, see the following topics in the [AWS Command Line Interface User Guide](#).
  - [Getting Set Up with the AWS Command Line Interface](#)
  - [Configuring the AWS Command Line Interface](#)
2. Add a named profile for the administrator user in the [AWS CLI config file](#). You use this profile when executing the AWS CLI commands. For more information on creating this profile, see [Named Profiles](#).

```
[profile adminuser]
aws_access_key_id = adminuser access key ID
aws_secret_access_key = adminuser secret access key
region = aws-region
```

For a list of available AWS regions, see [Regions and Endpoints](#) in the *Amazon Web Services General Reference*.

3. Verify the setup by entering the following commands at the command prompt.

- Try the help command to verify that the AWS CLI is installed on your computer:

```
aws help
```

- Try a Lambda command to verify the user can reach AWS Lambda. This command lists Lambda functions in the account, if any. The AWS CLI uses the `adminuser` credentials to authenticate the request.

```
aws lambda list-functions --profile adminuser
```

## Next Step

[Install SAM CLI \(p. 7\)](#)

# Install SAM CLI

SAM CLI is a tool that also allows faster, iterative development of your Lambda function code, which is explained at [Test Your Serverless Applications Locally Using SAM CLI \(Public Beta\) \(p. 99\)](#). To use SAM CLI, you first need to install Docker.

## Installing Docker

Docker is an open-source software container platform that allows you to build, manage and test applications, whether you're running on Linux, Mac or Windows. For more information and download instructions, see [Docker](#).

Once you have Docker installed, SAM CLI automatically provides a customized Docker image called `docker-lambda`. This image is designed specifically by an AWS partner to simulate the live AWS Lambda execution environment. This environment includes installed software, libraries, security permissions, environment variables, and other features outlined at [Lambda Execution Environment and Available Libraries \(p. 391\)](#).

Using `docker-lambda`, you can invoke your Lambda function locally. In this environment, your serverless applications execute and perform much as in the AWS Lambda runtime, without your having to redeploy the runtime. Their execution and performance in this environment reflect such considerations as timeouts and memory use.

### Important

Because this is a simulated environment, there is no guarantee that your local testing results will exactly match those in the actual AWS runtime.

For more information, see [Docker Lambda on GitHub](#). (If you don't have a Github account, you can create one for free and then access Docker Lambda).

## Installing SAM CLI

You can run SAM CLI on Linux, Mac, and Windows environments. The easiest way to install SAM CLI is to use [pip](#).

To use pip, you must have [Python 2.7](#) installed and pointed to in your system's Environment path.

**Note**

In a Windows environment, you run pip from the \Python27\Scripts directory.

```
pip install aws-sam-cli
```

Then verify that the installation succeeded.

```
sam --version
```

You should see something similar to the following:

```
SAM CLI, version 0.3.0
```

If pip doesn't work for you, you can download the latest binary and start using SAM CLI immediately. You can find the binaries under the Releases section in the [SAM CLI GitHub Repository](#).

To begin using the SAM CLI with your serverless applications, see [Test Your Serverless Applications Locally Using SAM CLI \(Public Beta\) \(p. 99\)](#)

## Next Step

[Create a Simple Lambda Function and Explore the Console \(p. 8\)](#)

## Create a Simple Lambda Function and Explore the Console

In this Getting Started exercise you first create a Lambda function using the AWS Lambda console. Next, you manually invoke the Lambda function using sample event data. AWS Lambda executes the Lambda function and returns results. You then verify execution results, including the logs that your Lambda function created and various CloudWatch metrics.

As you follow the steps, you will also familiarize yourself with the AWS Lambda console including:

- Explore the blueprints. Each blueprint provides sample code and sample configurations that enable you to create Lambda functions with just a few clicks.
- View and update configuration information of your Lambda function.
- Invoke a Lambda function manually and explore results in the **Execution results** section.
- Monitor CloudWatch metrics in the console.

## Preparing for the Getting Started

First, you need to sign up for an AWS account and create an administrator user in your account. For instructions, see [Set Up an AWS Account \(p. 4\)](#).

## Next Step

[Create a Simple Lambda Function \(p. 9\)](#)

# Create a Simple Lambda Function

Follow the steps in this section to create a simple Lambda function.

### To create a Lambda function

1. Sign in to the AWS Management Console and open the AWS Lambda console.
2. Note that AWS Lambda offers a simple `Hello World` function upon introduction under the **How it works** label and includes a **Run** option, allowing you to invoke the function as a general introduction. This tutorial introduces additional options you have to create, test and update your Lambda functions, as well as other features provided by the Lambda console and provides links to each, inviting you to explore each one in depth.

Choose **Create a function** under the **Get Started** section to proceed.

#### Note

The console shows the **Get Started** page only if you do not have any Lambda functions created. If you have created functions already, you will see the **Lambda > Functions** page. On the list page, choose **Create a function** to go to the **Create function** page.

3. On the **Create function** page, you are presented with three options:
  - **Author from scratch**
  - **Blueprints**
  - **Serverless Application Repository**

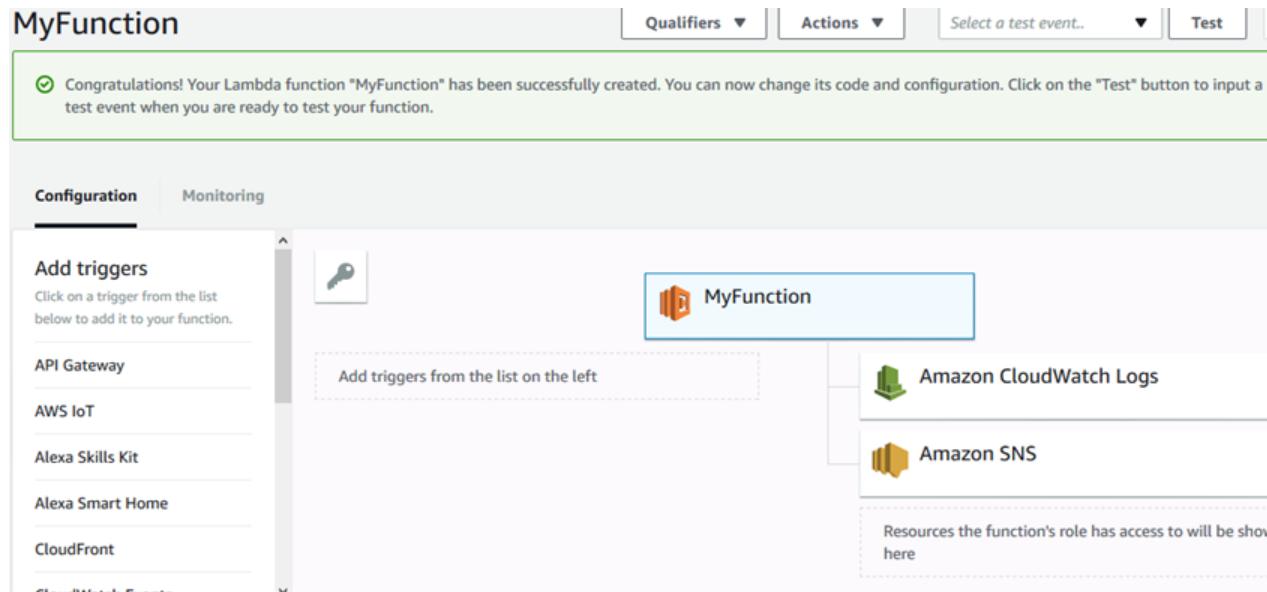
For more information on using the Serverless Application Repository, see [What Is the AWS Serverless Application Repository?](#)

- a. If you'd like to review the blueprints, choose the **Blueprints** button, which will display the available blueprints. You can also use the **Filter** to search for specific blueprints. For example:
  - Enter `s3` in **Filter** to get only the list of blueprints available to process Amazon S3 events.
  - Enter `dynamodb` in **Filter** to get a list of available blueprints to process Amazon DynamoDB events.
- b. For this Getting Started exercise, choose the **Author from scratch** button.
4. In **Author from scratch**, do the following:
  - In **Name\***, specify your Lambda function name.
  - In **Runtime\***, choose `Python 3.6`.
  - In **Role\***, choose **Create new role from template(s)**:
  - In **Role name\***, enter a name for your role.
  - Leave the **Policy templates** field blank. For the purposes of this introduction, your Lambda function will have the necessary execution permissions.

#### Note

For an in-depth look at AWS Lambda's security policies, see [Authentication and Access Control for AWS Lambda \(p. 340\)](#).

- Choose **Create Function**.
5. Under your new **function-name** page, note the following:



In the **Add triggers** panel, you can optionally choose a service that automatically triggers your Lambda function by choosing one of the service options listed.

- a. Depending on which service you select, you are prompted to provide relevant information for that service. For example, if you select DynamoDB, you need to provide the following:
  - The name of the DynamoDB table
  - Batch size
  - Starting position
- b. For this example, do not configure a trigger.
- In **Function code** note that code is provided. It returns a simple "Hello from Lambda" greeting.
- **Handler** shows `lambda_function.lambda_handler` value. It is the `filename.handler-function`. The console saves the sample code in the `lambda_function.py` file and in the code `lambda_handler` is the function name that receives the event as a parameter when the Lambda function is invoked. For more information, see [Lambda Function Handler \(Python\) \(p. 50\)](#).
- Note the embedded IDE (Integrated Development Environment). To learn more, see [Creating Functions Using the AWS Lambda Console Editor \(p. 106\)](#).
6. Other configuration options on this page include:
  - **Environment variables** – for Lambda functions enable you to dynamically pass settings to your function code and libraries, without making changes to your code. For more information, see [Environment Variables \(p. 377\)](#).
  - **Tags** – are key-value pairs that you attach to AWS resources to better organize them. For more information, see [Tagging Lambda Functions \(p. 334\)](#).
  - **Execution role** – which allows you to administer security on your function, using defined roles and policies or creating new ones. For more information, see [Authentication and Access Control for AWS Lambda \(p. 340\)](#).
  - **Basic settings** – allows you to dictate the memory allocation and timeout limit for your Lambda function. For more information, see [AWS Lambda Limits \(p. 394\)](#).
  - **Network** – allows you to select a VPC your function will access. For more information, see [Configuring a Lambda Function to Access Resources in an Amazon VPC \(p. 133\)](#).

- **Debugging and error handling** – allows you to select a [Dead Letter Queues \(p. 385\)](#) resource to analyze failed function invocation retries. It also allows you to enable active tracing. For more information, see [Using AWS X-Ray \(p. 322\)](#).
- **Concurrency** – allows you to allocate a specific limit of concurrent executions allowed for this function. For more information, see [Function Level Concurrent Execution Limit \(p. 374\)](#).
- **Auditing and compliance** – logs function invocations for operational and risk auditing, governance and compliance. For more information, see [Using AWS Lambda with AWS CloudTrail \(p. 213\)](#).

## Invoke the Lambda Function Manually and Verify Results, Logs, and Metrics

Follow the steps to invoke your Lambda function using the sample event data provided in the console.

1. On the [yourfunction](#) page, choose **Test**.
2. In the **Configure test event** page, choose **Create new test event** and in **Event template**, leave the default **Hello World** option. Enter an **Event name** and note the following sample event template:

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

You can change key and values in the sample JSON, but don't change the event structure. If you do change any keys and values, you must update the sample code accordingly. Choose **Save and test**.

### Note

If you choose to delete the test event, go to the **Configure test event** page and then choose **Delete**.

3. AWS Lambda executes your function on your behalf. The **handler** in your Lambda function receives and then processes the sample event.
4. Upon successful execution, view results in the console.

The screenshot shows the AWS Lambda Test Execution results page. At the top, there's a green checkmark icon next to the text "Execution result: succeeded (logs)". Below this, a "Details" button is highlighted with a blue border. A note below the button says, "The area below shows the result returned by your function execution. [Learn more](#) about returning results from your function." Under the "Details" section, there's a summary table with the following data:

Code SHA-256	EK2s5r/qvcinS/tlz7w9OWqkT6XkRzQ6RtC2JFG3K8o=	Request ID	5e2630d3-d476-11e7-8121-ff2df5001d1f
Duration	9.04 ms	Billed duration	100 ms
Resources configured	128 MB	Max memory used	19 MB

Below the summary is a "Log output" section. It contains a note: "The area below shows the logging calls in your code. These correspond to a single row within the CloudWatch log group corresponding to this Lambda function. [View the CloudWatch log group.](#)" The log output itself is a single row of text:

```
START RequestId: 5e2630d3-d476-11e7-8121-ff2df5001d1f Version: $LATEST  
END RequestId: 5e2630d3-d476-11e7-8121-ff2df5001d1f  
REPORT RequestId: 5e2630d3-d476-11e7-8121-ff2df5001d1f Duration: 9.04 ms Billed Duration: 100 ms Memory Size: 128 MB Max Mem
```

Note the following:

- The **Execution result** section shows the execution status as **succeeded** and also shows the function execution results, returned by the `return` statement.

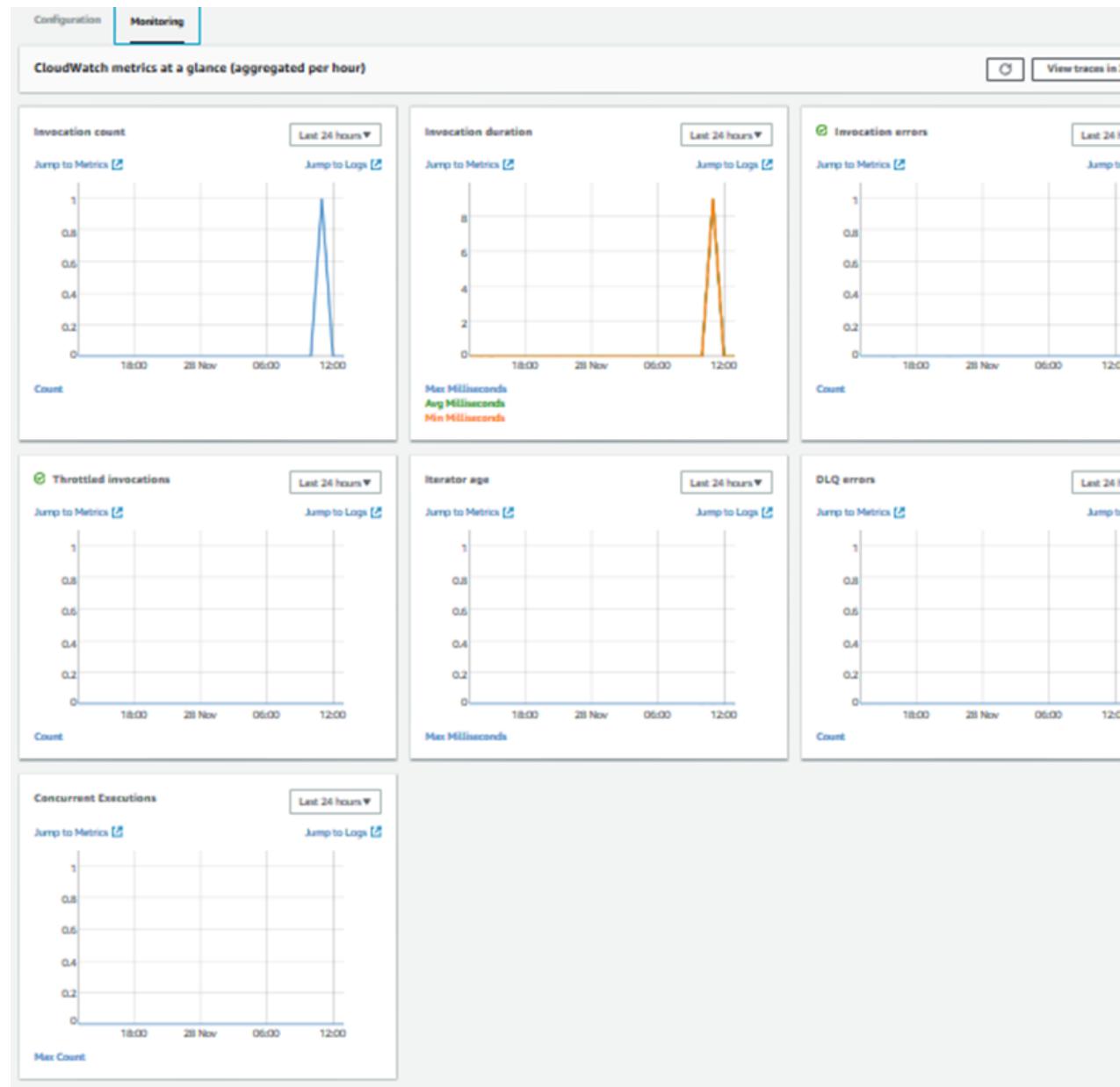
**Note**

The console always uses the `RequestResponse` invocation type (synchronous invocation) when invoking a Lambda function which causes AWS Lambda to return a response immediately. For more information, see [Invocation Types \(p. 148\)](#).

- 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 AWS Lambda generates for each execution. These are the logs written to CloudWatch by the Lambda function. The AWS Lambda console shows these logs for your convenience.

Note that the **Click here** link shows logs in the CloudWatch console. The function then adds logs to Amazon CloudWatch in the log group that corresponds to the Lambda function.

5. Run the Lambda function a few times to gather some metrics that you can view in the next step.
6. Choose the **Monitoring** tab to view the CloudWatch metrics for your Lambda function. This page shows the CloudWatch metrics.



Note the following:

- The X-axis shows the past 24 hours from the current time.
- Invocation count shows the number of invocations during this interval.
- Invocation duration shows how long it took for your Lambda function to run. It shows minimum, maximum, and average time of execution.
- Invocation errors show the number of times your Lambda function failed. You can compare the number of times your function executed and how many times it failed (if any).
- Throttled invocation metrics show whether AWS Lambda throttled your Lambda function invocation. For more information, see [AWS Lambda Limits \(p. 394\)](#).
- Concurrent execution metrics show the number of concurrent invocations of your Lambda function. For more information, see [Managing Concurrency \(p. 373\)](#).

- The AWS Lambda console shows these CloudWatch metrics for your convenience. You can see these metrics in the Amazon CloudWatch console by clicking any of these metrics.

For more information on these metrics and what they mean, see [AWS Lambda CloudWatch Metrics \(p. 320\)](#).

# Lambda Functions

If you are new to AWS Lambda, you might ask: How does AWS Lambda execute my code? How does AWS Lambda know the amount of memory and CPU requirements needed to run my Lambda code? The following sections provide an overview of how a Lambda function works.

In subsequent sections, we cover how the functions you create get invoked, and how to deploy and monitor them. We also recommend reading the **Function Code** and **Function Configuration** sections at [Best Practices for Working with AWS Lambda Functions \(p. 386\)](#).

To begin, we introduce you to the topic that explains the fundamentals of building a Lambda function, [Building Lambda Functions \(p. 15\)](#).

## Building Lambda Functions

You upload your application code in the form of one or more *Lambda functions* to AWS Lambda, a compute service. In turn, AWS Lambda executes the code on your behalf. AWS Lambda takes care of provisioning and managing the servers to run the code upon invocation.

Typically, the lifecycle for an AWS Lambda-based application includes authoring code, deploying code to AWS Lambda, and then monitoring and troubleshooting. The following are general questions that come up in each of these lifecycle phases:

- **Authoring code for your Lambda function** – What languages are supported? Is there a programming model that I need to follow? How do I package my code and dependencies for uploading to AWS Lambda? What tools are available?
- **Uploading code and creating Lambda functions** – How do I upload my code package to AWS Lambda? How do I tell AWS Lambda where to begin executing my code? How do I specify compute requirements like memory and timeout?
- **Monitoring and troubleshooting** – For my Lambda function that is in production, what metrics are available? If there are any failures, how do I get logs or troubleshoot issues?

The following sections provide introductory information and the Example section at the end provides working examples for you to explore.

### Authoring Code for Your Lambda Function

You can author your Lambda function code in the languages that are supported by AWS Lambda. For a list of supported languages, see [Lambda Execution Environment and Available Libraries \(p. 391\)](#). There are tools for authoring code, such as the AWS Lambda console, Eclipse IDE, and Visual Studio IDE. But the available tools and options depend on the following:

- Language you choose to write your Lambda function code.
- Libraries that you use in your code. AWS Lambda runtime provides some of the libraries and you must upload any additional libraries that you use.

The following table lists languages, and the available tools and options that you can use.

Language	Tools and Options for Authoring Code
Node.js	<ul style="list-style-type: none"><li>AWS Lambda console</li><li>Visual Studio, with IDE plug-in (see <a href="#">AWS Lambda Support in Visual Studio</a>)</li><li>Your own authoring environment</li><li>For more information, see <a href="#">Deploying Code and Creating a Lambda Function (p. 16)</a>.</li></ul>
Java	<ul style="list-style-type: none"><li>Eclipse, with AWS Toolkit for Eclipse (see <a href="#">Using AWS Lambda with the AWS Toolkit for Eclipse</a>)</li><li>Your own authoring environment</li><li>For more information, see <a href="#">Deploying Code and Creating a Lambda Function (p. 16)</a>.</li></ul>
C#	<ul style="list-style-type: none"><li>Visual Studio, with IDE plug-in (see <a href="#">AWS Lambda Support in Visual Studio</a>)</li><li>.NET Core (see <a href="#">.NET Core installation guide</a>)</li><li>Your own authoring environment</li><li>For more information, see <a href="#">Deploying Code and Creating a Lambda Function (p. 16)</a>.</li></ul>
Python	<ul style="list-style-type: none"><li>AWS Lambda console</li><li>Your own authoring environment</li><li>For more information, see <a href="#">Deploying Code and Creating a Lambda Function (p. 16)</a>.</li></ul>
Go	<ul style="list-style-type: none"><li>Your own authoring environment</li><li>For more information, see <a href="#">Deploying Code and Creating a Lambda Function (p. 16)</a>.</li></ul>

In addition, regardless of the language you choose, there is a pattern to writing Lambda function code. For example, how you write the handler method of your Lambda function (that is, the method that AWS Lambda first calls when it begins executing the code), how you pass events to the handler, what statements you can use in your code to generate logs in CloudWatch Logs, how to interact with AWS Lambda runtime and obtain information such as the time remaining before timeout, and how to handle exceptions. The [Programming Model \(p. 18\)](#) section provides information for each of the supported languages.

**Note**

After you familiarize yourself with AWS Lambda, see the [Use Cases \(p. 173\)](#), which provide step-by-step instructions to help you explore the end-to-end experience.

## Deploying Code and Creating a Lambda Function

To create a Lambda function, you first package your code and dependencies in a deployment package. Then, you upload the deployment package to AWS Lambda to create your Lambda function.

### Topics

- [Creating a Deployment Package – Organizing Code and Dependencies \(p. 17\)](#)
- [Uploading a Deployment Package – Creating a Lambda Function \(p. 17\)](#)

- [Testing a Lambda Function \(p. 17\)](#)

## Creating a Deployment Package – Organizing Code and Dependencies

You must first organize your code and dependencies in certain ways and create a *deployment package*. Instructions to create a deployment package vary depending on the language you choose to author the code. For example, you can use build plugins such as Jenkins (for Node.js and Python), and Maven (for Java) to create the deployment packages. For more information, see [Creating a Deployment Package \(p. 77\)](#).

When you create Lambda functions using the console, the console creates the deployment package for you, and then uploads it to create your Lambda function.

## Uploading a Deployment Package – Creating a Lambda Function

AWS Lambda provides the [CreateFunction \(p. 412\)](#) operation, which is what you use to create a Lambda function. You can use the AWS Lambda console, AWS CLI, and AWS SDKs to create a Lambda function. Internally, all of these interfaces call the `CreateFunction` operation.

In addition to providing your deployment package, you can provide configuration information when you create your Lambda function including the compute requirements of your Lambda function, the name of the handler method in your Lambda function, and the runtime, which depends on the language you chose to author your code. For more information, see [Lambda Functions \(p. 15\)](#).

## Testing a Lambda Function

If your Lambda function is designed to process events of a specific type, you can use sample event data to test your Lambda function using one of the following methods:

- Test your Lambda function in the console.
- Test your Lambda function using the AWS CLI. You can use the `Invoke` method to invoke your Lambda function and pass in sample event data.
- Test your Lambda function locally using [Test Your Serverless Applications Locally Using SAM CLI \(Public Beta\) \(p. 99\)](#).

The console provides sample event data. The same data is also provided in the [Sample Events Published by Event Sources \(p. 162\)](#) topic, which you can use in the AWS CLI to invoke your Lambda function.

## Monitoring and Troubleshooting

After your Lambda function is in production, AWS Lambda automatically monitors functions on your behalf, reporting metrics through Amazon CloudWatch. For more information, see [Accessing Amazon CloudWatch Metrics for AWS Lambda \(p. 316\)](#).

To help you troubleshoot failures in a function, Lambda logs all requests handled by your function and also automatically stores logs that your code generates in Amazon CloudWatch Logs. For more information, see [Accessing Amazon CloudWatch Logs for AWS Lambda \(p. 318\)](#).

## AWS Lambda-Based Application Examples

This guide provides several examples with step-by-step instructions. If you are new to AWS Lambda, we recommend you try the following exercises:

- [Getting Started \(p. 3\)](#) – The Getting Started exercise provides a console-based experience. Sample code is provided for your preferred runtimes. You can also code within the console, using the [Code Editor](#) and upload it to AWS Lambda, and test it using sample event data provided in the console.
- [Use Cases \(p. 173\)](#) – If you cannot author your code using the console, you must create your own deployment packages and use the AWS CLI (or SDKs) to create your Lambda function. For more information, see [Authoring Code for Your Lambda Function \(p. 15\)](#). Most examples in the Use Cases section use the AWS CLI. If you are new to AWS Lambda, we recommend that you try one of these exercises.

## Related Topics

The following topics provide additional information.

[Programming Model \(p. 18\)](#)

[Creating a Deployment Package \(p. 77\)](#)

[AWS Lambda Function Versioning and Aliases \(p. 277\)](#)

[Using Amazon CloudWatch \(p. 314\)](#)

## Programming Model

You write code for your Lambda function in one of the languages AWS Lambda supports. Regardless of the language you choose, there is a common pattern to writing code for a Lambda function that includes the following core concepts:

- **Handler** – Handler is the function AWS Lambda calls to start execution of your Lambda function. You identify the handler when you create your Lambda function. When a Lambda function is invoked, AWS Lambda starts executing your code by calling the handler function. AWS Lambda passes any event data to this handler as the first parameter. Your handler should process the incoming event data and may invoke any other functions/methods in your code.
- **The context object and how it interacts with Lambda at runtime** – AWS Lambda also passes a context object to the handler function, as the second parameter. Via this context object your code can interact with AWS Lambda. For example, your code can find the execution time remaining before AWS Lambda terminates your Lambda function.

In addition, for languages such as Node.js, there is an asynchronous platform that uses callbacks. AWS Lambda provides additional methods on this context object. You use these context object methods to tell AWS Lambda to terminate your Lambda function and optionally return values to the caller.

- **Logging** – Your Lambda function can contain logging statements. AWS Lambda writes these logs to CloudWatch Logs. Specific language statements generate log entries, depending on the language you use to author your Lambda function code.
- **Exceptions** – Your Lambda function needs to communicate the result of the function execution to AWS Lambda. Depending on the language you author your Lambda function code, there are different ways to end a request successfully or to notify AWS Lambda an error occurred during execution. If you invoke the function synchronously, then AWS Lambda forwards the result back to the client.

### Note

Your Lambda function code must be written in a stateless style, and have no affinity with the underlying compute infrastructure. Your code should expect local file system access, child processes, and similar artifacts to be limited to the lifetime of the request. Persistent state should be stored in Amazon S3, Amazon DynamoDB, or another cloud storage service. Requiring functions to be stateless enables AWS Lambda to launch as many copies of a function as needed to scale to the incoming rate of events and requests. These functions may not always run on the same compute instance from request to request, and a given instance of your Lambda function may be used more than once by AWS Lambda. For more information, see [Best Practices for Working with AWS Lambda Functions \(p. 386\)](#)

The following language specific topics provide detailed information:

- [Programming Model\(Node.js\) \(p. 19\)](#)
- [Programming Model for Authoring Lambda Functions in Java \(p. 30\)](#)
- [Programming Model for Authoring Lambda Functions in C# \(p. 67\)](#)
- [Programming Model for Authoring Lambda Functions in Python \(p. 50\)](#)
- [Programming Model for Authoring Lambda Functions in Go \(p. 58\)](#)

## Programming Model(Node.js)

AWS Lambda currently supports the following Node.js runtimes:

- Node.js runtime v8.10 (runtime = nodejs8.10)
- Node.js runtime v6.10 (runtime = nodejs6.10)
- Node.js runtime v4.3 (runtime = nodejs4.3)\*
- Node.js runtime v0.10.42 (runtime = nodejs)\*

### Important

\*Node v0.10.42 and Node v4.3 are currently marked as deprecated. For more information, see [Runtime Support Policy \(p. 390\)](#). You must migrate existing functions to the newer Node.js runtime versions available on AWS Lambda (nodejs8.10 or nodejs6.10) as soon as possible.

When you create a Lambda function, you specify the runtime that you want to use. For more information, see `runtime` parameter of [CreateFunction \(p. 412\)](#).

The following sections explain how [common programming patterns and core concepts](#) apply when authoring Lambda function code in Node.js. The programming model described in the following sections applies to all supported runtime versions, except where indicated.

### Topics

- [Lambda Function Handler \(Node.js\) \(p. 19\)](#)
- [The Context Object \(Node.js\) \(p. 22\)](#)
- [Logging \(Node.js\) \(p. 25\)](#)
- [Function Errors \(Node.js\) \(p. 27\)](#)

## Lambda Function Handler (Node.js)

AWS Lambda invokes your Lambda function via a `handler` object. A `handler` represents the name of your Lambda function (and serves as the entry point that AWS Lambda uses to execute your function code). For example:

```
exports.myHandler = function(event, context) {  
    ...  
}
```

- **myHandler** – This is the name of the function AWS Lambda invokes. Suppose you save this code as `helloworld.js`. Then, `myHandler` is the function that contains your Lambda function code and `helloworld` is the name of the file that represents your deployment package. For more information, see [Creating a Deployment Package \(Node.js\) \(p. 78\)](#).

AWS Lambda supports two invocation types:

- **RequestResponse**, or *synchronous execution*: AWS Lambda returns the result of the function call to the client invoking the Lambda function. If the handler code of your Lambda function does not specify a return value, AWS Lambda will automatically return `null` for that value.
- **Event**, or *asynchronous execution*: AWS Lambda will discard any results of the function call.

**Note**

If you discover that your Lambda function does not process the event using asynchronous invocation, you can investigate the failure using [Dead Letter Queues \(p. 385\)](#).

Event sources can range from a supported AWS service or custom applications that invoke your Lambda function. For examples, see [Sample Events Published by Event Sources \(p. 162\)](#)

- `context` – AWS Lambda uses this parameter to provide details of your Lambda function's execution. For more information, see [The Context Object \(Node.js\) \(p. 22\)](#).

## Using the Callback Parameter

The Node.js runtimes v6.10 and v8.10 support the optional `callback` parameter. You can use it to explicitly return information back to the caller. The general syntax is:

```
callback(Error error, Object result);
```

Where:

- `error` – is an optional parameter that you can use to provide results of the failed Lambda function execution. When a Lambda function succeeds, you can pass `null` as the first parameter.
- `result` – is an optional parameter that you can use to provide the result of a successful function execution. The result provided must be `JSON.stringify` compatible. If an `error` is provided, this parameter is ignored.

If you don't use `callback` in your code, AWS Lambda will call it implicitly and the return value is `null`.

When the callback is called (explicitly or implicitly), AWS Lambda continues the Lambda function invocation until the event loop is empty.

The following are example callbacks:

```
callback();      // Indicates success but no information returned to the caller.  
callback(null); // Indicates success but no information returned to the caller.  
callback(null, "success"); // Indicates success with information returned to the caller.  
callback(error); // Indicates error with error information returned to the caller.
```

AWS Lambda treats any non-null value for the `error` parameter as a handled exception.

Note the following:

- Regardless of the invocation type specified at the time of the Lambda function invocation (see [Invoke \(p. 450\)](#)), the callback method automatically logs the string representation of non-null values of `error` to the Amazon CloudWatch Logs stream associated with the Lambda function.
- If the Lambda function was invoked synchronously (using the `RequestResponse` invocation type), the callback returns a response body as follows:
  - If `error` is null, the response body is set to the string representation of `result`.
  - If the `error` is not null, the `error` value will be populated in the response body.

**Note**

When the `callback(error, null)` (and `callback(error)`) is called, Lambda will log the first 256 KB of the error object. For a larger error object, AWS Lambda truncates the log and displays the text Truncated by Lambda next to the error object.

If you are using runtime version 8.10, you can include the `async` keyword:

```
exports.myHandler = async function(event, context) {  
    ...  
  
    // return information to the caller.  
}
```

**Example**

Consider the following Node.js example code.

```
exports.myHandler = function(event, context, callback) {  
    console.log("value1 = " + event.key1);  
    console.log("value2 = " + event.key2);  
    callback(null, "some success message");  
    // or  
    // callback("some error type");  
}
```

This example has one function, `myHandler`

In the function, the `console.log()` statements log some of the incoming event data to CloudWatch Logs. When the `callback` parameter is called, the Lambda function exits only after the event loop passed is empty.

If you want to use the `async` feature provided by the v8.10 runtime, consider the following code sample:

```
exports.myHandler = async function(event, context) {  
    console.log("value1 = " + event.key1);  
    console.log("value2 = " + event.key2);  
    return "some success message";  
    // or  
    // throw new Error("some error type");  
}
```

**To upload and test this code as a Lambda function (console)**

1. In the console, create a Lambda function using the following information:
  - Use the hello-world blueprint.
  - The sample uses **nodejs6.10** as the **runtime** but you can also select **nodejs8.10**. The code samples provided will work for any version.

For instructions to create a Lambda function using the console, see [Create a Simple Lambda Function \(p. 9\)](#).

2. Replace the template code with the code provided in this section and create the function.
3. Test the Lambda function using the **Sample event template** called **Hello World** provided in the Lambda console.

## The Context Object (Node.js)

While a Lambda function is executing, it can interact with AWS Lambda to get useful runtime information such as:

- How much time is remaining before AWS Lambda terminates your Lambda function (timeout is one of the Lambda function configuration properties).
- The CloudWatch log group and log stream associated with the Lambda function that is executing.
- The AWS request ID returned to the client that invoked the Lambda function. You can use the request ID for any follow up inquiry with AWS support.
- If the Lambda function is invoked through AWS Mobile SDK, you can learn more about the mobile application calling the Lambda function.

AWS Lambda provides this information via the `context` object that the service passes as the second parameter to your Lambda function handler. For more information, see [Lambda Function Handler \(Node.js\) \(p. 19\)](#).

The following sections provide an example Lambda function that uses the `context` object, and then lists all of the available methods and attributes.

### Example

Consider the following Node.js example. The handler receives runtime information via a `context` parameter.

```
console.log('Loading function');

exports.handler = function(event, context, callback) {
    //console.log('Received event:', JSON.stringify(event, null, 2));
    console.log('value1 =', event.key1);
    console.log('value2 =', event.key2);
    console.log('value3 =', event.key3);
    console.log('remaining time =', context.getRemainingTimeInMillis());
    console.log('functionName =', context.functionName);
    console.log('AWSrequestID =', context.awsRequestId);
    console.log('logGroupName =', context.log_group_name);
    console.log('logStreamName =', context.log_stream_name);
    console.log('clientContext =', context.clientContext);
    if (typeof context.identity !== 'undefined') {
        console.log('Cognito
identity ID =', context.identity.cognitoIdentityId);
    }
    callback(null, event.key1); // Echo back the first key value
    // or
    // callback("some error type");
};
```

The handler code in this example logs some of the runtime information of the Lambda function to CloudWatch. If you invoke the function using the Lambda console, the console displays the logs in the **Log output** section. You can create a Lambda function using this code and test it using the console.

## To test this code in the AWS Lambda console

1. In the console, create a Lambda function using the hello-world blueprint. In **runtime**, choose **nodejs6.10**. For instructions on how to do this, see [Create a Simple Lambda Function \(p. 9\)](#).
2. Test the function, and then you can also update the code to get more context information.

## The Context Object Methods (Node.js)

The context object provides the following methods.

### `context.getRemainingTimeInMillis()`

Returns the approximate remaining execution time (before timeout occurs) of the Lambda function that is currently executing. The timeout is one of the Lambda function configuration. When the timeout reaches, AWS Lambda terminates your Lambda function.

You can use this method to check the remaining time during your function execution and take appropriate corrective action at run time.

The general syntax is:

```
context.getRemainingTimeInMillis();
```

## The Context Object Properties (Node.js)

The `context` object provides the following property that you can update:

### `callbackWaitsForEmptyEventLoop`

The default value is true. This property is useful only to modify the default behavior of the callback. By default, the callback will wait until the event loop is empty before freezing the process and returning the results to the caller. You can set this property to false to request AWS Lambda to freeze the process soon after the callback is called, even if there are events in the event loop. AWS Lambda will freeze the process, any state data and the events in the event loop (any remaining events in the event loop processed when the Lambda function is called next and if AWS Lambda chooses to use the frozen process). For more information about callback, see [Using the Callback Parameter \(p. 20\)](#).

In addition, the `context` object provides the following properties that you can use obtain runtime information:

### `functionName`

Name of the Lambda function that is executing.

### `functionVersion`

The Lambda function version that is executing. If an alias is used to invoke the function, then `function_version` will be the version the alias points to.

### `invokedFunctionArn`

The ARN used to invoke this function. It can be a function ARN or an alias ARN. An unqualified ARN executes the `$LATEST` version and aliases execute the function version it is pointing to.

### `memoryLimitInMB`

Memory limit, in MB, you configured for the Lambda function. You set the memory limit at the time you create a Lambda function and you can change it later.

#### **awsRequestId**

AWS request ID associated with the request. This is the ID returned to the client that called the `invoke` method.

##### **Note**

If AWS Lambda retries the invocation (for example, in a situation where the Lambda function that is processing Kinesis records throws an exception), the request ID remains the same.

#### **logGroupName**

The name of the CloudWatch log group where you can find logs written by your Lambda function.

#### **logStreamName**

The name of the CloudWatch log group where you can find logs written by your Lambda function. The log stream may or may not change for each invocation of the Lambda function.

The value is null if your Lambda function is unable to create a log stream, which can happen if the execution role that grants necessary permissions to the Lambda function does not include permissions for the CloudWatch actions.

#### **identity**

Information about the Amazon Cognito identity provider when invoked through the AWS Mobile SDK. It can be null.

- `identity.cognitoIdentityId`
- `identity.cognitoIdentityPoolId`

For more information about the exact values for a specific mobile platform, see [Identity Context](#) in the *AWS Mobile SDK for iOS Developer Guide*, and [Identity Context](#) in the AWS Mobile SDK for Android Developer Guide.

#### **clientContext**

Information about the client application and device when invoked through the AWS Mobile SDK. It can be null. Using `clientContext`, you can get the following information:

- `clientContext.client.installation_id`
- `clientContext.client.app_title`
- `clientContext.client.app_version_name`
- `clientContext.client.app_version_code`
- `clientContext.client.app_package_name`
- `clientContext.Custom`

Custom values set by the mobile client application.

- `clientContext.env.platform_version`
- `clientContext.env.platform`
- `clientContext.env.make`
- `clientContext.env.model`
- `clientContext.env.locale`

For more information about the exact values for a specific mobile platform, see [Client Context](#) in the *AWS Mobile SDK for iOS Developer Guide*, and [Client Context](#) in the *AWS Mobile SDK for Android Developer Guide*.

## Logging (Node.js)

Your Lambda function can contain logging statements. AWS Lambda writes these logs to CloudWatch. If you use the Lambda console to invoke your Lambda function, the console displays the same logs.

The following Node.js statements generate log entries:

- `console.log()`
- `console.error()`
- `console.warn()`
- `console.info()`

For example, consider the following Node.js code examples:

- The first sample can be written using either runtime version 6.10 or 4.3.

```
console.log('Loading function');

exports.handler = function(event, context, callback) {
    //console.log('Received event:', JSON.stringify(event, null, 2));
    console.log('value1 =', event.key1);
    console.log('value2 =', event.key2);
    console.log('value3 =', event.key3);
    callback(null, event.key1); // Echo back the first key value

};
```

- The second sample uses the Node.js `async` feature, available only in runtime versions 8.10 or later.

```
console.log('Loading function');

exports.handler = async function(event) {
    //console.log('Received event:', JSON.stringify(event, null, 2));
    console.log('value1 =', event.key1);
    console.log('value2 =', event.key2);
    console.log('value3 =', event.key3);
    return event.key1 // Echo back the first key value
};
```

In either case, the following screenshot shows an example **Log output** section in the Lambda console. You can examine the same information in CloudWatch Logs. For more information, see [Accessing Amazon CloudWatch Logs for AWS Lambda \(p. 318\)](#).

The screenshot shows the AWS Lambda console after a successful function execution. The top bar indicates a green checkmark and the text "Execution result: succeeded (logs)". Below this, there's a "Details" section with a note about returning results from your function. A box contains the return value "value1". The "Summary" section lists the Code SHA-256, Request ID, Duration, and Billed duration. The "Log output" section displays CloudWatch logs for the request, including START, MIDDLE, and END events, along with a REPORT event at the end.

Log Type	Timestamp	Request ID	Log Content
START	2017-07-20T18:24:06.610Z	9c454e0d-6d78-11e7-b93a-439d5c9ba65d	value1 = value1
MIDDLE	2017-07-20T18:24:06.629Z	9c454e0d-6d78-11e7-b93a-439d5c9ba65d	value2 = value2
MIDDLE	2017-07-20T18:24:06.629Z	9c454e0d-6d78-11e7-b93a-439d5c9ba65d	value3 = value3
END	2017-07-20T18:24:06.629Z	9c454e0d-6d78-11e7-b93a-439d5c9ba65d	
REPORT		9c454e0d-6d78-11e7-b93a-439d5c9ba65d	Duration: 472.47 ms      Billed Duration: 500 ms      Memory Size: 128 MB      Max Memory Used: 18 MB

The console uses the `RequestResponse` invocation type (synchronous invocation) when invoking the function, therefore it gets the return value (`value1`) back from AWS Lambda which the console displays.

### To test the preceding Node.js code in AWS Lambda console

1. In the console, create a Lambda function using the hello-world blueprint. Make sure to select the Node.js as the **runtime**. For instructions on how to do this, see [Create a Simple Lambda Function \(p. 9\)](#).
2. Test the Lambda function using the **Sample event template** called **Hello World** provided in the Lambda console. You can also update the code and try other logging methods and properties discussed in this section.

For step-by-step instructions, see [Getting Started \(p. 3\)](#).

### Finding Logs

You can find the logs that your Lambda function writes, as follows:

- **In the AWS Lambda console** – The **Log output** section in the AWS Lambda console shows the logs.
- **In the response header, when you invoke a Lambda function programmatically** – If you invoke a Lambda function programmatically, you can add the `LogType` parameter to retrieve the last 4 KB of log data that is written to CloudWatch Logs. AWS Lambda returns this log information in the `x-amz-log-results` header in the response. For more information, see [Invoke](#).

If you use AWS CLI to invoke the function, you can specify the `--log-type` parameter with value `Tail` to retrieve the same information.

- **In CloudWatch Logs** – To find your logs in CloudWatch you need to know the log group name and log stream name. You can get that information by adding the `context.logGroupName`, and

`context.logStreamName` methods in your code. When you run your Lambda function, the resulting logs in the console or CLI will show you the log group name and log stream name.

## Function Errors (Node.js)

If your Lambda function notifies AWS Lambda that it failed to execute properly, Lambda will attempt to convert the error object to a String. Consider the following example:

```
console.log('Loading function');

exports.handler = function(event, context, callback) {
    // This example code only throws error.
    var error = new Error("something is wrong");
    callback(error);

};
```

When you invoke this Lambda function, it will notify AWS Lambda that function execution completed with an error and passes the error information to AWS Lambda. AWS Lambda returns the error information back to the client:

```
{
  "errorMessage": "something is wrong",
  "errorType": "Error",
  "stackTrace": [
    "exports.handler (/var/task/index.js:10:17)"
  ]
}
```

You would get the same result if you write the function using the `async` feature of Node.js runtime version 8.10. For example:

```
exports.handler = async function(event, context) {
    function AccountAlreadyExistsError(message) {
        this.name = "AccountAlreadyExistsError";
        this.message = message;
    }
    AccountAlreadyExistsError.prototype = new Error();

    const error = new AccountAlreadyExistsError("Account is in use!");
    throw error
};
```

Again, when this Lambda function is invoked, it will notify AWS Lambda that function execution completed with an error and passes the error information to AWS Lambda. AWS Lambda returns the error information back to the client:

```
{
  "errorMessage": "Acccount is in use!",
  "errorType": "Error",
  "stackTrace": [
    "exports.handler (/var/task/index.js:10:17)"
  ]
}
```

Note that the error information is returned as the `stackTrace` JSON array of stack trace elements.

How you get the error information back depends on the invocation type that the client specifies at the time of function invocation:

- If a client specifies the `RequestResponse` invocation type (that is, synchronous execution), it returns the result to the client that made the invoke call.

For example, the console always use the `RequestResponse` invocation type, so the console will display the error in the **Execution result** section as shown:

The screenshot shows the "Execution result" section of the AWS Lambda console. It displays an error message: "Execution result: failed (logs)" with a "Details" link. Below the link is a note: "The area below shows the result returned by your function execution. [Learn more](#) about returning results from your function." A code block shows the JSON response: {"errorMessage": "Something went wrong"}.

The same information is also sent to CloudWatch and the **Log output** section shows the same logs.

The screenshot shows the "Log output" section of the AWS Lambda console. It displays CloudWatch logs for a failed request. The logs show the start of the request, multiple log entries with timestamp, RequestId, and log details, and the end of the request. One log entry contains the error message: {"errorMessage": "Something went wrong"}. The logs also show metrics like Duration and Billed duration.

Summary	Log output
Code SHA-256 U4b2T1lAJ6JHw7VXNt W0Zs3RXCtox6Ph3Jw3 7xQfO6g=	START RequestId: 093bf2a1-6cba-11e7-b9ad-850729ae85a8 Version: \$LATEST 2017-07-19T19:39:53.469Z 093bf2a1-6cba-11e7-b9ad-850729ae85a8 value3 = undefined 2017-07-19T19:39:53.469Z 093bf2a1-6cba-11e7-b9ad-850729ae85a8 value4 = undefined 2017-07-19T19:39:53.488Z 093bf2a1-6cba-11e7-b9ad-850729ae85a8 value5 = undefined {"errorMessage": "Something went wrong"} END RequestId: 093bf2a1-6cba-11e7-b9ad-850729ae85a8 REPORT RequestId: 093bf2a1-6cba-11e7-b9ad-850729ae85a8 Duration: 41.24 ms Billed Duration: 100 ms Memory Size: 128 MB Max Memory Used: 17 MB
Request ID 093bf2a1-6cba-11e7-b9ad-850729ae85a8	
Duration 41.24 ms	
Billed duration 100 ms	

- If a client specifies the `Event` invocation type (that is, asynchronous execution), AWS Lambda will not return anything. Instead, it logs the error information to [CloudWatch Logs](#). You can also see the error metrics in [CloudWatch Metrics](#).

Depending on the event source, AWS Lambda may retry the failed Lambda function. For example, if Kinesis is the event source, AWS Lambda will retry the failed invocation until the Lambda function succeeds or the records in the stream expire. For more information on retries, see [Understanding Retry Behavior \(p. 152\)](#).

### To test the preceding Node.js code (console)

- In the console, create a Lambda function using the hello-world blueprint. In **runtime**, choose **Node.js** and, in **Role**, choose **Basic execution role**. For instructions on how to do this, see [Create a Simple Lambda Function \(p. 9\)](#).
- Replace the template code with the code provided in this section.
- Test the Lambda function using the **Sample event template** called **Hello World** provided in the Lambda console.

## Function Error Handling

You can create custom error handling to raise an exception directly from your Lambda function and handle it directly (Retry or Catch) within an AWS Step Functions State Machine. For more information, see [Handling Error Conditions Using a State Machine](#).

Consider a `CreateAccount` state is a [task](#) that writes a customer's details to a database using a Lambda function.

- If the task succeeds, an account is created and a welcome email is sent.
- If a user tries to create an account for a username that already exists, the Lambda function raises an error, causing the state machine to suggest a different username and to retry the account-creation process.

The following code samples demonstrate how to do this. Note that custom errors in Node.js must extend the `error` prototype.

```
exports.handler = function(event, context, callback) {
    function AccountAlreadyExistsError(message) {
        this.name = "AccountAlreadyExistsError";
        this.message = message;
    }
    AccountAlreadyExistsError.prototype = new Error();

    const error = new AccountAlreadyExistsError("Account is in use!");
    callback(error);
};
```

You can configure Step Functions to catch the error using a [Catch rule](#):

```
{
  "StartAt": "CreateAccount",
  "States": {
    "CreateAccount": {
      "Type": "Task",
      "Resource": "arn:aws:lambda:us-east-1:123456789012:function:CreateAccount",
      "Next": "SendWelcomeEmail",
      "Catch": [
        {
          "ErrorEquals": ["AccountAlreadyExistsError"],
          "Next": "SuggestAccountName"
        }
      ],
      ...
    }
  }
}
```

At runtime, AWS Step Functions catches the error, [transitioning](#) to the `SuggestAccountName` state as specified in the `Next` transition.

### Note

The `name` property of the `Error` object must match the `ErrorEquals` value.

Custom error handling makes it easier to create [serverless](#) applications. This feature integrates with all the languages supported by the Lambda [Programming Model \(p. 18\)](#), allowing you to design your application in the programming languages of your choice, mixing and matching as you go.

To learn more about creating your own serverless applications using AWS Step Functions and AWS Lambda, see [AWS Step Functions](#).

## Programming Model for Authoring Lambda Functions in Java

The following sections explain how [common programming patterns and core concepts](#) apply when authoring Lambda function code in Java.

### Topics

- [Lambda Function Handler \(Java\) \(p. 30\)](#)
- [The Context Object \(Java\) \(p. 40\)](#)
- [Logging \(Java\) \(p. 42\)](#)
- [Function Errors \(Java\) \(p. 46\)](#)
- [Using Earlier Custom Appender for Log4j™ 1.2 \(Not Recommended\) \(p. 48\)](#)
- [\(Optional\) Create a Lambda Function Authored in Java \(p. 49\)](#)

Additionally, note that AWS Lambda provides the following libraries:

- **aws-lambda-java-core** – This library provides the Context object, RequestStreamHandler, and the RequestHandler interfaces. The Context object ([The Context Object \(Java\) \(p. 40\)](#)) provides runtime information about your Lambda function. The predefined interfaces provide one way of defining your Lambda function handler. For more information, see [Leveraging Predefined Interfaces for Creating Handler \(Java\) \(p. 36\)](#).
- **aws-lambda-java-events** – This library provides predefined types that you can use when writing Lambda functions to process events published by Amazon S3, Kinesis, Amazon SNS, and Amazon Cognito. These classes help you process the event without having to write your own custom serialization logic.
- **Custom Appender for Log4j2.8** – You can use the custom Log4j (see [Apache Log4j 2](#)) appender provided by AWS Lambda for logging from your lambda functions. Every call to Log4j methods, such as log.info() or log.error(), will result in a CloudWatch Logs event. The custom appender is called LambdaAppender and must be used in the log4j2.xml file. You must include the aws-lambda-java-log4j2 artifact (artifactId:aws-lambda-java-log4j2) in the deployment package (.jar file). For more information, see [Logging \(Java\) \(p. 42\)](#).
- **Custom Appender for Log4j1.2** – You can use the custom Log4j (see [Apache Log4j 1.2](#)) appender provided by AWS Lambda for logging from your lambda functions. For more information, see [Logging \(Java\) \(p. 42\)](#).

### Note

Support for the Log4j v1.2 custom appender is marked for End-Of-Life. It will not receive ongoing updates and is not recommended for use.

These libraries are available through the [Maven Central Repository](#) and can also be found on [GitHub](#).

## Lambda Function Handler (Java)

At the time you create a Lambda function you specify a handler that AWS Lambda can invoke when the service executes the Lambda function on your behalf.

Lambda supports two approaches for creating a handler:

- Loading the handler method directly without having to implement an interface. This section describes this approach.
- Implementing standard interfaces provided as part of `aws-lambda-java-core` library (interface approach). For more information, see [Leveraging Predefined Interfaces for Creating Handler \(Java\) \(p. 36\)](#).

The general syntax for the handler is as follows:

```
outputType handler-name(inputType input, Context context) {  
    ...  
}
```

In order for AWS Lambda to successfully invoke a handler it must be invoked with input data that can be serialized into the data type of the `input` parameter.

In the syntax, note the following:

- `inputType` – The first handler parameter is the input to the handler, which can be event data (published by an event source) or custom input that you provide such as a string or any custom data object. In order for AWS Lambda to successfully invoke this handler, the function must be invoked with input data that can be serialized into the data type of the `input` parameter.
- `outputType` – 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 will be serialized into JSON.

If you plan to invoke the Lambda function asynchronously (using the `Event` invocation type), the `outputType` should be `void`. For example, if you use AWS Lambda with event sources such as Amazon S3 or Amazon SNS, these event sources invoke the Lambda function using the `Event` invocation type.

- The `inputType` and `outputType` can be one of the following:
  - Primitive Java types (such as `String` or `int`).
  - Predefined AWS event types defined in the `aws-lambda-java-events` library.

For example `S3Event` is one of the POJOs predefined in the library that provides methods for you to easily read information from the incoming Amazon S3 event.

- You can also write your own POJO class. AWS Lambda will automatically serialize and deserialize input and output JSON based on the POJO type.

For more information, see [Handler Input/Output Types \(Java\) \(p. 32\)](#).

- You can omit the `Context` object from the handler method signature if it isn't needed. For more information, see [The Context Object \(Java\) \(p. 40\)](#).

For example, consider the following Java example code.

```
package example;  
  
import com.amazonaws.services.lambda.runtime.Context;  
import com.amazonaws.services.lambda.runtime.RequestHandler;  
  
public class Hello implements RequestHandler<Integer, String>{  
    public String myHandler(int myCount, Context context) {  
        return String.valueOf(myCount);  
    }  
}
```

In this example input is of type `Integer` and output is of type `String`. If you package this code and dependencies, and create your Lambda function, you specify `example.Hello::myHandler` ([package.class::method-reference](#)) as the handler.

In the example Java code, the first handler parameter is the input to the handler (`myHandler`), which can be event data (published by an event source such as Amazon S3) or custom input you provide such as an `Integer` object (as in this example) or any custom data object.

For instructions to create a Lambda function using this Java code, see [\(Optional\) Create a Lambda Function Authored in Java \(p. 49\)](#).

### Handler Overload Resolution

If your Java code contains multiple methods with same name as the `handler` name, then AWS Lambda uses the following rules to pick a method to invoke:

1. Select the method with the largest number of parameters.
2. If two or more methods have the same number of parameters, AWS Lambda selects the method that has the `Context` as the last parameter.

If none or all of these methods have the `Context` parameter, then the behavior is undefined.

### Additional Information

The following topics provide more information about the handler.

- For more information about the handler input and output types, see [Handler Input/Output Types \(Java\) \(p. 32\)](#).
- For information about using predefined interfaces to create a handler, see [Leveraging Predefined Interfaces for Creating Handler \(Java\) \(p. 36\)](#).

If you implement these interfaces, you can validate your handler method signature at compile time.

- If your Lambda function throws an exception, AWS Lambda records metrics in CloudWatch indicating that an error occurred. For more information, see [Function Errors \(Java\) \(p. 46\)](#).

### Handler Input/Output Types (Java)

When AWS Lambda executes the Lambda function, it invokes the handler. The first parameter is the input to the handler which can be event data (published by an event source) or custom input you provide such as a string or any custom data object.

AWS Lambda supports the following input/output types for a handler:

- Simple Java types (AWS Lambda supports the String, Integer, Boolean, Map, and List types)
- POJO (Plain Old Java Object) type
- Stream type (If you do not want to use POJOs or if Lambda's serialization approach does not meet your needs, you can use the byte stream implementation. For more information, see [Example: Using Stream for Handler Input/Output \(Java\) \(p. 35\)](#).)

### Handler Input/Output: String Type

The following Java class shows a handler called `myHandler` that uses String type for input and output.

```
package example;

import com.amazonaws.services.lambda.runtime.Context;

public class Hello {
    public String myHandler(String name, Context context) {
        return String.format("Hello %s.", name);
    }
}
```

You can have similar handler functions for other simple Java types.

**Note**

When you invoke a Lambda function asynchronously, any return value by your Lambda function will be ignored. Therefore you might want to set the return type to void to make this clear in your code. For more information, see [Invoke \(p. 450\)](#).

To test an end-to-end example, see [\(Optional\) Create a Lambda Function Authored in Java \(p. 49\)](#).

**Handler Input/Output: POJO Type**

The following Java class shows a handler called `myHandler` that uses POJOs for input and output.

```
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 {
        ...
    }

    public static class ResponseClass {
        ...
    }

    public static ResponseClass myHandler(RequestClass request, Context context) {
        String greetingString = String.format("Hello %s, %s.", request.getFirstName(),
        request.getLastName());
        return new ResponseClass(greetingString);
    }
}
```

AWS Lambda serializes based on standard bean naming conventions (see [The Java EE 6 Tutorial](#)). You should use mutable POJOs with public getters and setters.

**Note**

You shouldn't rely on any other features of serialization frameworks such as annotations. If you need to customize the serialization behavior, you can use the raw byte stream to use your own serialization.

If you use POJOs for input and output, you need to provide implementation of the `RequestClass` and `ResponseClass` types. For an example, see [Example: Using POJOs for Handler Input/Output \(Java\) \(p. 33\)](#).

**Example: Using POJOs for Handler Input/Output (Java)**

Suppose your application events generate data that includes first name and last name as shown:

```
{ "firstName": "John", "lastName": "Doe" }
```

For this example, the handler receives this JSON and returns the string "Hello John Doe".

```
public static ResponseClass handleRequest(RequestClass request, Context context){
    String greetingString = String.format("Hello %s, %s.", request.firstName,
    request.lastName);
    return new ResponseClass(greetingString);
}
```

To create a Lambda function with this handler, you must provide implementation of the input and output types as shown in the following Java example. The `HelloPojo` class defines the `handler` method.

```
package example;

import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.services.lambda.runtime.RequestHandler;

public class HelloPojo implements RequestHandler<RequestClass, ResponseClass>{

    public ResponseClass handleRequest(RequestClass request, Context context){
        String greetingString = String.format("Hello %s, %s.", request.firstName,
request.lastName);
        return new ResponseClass(greetingString);
    }
}
```

In order to implement the input type, add the following code to a separate file and name it *RequestClass.java*. Place it next to the *HelloPojo.java* class in your directory structure:

```
package example;

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() {
    }
}
```

In order to implement the output type, add the following code to a separate file and name it *ResponseClass.java*. Place it next to the *HelloPojo.java* class in your directory structure:

```
package example;

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() {
    }

}
```

**Note**

The `get` and `set` methods are required in order for the POJOs to work with AWS Lambda's built in JSON serializer. The constructors that take no arguments are usually not required, however in this example we provided other constructors and therefore we need to explicitly provide the zero argument constructors.

You can upload this code as your Lambda function and test as follows:

- Using the preceding code files, create a deployment package.
- Upload the deployment package to AWS Lambda and create your Lambda function. You can do this using the console or AWS CLI.
- Invoke the Lambda function manually using the console or the CLI. You can use provide sample JSON event data when you manually invoke your Lambda function. For example:

```
{ "firstName": "John", "lastName": "Doe" }
```

For more information, see [\(Optional\) Create a Lambda Function Authored in Java \(p. 49\)](#). Note the following differences:

- When you create a deployment package, don't forget the `aws-lambda-java-core` library dependency.
- When you create the Lambda function, specify `example.HelloPojo::handleRequest` (`package.class::method`) as the handler value.

### Example: Using Stream for Handler Input/Output (Java)

If you do not want to use POJOs or if Lambda's serialization approach does not meet your needs, you can use the byte stream implementation. In this case, you can use the `InputStream` and `OutputStream` as the input and output types for the handler. An example handler function is shown:

```
public void handler(InputStream inputStream, OutputStream outputStream, Context context)
    throws IOException{
    ...
}
```

Note that in this case the handler function uses parameters for both the request and response streams.

The following is a Lambda function example that implements the handler that uses `InputStream` and `OutputStream` types for the `input` and `output` parameters.

**Note**

The input payload must be valid JSON but the output stream does not carry such a restriction. Any bytes are supported.

```
package example;
```

```
import java.io.InputStream;
import java.io.OutputStream;
import com.amazonaws.services.lambda.runtime.RequestStreamHandler;
import com.amazonaws.services.lambda.runtime.Context;

public class Hello implements RequestStreamHandler{
    public void handler(InputStream inputStream, OutputStream outputStream, Context context) throws IOException {
        int letter;
        while((letter = inputStream.read()) != -1)
        {
            outputStream.write(Character.toUpperCase(letter));
        }
    }
}
```

You can do the following to test the code:

- Using the preceding code, create a deployment package.
- Upload the deployment package to AWS Lambda and create your Lambda function. You can do this using the console or AWS CLI.
- You can manually invoke the code by providing sample input. For example:

```
test
```

Follow instructions provided in the Getting Started. For more information, see [\(Optional\) Create a Lambda Function Authored in Java \(p. 49\)](#). Note the following differences:

- When you create a deployment package, don't forget the `aws-lambda-java-core` library dependency.
- When you create the Lambda function, specify `example.Hello::handler` (`package.class::method`) as the handler value.

### Leveraging Predefined Interfaces for Creating Handler (Java)

You can use one of the predefined interfaces provided by the AWS Lambda Java core library (`aws-lambda-java-core`) to create your Lambda function handler, as an alternative to writing your own handler method with an arbitrary name and parameters. For more information about handlers, see [\(see Lambda Function Handler \(Java\) \(p. 30\)\)](#).

You can implement one of the predefined interfaces, `RequestStreamHandler` or `RequestHandler` and provide implementation for the `handleRequest` method that the interfaces provide. You implement one of these interfaces depending on whether you want to use standard Java types or custom POJO types for your handler input/output (where AWS Lambda automatically serializes and deserializes the input and output to Match your data type), or customize the serialization using the `Stream` type.

#### Note

These interfaces are available in the `aws-lambda-java-core` library.

When you implement standard interfaces, they help you validate your method signature at compile time.

If you implement one of the interfaces, you specify `package.class` in your Java code as the handler when you create the Lambda function. For example, the following is the modified `create-function` CLI command from the getting started. Note that the `--handler` parameter specifies "example.Hello" value:

```
aws lambda create-function \
```

```
--region region \
--function-name getting-started-lambda-function-in-java \
--zip-file fileb://deployment-package (zip or jar)
  path \
--role arn:aws:iam::account-id:role/lambda_basic_execution \
--handler example.Hello \
--runtime java8 \
--timeout 15 \
--memory-size 512
```

The following sections provide examples of implementing these interfaces.

### Example 1: Creating Handler with Custom POJO Input/Output (Leverage the RequestHandler Interface)

The example `Hello` class in this section implements the `RequestHandler` interface. The interface defines `handleRequest()` method that takes in event data as input parameter of the `Request` type and returns an POJO object of the `Response` type:

```
public Response handleRequest(Request request, Context context) {
    ...
}
```

The `Hello` class with sample implementation of the `handleRequest()` method is shown. For this example, we assume event data consists of first name and last name.

```
package example;

import com.amazonaws.services.lambda.runtime.RequestHandler;
import com.amazonaws.services.lambda.runtime.Context;

public class Hello implements RequestHandler<Request, Response> {

    public Response handleRequest(Request request, Context context) {
        String greetingString = String.format("Hello %s %s.", request.firstName,
        request.lastName);
        return new Response(greetingString);
    }
}
```

For example, if the event data in the `Request` object is:

```
{
  "firstName": "value1",
  "lastName" : "value2"
}
```

The method returns a `Response` object as follows:

```
{
  "greetings": "Hello value1 value2."
}
```

Next, you need to implement the `Request` and `Response` classes. You can use the following implementation for testing:

The `Request` class:

```
package example;
```

```

public class Request {
    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 Request(String firstName, String lastName) {
        this.firstName = firstName;
        this.lastName = lastName;
    }

    public Request() {
    }
}

```

The Response class:

```

package example;

public class Response {
    String greetings;

    public String getGreetings() {
        return greetings;
    }

    public void setGreetings(String greetings) {
        this.greetings = greetings;
    }

    public Response(String greetings) {
        this.greetings = greetings;
    }

    public Response() {
    }
}

```

You can create a Lambda function from this code and test the end-to-end experience as follows:

- Using the preceding code, create a deployment package. For more information, see [Creating a Deployment Package \(Java\) \(p. 89\)](#)
- Upload the deployment package to AWS Lambda and create your Lambda function.
- Test the Lambda function using either the console or CLI. You can specify any sample JSON data that conform to the getter and setter in your Request class, for example:

```
{
    "firstName": "John",
}
```

```
    "lastName" : "Doe"
}
```

The Lambda function will return the following JSON in response.

```
{
    "greetings": "Hello John, Doe."
}
```

Follow instructions provided in the getting started (see [\(Optional\) Create a Lambda Function Authored in Java \(p. 49\)](#)). Note the following differences:

- When you create a deployment package, don't forget the `aws-lambda-java-core` library dependency.
- When you create the Lambda function specify `example.Hello` (`package.class`) as the handler value.

### Example 2: Creating Handler with Stream Input/Output (Leverage the RequestStreamHandler Interface)

The `Hello` class in this example implements the `RequestStreamHandler` interface. The interface defines `handleRequest` method as follows:

```
public void handleRequest(InputStream inputStream, OutputStream outputStream, Context
    context)
        throws IOException {
    ...
}
```

The `Hello` class with sample implementation of the `handleRequest()` handler is shown. The handler processes incoming event data (for example, a string "hello") by simply converting it to uppercase and return it.

```
package example;

import java.io.IOException;
import java.io.InputStream;
import java.io.OutputStream;

import com.amazonaws.services.lambda.runtime.RequestStreamHandler;
import com.amazonaws.services.lambda.runtime.Context;

public class Hello implements RequestStreamHandler {
    public void handleRequest(InputStream inputStream, OutputStream outputStream, Context
    context)
        throws IOException {
        int letter;
        while((letter = inputStream.read()) != -1)
        {
            outputStream.write(Character.toUpperCase(letter));
        }
    }
}
```

You can create a Lambda function from this code and test the end-to-end experience as follows:

- Use the preceding code to create deployment package.

- Upload the deployment package to AWS Lambda and create your Lambda function.
- Test the Lambda function using either the console or CLI. You can specify any sample string data, for example:

```
"test"
```

The Lambda function will return TEST in response.

Follow instructions provided in the getting started (see [\(Optional\) Create a Lambda Function Authored in Java \(p. 49\)](#)). Note the following differences:

- When you create a deployment package, don't forget the aws-lambda-java-core library dependency.
- When you create the Lambda function specify example.Hello (*package.class*) as the handler value.

## The Context Object (Java)

You interact with AWS Lambda execution environment via the context parameter. The context object allows you to access useful information available within the Lambda execution environment. For example, you can use the context parameter to determine the CloudWatch log stream associated with the function, or use the clientContext property of the context object to learn more about the application calling the Lambda function (when invoked through the AWS Mobile SDK).

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The context object properties are:

- `getMemoryLimitInMB()`: Memory limit, in MB, you configured for the Lambda function.
- `getFunctionName()`: Name of the Lambda function that is running.
- `getFunctionVersion()`: The Lambda function version that is executing. If an alias is used to invoke the function, then `getFunctionVersion` will be the version the alias points to.
- `getInvokedFunctionArn()`: The ARN used to invoke this function. It can be function ARN or alias ARN. An unqualified ARN executes the \$LATEST version and aliases execute the function version it is pointing to.
- `getAwsRequestId()`: AWS request ID associated with the request. This is the ID returned to the client that called `invoke()`. You can use the request ID for any follow up enquiry with AWS support. Note that if AWS Lambda retries the function (for example, in a situation where the Lambda function processing Kinesis records throw an exception), the request ID remains the same.
- `getLogStreamName()`: The CloudWatch log stream name for the particular Lambda function execution. It can be null if the IAM user provided does not have permission for CloudWatch actions.
- `getLogGroupName()`: The CloudWatch log group name associated with the Lambda function invoked. It can be null if the IAM user provided does not have permission for CloudWatch actions.
- `getClientContext()`: Information about the client application and device when invoked through the AWS Mobile SDK. It can be null. Client context provides client information such as client ID, application title, version name, version code, and the application package name.
- `getIdentity()`: Information about the Amazon Cognito identity provider when invoked through the AWS Mobile SDK. It can be null.
- `getRemainingTimeInMillis()`: Remaining execution time till the function will be terminated, in milliseconds. At the time you create the Lambda function you set maximum time limit, at which time AWS Lambda will terminate the function execution. Information about the remaining time of function execution can be used to specify function behavior when nearing the timeout.
- `getLogger()`: Returns the Lambda logger associated with the Context object. For more information, see [Logging \(Java\) \(p. 42\)](#).

The following Java code snippet shows a handler function that prints some of the context information.

```
public static void handler(InputStream inputStream, OutputStream outputStream, Context context) {  
  
    ...  
    System.out.println("Function name: " + context.getFunctionName());  
    System.out.println("Max mem allocated: " + context.getMemoryLimitInMB());  
    System.out.println("Time remaining in milliseconds: " +  
    context.getRemainingTimeInMillis());  
    System.out.println("CloudWatch log stream name: " + context.getLogStreamName());  
    System.out.println("CloudWatch log group name: " + context.getLogGroupName());  
  
}
```

### Example: Using Context Object (Java)

The following Java code example shows how to use the `Context` object to retrieve runtime information of your Lambda function, while it is running.

```
package example;  
import java.io.InputStream;  
import java.io.OutputStream;  
import com.amazonaws.services.lambda.runtime.Context;  
  
public class Hello {  
    public static void myHandler(InputStream inputStream, OutputStream outputStream,  
    Context context) {  
  
        int letter;  
        try {  
            while((letter = inputStream.read()) != -1)  
            {  
                outputStream.write(Character.toUpperCase(letter));  
            }  
            Thread.sleep(3000); // Intentional delay for testing the  
getRemainingTimeInMillis() result.  
        }  
        catch (Exception e)  
        {  
            e.printStackTrace();  
        }  
  
        // For fun, let us get function info using the context object.  
        System.out.println("Function name: " + context.getFunctionName());  
        System.out.println("Max mem allocated: " + context.getMemoryLimitInMB());  
        System.out.println("Time remaining in milliseconds: " +  
        context.getRemainingTimeInMillis());  
        System.out.println("CloudWatch log stream name: " + context.getLogStreamName());  
        System.out.println("CloudWatch log group name: " + context.getLogGroupName());  
    }  
}
```

You can do the following to test the code:

- Using the preceding code, create a deployment package.
- Upload the deployment package to AWS Lambda to create your Lambda function. You can do this using the console or AWS CLI.
- To test your Lambda function use the "Hello World" **Sample event** that the Lambda console provides.

You can type any string and the function will return the same string in uppercase. In addition, you will also get the useful function information provided by the `context` object.

Follow the instructions provided in the Getting Started. For more information, see [\(Optional\) Create a Lambda Function Authored in Java \(p. 49\)](#). Note the following differences:

- When you create a deployment package, don't forget the `aws-lambda-java-core` library dependency.
- When you create the Lambda function, specify `example.Hello::myHandler` (`package.class::method`) as the handler value.

## Logging (Java)

Your Lambda function can contain logging statements. AWS Lambda writes these logs to CloudWatch. We recommend you use one of the following to write logs.

### Custom Appender for Log4j™ 2

AWS Lambda recommends Log4j 2 to provide a custom appender. You can use the custom Log4j (see [Apache log4j](#)) appender provided by Lambda for logging from your lambda functions. Every call to Log4j methods, such as `log.info()` or `log.error()`, will result in a CloudWatch Logs event. The custom appender is called `LambdaAppender` and must be used in the `log4j2.xml` file. You must include the `aws-lambda-java-log4j2` artifact (`artifactId:aws-lambda-java-log4j2`) in the deployment package (.jar file). For an example, see [Example 1: Writing Logs Using Log4J v2.8 \(p. 43\)](#).

### `LambdaLogger.log()`

Each call to `LambdaLogger.log()` results in a CloudWatch Logs event, provided the event size is within the allowed limits. For information about CloudWatch Logs limits, see [CloudWatch Logs Limits](#) in the [Amazon CloudWatch User Guide](#). For an example, see [Example 2: Writing Logs Using LambdaLogger \(Java\) \(p. 45\)](#).

In addition, you can also use the following statements in your Lambda function code to generate log entries:

- `System.out()`
- `System.err()`

However, note that AWS Lambda treats each line returned by `System.out` and `System.err` as a separate event. This works well when each output line corresponds to a single log entry. When a log entry has multiple lines of output, AWS Lambda attempts to parse them using line breaks to identify separate events. For example, the following logs the two words ("Hello" and "world") as two separate events:

```
System.out.println("Hello \n world");
```

## How to Find Logs

You can find the logs that your Lambda function writes, as follows:

- Find logs in CloudWatch Logs. The `context` object (in the `aws-lambda-java-core` library) provides the `getLogStreamName()` and the `getLogGroupName()` methods. Using these methods, you can find the specific log stream where logs are written.
- If you invoke a Lambda function via the console, the invocation type is always `RequestResponse` (that is, synchronous execution) and the console displays the logs that the Lambda function writes using the `LambdaLogger` object. AWS Lambda also returns logs from `System.out` and `System.err` methods.
- If you invoke a Lambda function programmatically, you can add the `LogType` parameter to retrieve the last 4 KB of log data that is written to CloudWatch Logs. For more information, see

[Invoke \(p. 450\)](#). AWS Lambda returns this log information in the `x-amz-log-results` header in the response. If you use the AWS Command Line Interface to invoke the function, you can specify the `--log-type` parameter with value `Tail`.

## Logging Examples (Java)

This section provides examples of using Custom Appender for Log4j and the `LambdaLogger` objects for logging information.

### Example 1: Writing Logs Using Log4j v2.8

- The following shows how to build your artifact with Maven to correctly include the Log4j v2.8 plugins:
  - For Maven `pom.xml`:

```
<dependencies>
  ...
  <dependency>
    <groupId>com.amazonaws</groupId>
    <artifactId>aws-lambda-java-log4j2</artifactId>
    <version>1.0.0</version>
  </dependency>
  <dependency>
    <groupId>org.apache.logging.log4j</groupId>
    <artifactId>log4j-core</artifactId>
    <version>2.8.2</version>
  </dependency>
  <dependency>
    <groupId>org.apache.logging.log4j</groupId>
    <artifactId>log4j-api</artifactId>
    <version>2.8.2</version>
  </dependency>
  ...
</dependencies>
```

- If using the Maven shade plugin, set the plugin configuration as follows:

```
<plugins>
  ...
  <plugin>
    <groupId>org.apache.maven.plugins</groupId>
    <artifactId>maven-shade-plugin</artifactId>
    <version>2.4.3</version>
    <executions>
      <execution>
        <phase>package</phase>
        <goals>
          <goal>shade</goal>
        </goals>
        <configuration>
          <transformers>
            <transformer
              implementation="com.github.edwgiz.mavenShadePlugin.log4j2CacheTransformer.PluginsCacheFileTransformer"
            ></transformer>
          </transformers>
        </configuration>
      </execution>
    </executions>
    <dependencies>
```

```

<dependency>
    <groupId>com.github.edwgiz</groupId>
    <artifactId>maven-shade-plugin.log4j2-cachefile-transformer</artifactId>
    <version>2.8.1</version>
</dependency>
</dependencies>
</plugin>
...
</plugins>

```

- The following Java code example shows how to use Log4j with Lambda:

```

package example;

import com.amazonaws.services.lambda.runtime.Context;

import org.apache.logging.log4j.LogManager;
import org.apache.logging.log4j.Logger;

public class Hello {
    // Initialize the Log4j logger.
    static final Logger logger = LogManager.getLogger(Hello.class);

    public String myHandler(String name, Context context) {
        // System.out: One log statement but with a line break (AWS Lambda writes two
        // events to CloudWatch).
        System.out.println("log data from stdout \n this is continuation of
        system.out");

        // System.err: One log statement but with a line break (AWS Lambda writes two
        // events to CloudWatch).
        System.err.println("log data from stderr. \n this is a continuation of
        system.err");

        logger.error("log data from log4j err. \n this is a continuation of
        log4j.err");

        // Return will include the log stream name so you can look
        // up the log later.
        return String.format("Hello %s. log stream = %s", name,
        context.getLogStreamName());
    }
}

```

- The example preceding uses the following log4j2.xml file to load properties

```

<?xml version="1.0" encoding="UTF-8"?>
<Configuration packages="com.amazonaws.services.lambda.runtime.log4j2">
    <Appenders>
        <Lambda name="Lambda">
            <PatternLayout>
                <pattern>%d{yyyy-MM-dd HH:mm:ss} %X{AWSRequestId} %-5p %c{1}:%L - %m%n</
                pattern>
            </PatternLayout>
        </Lambda>
    </Appenders>
    <Loggers>
        <Root level="info">
            <AppenderRef ref="Lambda" />

```

```
</Root>
</Loggers>
</Configuration>
```

### Example 2: Writing Logs Using LambdaLogger (Java)

The following Java code example writes logs using both the System methods and the LambdaLogger object to illustrate how they differ when AWS Lambda logs information to CloudWatch.

```
package example;

import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.services.lambda.runtime.LambdaLogger;

public class Hello {
    public String myHandler(String name, Context context) {

        // System.out: One log statement but with a line break (AWS Lambda writes two
        events to CloudWatch).
        System.out.println("log data from stdout \n this is continuation of system.out");

        // System.err: One log statement but with a line break (AWS Lambda writes two
        events to CloudWatch).
        System.err.println("log data from stderr \n this is continuation of system.err");

        LambdaLogger logger = context.getLogger();
        // Write log to CloudWatch using LambdaLogger.
        logger.log("log data from LambdaLogger \n this is continuation of logger.log");

        // Return will include the log stream name so you can look
        // up the log later.
        return String.format("Hello %s. log stream = %s",
            name,
            context.getLogStreamName());
    }
}
```

The following is sample of log entries in CloudWatch Logs.

Note:

- AWS Lambda parses the log string in each of the `System.out.println()` and `System.err.println()` statements logs as two separate events (note the two down arrows in the screenshot) because of the line break.
- The `LambdaLogger.log()` produce one CloudWatch event.

You can do the following to test the code:

- Using the code, create a deployment package.
- Upload the deployment package to AWS Lambda to create your Lambda function.
- To test your Lambda function use a string ("this is a test") as sample event. The handler code receives the sample event but does nothing with it. It only shows how to write logs.

Follow the instructions provided in the Getting Started. For more information, see [\(Optional\) Create a Lambda Function Authored in Java \(p. 49\)](#). Note the following differences:

- When you create a deployment package, don't forget the `aws-lambda-java-core` library dependency.
- When you create the Lambda function, specify `example.Hello::myHandler` (`package.class::method`) as the handler value.

## Function Errors (Java)

If your Lambda function throws an exception, AWS Lambda recognizes the failure and serializes the exception information into JSON and returns it. Following is an example error message:

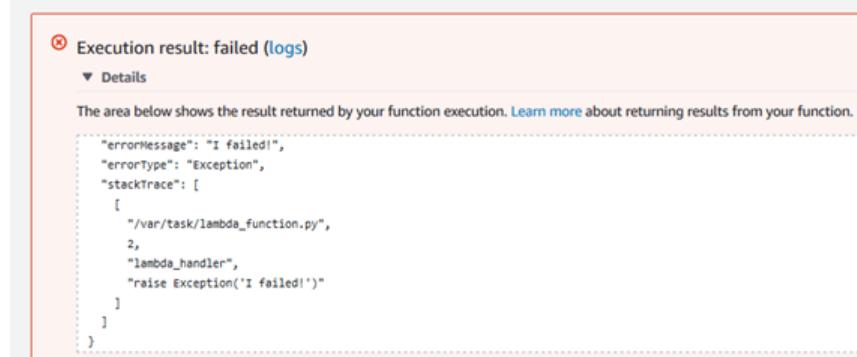
```
{
  "errorMessage": "Name John Doe is invalid. Exception occurred...",
  "errorType": "java.lang.Exception",
  "stackTrace": [
    "example.Hello.handler(Hello.java:9)",
    "sun.reflect.NativeMethodAccessorImpl.invoke0(Native Method)",
    "sun.reflect.NativeMethodAccessorImpl.invoke(NativeMethodAccessorImpl.java:62)",
    "sun.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAccessorImpl.java:43)",
    "java.lang.reflect.Method.invoke(Method.java:497)"
  ]
}
```

Note that the stack trace is returned as the `stackTrace` JSON array of stack trace elements.

The method in which you get the error information back depends on the invocation type that you specified at the time you invoked the function:

- **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 as shown in the following image.



- **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.

Depending on the event source, AWS Lambda may retry the failed Lambda function. For example, if Kinesis is the event source for the Lambda function, AWS Lambda retries the failed function until the Lambda function succeeds or the records in the stream expire.

### Function Error Handling

You can create custom error handling to raise an exception directly from your Lambda function and handle it directly (Retry or Catch) within an AWS Step Functions State Machine. For more information, see [Handling Error Conditions Using a State Machine](#).

Consider a `CreateAccount` state is a [task](#) that writes a customer's details to a database using a Lambda function.

- If the task succeeds, an account is created and a welcome email is sent.
- If a user tries to create an account for a username that already exists, the Lambda function raises an error, causing the state machine to suggest a different username and to retry the account-creation process.

The following code samples demonstrate how to do this. Note that custom errors in Java must extend the `Exception` class.

```
package com.example;

public static class AccountAlreadyExistsException extends Exception {
    public AccountAlreadyExistsException(String message) {
        super(message);
    }
}

package com.example;

import com.amazonaws.services.lambda.runtime.Context;

public class Handler {
    public static void CreateAccount(String name, Context context) throws
    AccountAlreadyExistsException {
        throw new AccountAlreadyExistsException ("Account is in use!");
    }
}
```

You can configure Step Functions to catch the error using a `Catch` rule. Lambda automatically sets the error name to the fully-qualified class name of the exception at runtime:

```
{
    "StartAt": "CreateAccount",
    "States": {
        "CreateAccount": {
            "Type": "Task",
            "Resource": "arn:aws:lambda:us-east-1:123456789012:function:CreateAccount",
            "Next": "SendWelcomeEmail",
            "Catch": [
                {
                    "ErrorEquals": ["com.example.AccountAlreadyExistsException"],
                    "Next": "SuggestAccountName"
                }
            ]
        },
        ...
    }
}
```

At runtime, AWS Step Functions catches the error, [transitioning](#) to the `SuggestAccountName` state as specified in the `Next` transition.

Custom error handling makes it easier to create [serverless](#) applications. This feature integrates with all the languages supported by the Lambda [Programming Model \(p. 18\)](#), allowing you to design your application in the programming languages of your choice, mixing and matching as you go.

To learn more about creating your own serverless applications using AWS Step Functions and AWS Lambda, see [AWS Step Functions](#).

## Using Earlier Custom Appender for Log4j™ 1.2 (Not Recommended)

### Note

Support for the Log4j v1.2 custom appender is marked for End-Of-Life. It will not receive ongoing updates and is not recommended for use. For more information, see [Log4j 1.2](#)

AWS Lambda supports Log4j 1.2 by providing a custom appender. You can use the custom Log4j (see [Apache log4j 1.2](#)) appender provided by Lambda for logging from your lambda functions. Every call to Log4j methods, such as `log.info()` or `log.error()`, will result in a CloudWatch Logs event. The custom appender is called `LambdaAppender` and must be used in the `log4j.properties` file. You must include the `aws-lambda-java-log4j` artifact (`artifactId:aws-lambda-java-log4j`) in the deployment package (.jar file). For an example, see [Example: Writing Logs Using Log4J v1.2 \(Not Recommended\) \(p. 48\)](#).

### Example: Writing Logs Using Log4J v1.2 (Not Recommended)

### Note

Versions 1.x of Log4j have been marked as end of life. For more information, see [Log4j 1.2](#)

The following Java code example writes logs using both the System methods and Log4j to illustrate how they differ when AWS Lambda logs information to CloudWatch.

```
package example;

import com.amazonaws.services.lambda.runtime.Context;
import org.apache.logging.log4j.Logger;

public class Hello {
    // Initialize the Log4j logger.
    static final Logger log = Logger.getLogger(Hello.class);

    public String myHandler(String name, Context context) {
        // System.out: One log statement but with a line break (AWS Lambda writes two events to CloudWatch).
        System.out.println("log data from stdout \n this is continuation of system.out");

        // System.err: One log statement but with a line break (AWS Lambda writes two events to CloudWatch).
        System.err.println("log data from stderr. \n this is a continuation of system.err");

        log.error("log data from log4j err. \n this is a continuation of log4j.err");

        // Return will include the log stream name so you can look
        // up the log later.
        return String.format("Hello %s. log stream = %s", name,
context.getLogStreamName());
    }
}
```

```
}
```

The example uses the following log4j.properties file ([project-dir](#)/src/main/resources/ directory).

```
log = .
log4j.rootLogger = INFO, LAMBDA

#Define the LAMBDA appender
log4j.appender.LAMBDA=com.amazonaws.services.lambda.runtime.log4j.LambdaAppender
log4j.appender.LAMBDA.layout=org.apache.log4j.PatternLayout
log4j.appender.LAMBDA.layout.conversionPattern=%d{yyyy-MM-dd HH:mm:ss} <%X{AWSRequestId}>
%-5p %c{1}:%m%n
```

You can do the following to test the code:

- Using the code, create a deployment package. In your project, don't forget to add the log4j.properties file in the [project-dir](#)/src/main/resources/ directory.
- Upload the deployment package to AWS Lambda to create your Lambda function.
- To test your Lambda function use a string ("this is a test") as sample event. The handler code receives the sample event but does nothing with it. It only shows how to write logs.

Follow the instructions provided in the Getting Started. For more information, see [\(Optional\) Create a Lambda Function Authored in Java \(p. 49\)](#). Note the following differences:

- When you create a deployment package, don't forget the aws-lambda-java-log4j dependency for Log4j 1.2 dependency.
- When you create the Lambda function, specify example.Hello::myHandler ([package.class::method](#)) as the handler value.

## (Optional) Create a Lambda Function Authored in Java

The blueprints provide sample code authored either in Python or Node.js. You can easily modify the example using the inline editor in the console. However, if you want to author code for your Lambda function in Java, there are no blueprints provided. Also, there is no inline editor for you to write Java code in the AWS Lambda console.

That means, you must write your Java code and also create your deployment package outside the console. After you create the deployment package, you can use the console to upload the package to AWS Lambda to create your Lambda function. You can also use the console to test the function by manually invoking it.

In this section you create a Lambda function using the following Java code example.

```
package example;

import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.services.lambda.runtime.LambdaLogger;

public class Hello {
    public String myHandler(int myCount, Context context) {
        LambdaLogger logger = context.getLogger();
        logger.log("received : " + myCount);
        return String.valueOf(myCount);
    }
}
```

The programming model explains how to write your Java code in detail, for example the input/output types AWS Lambda supports. For more information about the programming model, see [Programming Model for Authoring Lambda Functions in Java \(p. 30\)](#). For now, note the following about this code:

- When you package and upload this code to create your Lambda function, you specify the `example.Hello::myHandler` method reference as the handler.
- The handler in this example uses the `int` type for input and the `String` type for output.

AWS Lambda supports input/output of JSON-serializable types and `InputStream`/`OutputStream` types. When you invoke this function you will pass a sample `int` (for example, `123`).

- You can use the Lambda console to manually invoke this Lambda function. The console always uses the `RequestResponse` invocation type (`synchronous`) and therefore you will see the response in the console.
- The handler includes the optional `Context` parameter. In the code we use the `LambdaLogger` provided by the `Context` object to write log entries to CloudWatch logs. For information about using the `Context` object, see [The Context Object \(Java\) \(p. 40\)](#).

First, you need to package this code and any dependencies into a deployment package. Then, you can use the Getting Started exercise to upload the package to create your Lambda function and test using the console. For more information creating a deployment package, see [Creating a Deployment Package \(Java\) \(p. 89\)](#).

## Programming Model for Authoring Lambda Functions in Python

The following sections explain how [common programming patterns and core concepts](#) apply when authoring Lambda function code in Python.

### Topics

- [Lambda Function Handler \(Python\) \(p. 50\)](#)
- [The Context Object \(Python\) \(p. 51\)](#)
- [Logging \(Python\) \(p. 54\)](#)
- [Function Errors \(Python\) \(p. 56\)](#)

### Lambda Function Handler (Python)

At the time you create a Lambda function, you specify a *handler*, which is a function in your code, that AWS Lambda can invoke when the service executes your code. Use the following general syntax structure when creating a handler function in Python.

```
def handler_name(event, context):  
    ...  
    return some_value
```

In the syntax, note the following:

- `event` – AWS Lambda uses this parameter to pass in event data to the handler. This parameter is usually of the Python `dict` type. It can also be `list`, `str`, `int`, `float`, or `NoneType` type.
- `context` – AWS Lambda uses this parameter to provide runtime information to your handler. This parameter is of the `LambdaContext` type.
- Optionally, the handler can return a value. What happens to the returned value depends on the invocation type you use when invoking the Lambda function:
  - If you use the `RequestResponse` invocation type (`synchronous execution`), 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 using the console, the console will display the returned value.

- If the handler returns `NONE`, AWS Lambda returns null.
- If you use the `Event` invocation type (asynchronous execution), the value is discarded.

For example, consider the following Python example code.

```
def my_handler(event, context):
    message = 'Hello {} {}!'.format(event['first_name'],
                                    event['last_name'])
    return {
        'message' : message
    }
```

This example has one function called `my_handler`. The function returns a message containing data from the event it received as input.

### To upload and test this code as a Lambda function

- Save this file (for example, as `hello_python.py`).
- Package the file and any dependencies into a .zip file. When creating the zip, include only the code and its dependencies, not the containing folder.

For instructions, see [Creating a Deployment Package \(Python\) \(p. 96\)](#).

- Upload the .zip file using either the console or AWS CLI to create a Lambda function. You specify the function name in the Python code to be used as the handler when you create a Lambda function. For instructions to create a Lambda function using the console, see [Create a Simple Lambda Function \(p. 9\)](#). In this example, the handler is `hello_python.my_handler` (`file-name.function-name`). Note that the [Getting Started \(p. 3\)](#) uses a blueprint that provides sample code for a Lambda function. In this case you already have a deployment package. Therefore, in the configure function step you choose to upload a zip.

The following `create-function` AWS CLI command creates a Lambda function. Among other parameters, it specifies the `--handler` parameter to specify the handler name. Note that the `--runtime` parameter specifies `python3.6`. You can also use `python2.7`. For a complete description of the `create-function` command and its parameters, see [CreateFunction \(p. 412\)](#)

```
aws lambda create-function \
--region region \
--function-name HelloPython \
--zip-file fileb://deployment-package.zip \
--role arn:aws:iam::account-id:role/lambda_basic_execution \
--handler hello_python.my_handler \
--runtime python3.6 \
--timeout 15 \
--memory-size 512
```

## The Context Object (Python)

### Topics

- [Example \(p. 52\)](#)
- [The Context Object Methods \(Python\) \(p. 52\)](#)
- [The Context Object Attributes \(Python\) \(p. 53\)](#)

While a Lambda function is executing, it can interact with the AWS Lambda service to get useful runtime information such as:

- How much time is remaining before AWS Lambda terminates your Lambda function (timeout is one of the Lambda function configuration properties).
- The CloudWatch log group and log stream associated with the Lambda function that is executing.
- The AWS request ID returned to the client that invoked the Lambda function. You can use the request ID for any follow up inquiry with AWS support.
- If the Lambda function is invoked through AWS Mobile SDK, you can learn more about the mobile application calling the Lambda function.

AWS Lambda provides this information via the `context` object that the service passes as the second parameter to your Lambda function handler. For more information, see [Lambda Function Handler \(Python\) \(p. 50\)](#).

The following sections provide an example Lambda function that uses the `context` object, and then lists all of the available methods and attributes.

### Example

Consider the following Python example. It has one function that is also the handler. The handler receives runtime information via the `context` object passed as parameter.

```
from __future__ import print_function

import time
def get_my_log_stream(event, context):
    print("Log stream name:", context.log_stream_name)
    print("Log group name:", context.log_group_name)
    print("Request ID:", context.aws_request_id)
    print("Mem. limits(MB):", context.memory_limit_in_mb)
    # Code will execute quickly, so we add a 1 second intentional delay so you can see that
    # in time remaining value.
    time.sleep(1)
    print("Time remaining (MS):", context.get_remaining_time_in_millis())
```

The handler code in this example simply prints some of the runtime information. Each print statement creates a log entry in CloudWatch. If you invoke the function using the Lambda console, the console displays the logs. The `from __future__` statement enables you to write code that is compatible with Python 2 or 3.

### To test this code in the AWS Lambda console

1. In the console, create a Lambda function using the hello-world blueprint. In **runtime**, choose **Python 2.7**. In **Handler**, replace `lambda_function.lambda_handler` with `lambda_function.get_my_log_stream`. For instructions on how to do this, see [Create a Simple Lambda Function \(p. 9\)](#).
2. Test the function, and then you can also update the code to get more context information.

The following sections provide a list of available `context` object methods and attributes that you can use to get runtime information of your Lambda function.

### The Context Object Methods (Python)

The `context` object provides the following methods:

### **get\_remaining\_time\_in\_millis()**

Returns the remaining execution time, in milliseconds, until AWS Lambda terminates the function.

### **The Context Object Attributes (Python)**

The context object provides the following attributes:

#### **function\_name**

Name of the Lambda function that is executing.

#### **function\_version**

The Lambda function version that is executing. If an alias is used to invoke the function, then `function_version` will be the version the alias points to.

#### **invoked\_function\_arn**

The ARN used to invoke this function. It can be function ARN or alias ARN. An unqualified ARN executes the `$LATEST` version and aliases execute the function version it is pointing to.

#### **memory\_limit\_in\_mb**

Memory limit, in MB, you configured for the Lambda function. You set the memory limit at the time you create a Lambda function and you can change it later.

#### **aws\_request\_id**

AWS request ID associated with the request. This is the ID returned to the client that called the `invoke` method.

##### **Note**

If AWS Lambda retries the invocation (for example, in a situation where the Lambda function that is processing Kinesis records throws an exception), the request ID remains the same.

#### **log\_group\_name**

The name of the CloudWatch log group where you can find logs written by your Lambda function.

#### **log\_stream\_name**

The name of the CloudWatch log stream where you can find logs written by your Lambda function. The log stream may or may not change for each invocation of the Lambda function.

The value is null if your Lambda function is unable to create a log stream, which can happen if the execution role that grants necessary permissions to the Lambda function does not include permissions for the CloudWatch Logs actions.

#### **identity**

Information about the Amazon Cognito identity provider when invoked through the AWS Mobile SDK. It can be null.

- `identity.cognito_identity_id`
- `identity.cognito_identity_pool_id`

#### **client\_context**

Information about the client application and device when invoked through the AWS Mobile SDK. It can be null.

- `client_context.client.installation_id`
- `client_context.client.app_title`

- **client\_context.client.app\_version\_name**
- **client\_context.client.app\_version\_code**
- **client\_context.client.app\_package\_name**
- **client\_context.custom**

A dict of custom values set by the mobile client application.

- **client\_context.env**

A dict of environment information provided by the AWS Mobile SDK.

In addition to the options listed above, you can also use the AWS X-Ray SDK for [Python \(p. 328\)](#) to identify critical code paths, trace their performance and capture the data for analysis.

## Logging (Python)

Your Lambda function can contain logging statements. AWS Lambda writes these logs to CloudWatch. If you use the Lambda console to invoke your Lambda function, the console displays the same logs.

The following Python statements generate log entries:

- `print` statements.
- `Logger` functions in the `logging` module (for example, `logging.Logger.info` and `logging.Logger.error`).

Both `print` and `logging.*` functions write logs to CloudWatch Logs but the `logging.*` functions write additional information to each log entry, such as time stamp and log level.

For example, consider the following Python code example.

```
import logging
logger = logging.getLogger()
logger.setLevel(logging.INFO)
def my_logging_handler(event, context):
    logger.info('got event{}'.format(event))
    logger.error('something went wrong')
    return 'Hello from Lambda!'
```

Because the code example uses the `logging` module to write message to the logs, you also get some additional information in the log such as the time stamp and the log levels. The log level identifies the type of log, such as `[INFO]`, `[ERROR]`, and `[DEBUG]`.

You can also find these logs in CloudWatch. For more information, see [Accessing Amazon CloudWatch Logs for AWS Lambda \(p. 318\)](#).

Instead of using the `logging` module, you can use the `print` statements in your code as shown in the following Python example:

```
from __future__ import print_function
def lambda_handler(event, context):
    print('this will also show up in cloud watch')
    return 'Hello World!'
```

In this case only the text passed to the `print` method is sent to CloudWatch. The log entries will not have additional information that the `logging.*` function returns. The `from __future__` statement enables you to write code that is compatible with Python 2 or 3.

The screenshot shows the AWS Lambda console after a successful function execution. The top bar indicates a green checkmark and the text "Execution result: succeeded (logs)". Below this, a "Details" section shows the return value: "Hello World!". The "Summary" section includes the Code SHA-256 (Mj6sNoYuSX2UjGoUy 64+R/UvzWB0xJc7VdX HRN6hqY=), Request ID (6a6a240b-6cc4-11e7-8734-6f6a02ed0559), Duration (0.18 ms), and Billed duration (100 ms). The "Log output" section displays the following log entries:

```

START RequestId: 6a6a240b-6cc4-11e7-8734-6f6a02ed0559 Version: $LATEST
this will also show up in cloud watch
END RequestId: 6a6a240b-6cc4-11e7-8734-6f6a02ed0559
REPORT RequestId: 6a6a240b-6cc4-11e7-8734-6f6a02ed0559 Duration: 0.18 ms Billed
Duration: 100 ms Memory Size: 128 MB Max Memory Used: 17 MB

```

The console uses the `RequestResponse` invocation type (synchronous invocation) when invoking the function. And therefore it gets the return value ("Hello world!") back from AWS Lambda which the console displays.

### To test the preceding Python code (console)

1. In the console, create a Lambda function using the hello-world-python blueprint. In **runtime**, choose **Python 2.7**. In **Handler**, replace `lambda_function.lambda_handler` with `lambda_function.my_other_logging_handler` and in **Role**, choose **Basic execution role**. You also replace the code provided by the blueprint by the code in this section. For step-by-step instructions to create a Lambda function using the console, see [Create a Simple Lambda Function \(p. 9\)](#).
2. Replace the template code with the code provided in this section.
3. Test the Lambda function using the **Sample event template** called **Hello World** provided in the Lambda console.

### Finding Logs

You can find the logs that your Lambda function writes, as follows:

- **In the AWS Lambda console** – The **Log output** section in AWS Lambda console shows the logs.
- **In the response header, when you invoke a Lambda function programmatically** – If you invoke a Lambda function programmatically, you can add the `LogType` parameter to retrieve the last 4 KB of log data that is written to CloudWatch Logs. AWS Lambda returns this log information in the `x-amz-log-results` header in the response. For more information, see [Invoke \(p. 450\)](#).

If you use AWS CLI to invoke the function, you can specify the `--log-type` parameter with value `Tail` to retrieve the same information.

- **In CloudWatch Logs** – To find your logs in CloudWatch you need to know the log group name and log stream name. You can use the `context.log_group_name` and `context.log_stream_name`

properties in your code to get this information. When you run your Lambda function, the resulting logs in the console or CLI will show you the log group name and log stream name.

## Function Errors (Python)

If your Lambda function raises an exception, AWS Lambda recognizes the failure and serializes the exception information into JSON and returns it. Consider the following example:

```
def always_failed_handler(event, context):
    raise Exception('I failed!')
```

When you invoke this Lambda function, it will raise an exception and AWS Lambda returns the following error message:

```
{
    "errorMessage": "I failed!",
    "stackTrace": [
        [
            "/var/task/lambda_function.py",
            3,
            "my_always_fails_handler",
            "raise Exception('I failed!')"
        ]
    ],
    "errorType": "Exception"
}
```

Note that the stack trace is returned as the `stackTrace` JSON array of stack trace elements.

How you get the error information back depends on the invocation type that the client specifies at the time of function invocation:

- If a client specifies the `RequestResponse` invocation type (that is, synchronous execution), it returns the result to the client that made the invoke call.

For example, the console always use the `RequestResponse` invocation type, so the console will display the error in the **Execution result** section as shown:

The screenshot shows the AWS Lambda execution result page. At the top, there is a red circle with a question mark icon followed by the text "Execution result: failed (logs)". Below this, there is a "Details" section with a collapsed arrow. A note states: "The area below shows the result returned by your function execution. [Learn more](#) about returning results from your function." A JSON object is displayed, representing the error response. The JSON structure is identical to the one shown in the previous code block, indicating that the Lambda function's error was serialized and returned as a JSON object.

```
{"errorMessage": "I failed!", "stackTrace": [ [ "/var/task/lambda_function.py", 3, "lambda_handler", "raise Exception('I failed!')"] ], "errorType": "Exception"}
```

The same information is also sent to CloudWatch and the **Log output** section shows the same logs.

<b>Summary</b> Code SHA-256      QfF84kaK8oCUm7FYFs0ZNnnsDTQvF9MpVmRScWAFWvk= Duration      0.82 ms Resources configured      128 MB	Request ID      b5f4b0df-d47a-11e7-bac5-d145e32e9b46 Billed duration      100 ms Max memory used      22 MB
<b>Log output</b> <small>The area below shows the logging calls in your code. These correspond to a single row within the CloudWatch log group corresponding to this Lambda function. <a href="#">Click here</a> to view the CloudWatch log group.</small> <pre style="border: 1px dashed #ccc; padding: 5px; margin-top: 10px;">START RequestId: b5f4b0df-d47a-11e7-bac5-d145e32e9b46 Version: \$LATEST I failed: Exception Traceback (most recent call last):   File "/var/task/lambda_function.py", line 2, in lambda_handler     raise Exception('I failed!') Exception: I failed!  END RequestId: b5f4b0df-d47a-11e7-bac5-d145e32e9b46 REPORT RequestId: b5f4b0df-d47a-11e7-bac5-d145e32e9b46 Duration: 0.82 ms      Billed Duration: 100 ms      Memory Size: 128 MB      Max Memory Used: 22 MB</pre>	

- If a client specifies the `Event` invocation type (that is, asynchronous execution), AWS Lambda will not return anything. Instead, it logs the error information to CloudWatch Logs. You can also see the error metrics in CloudWatch Metrics.

Depending on the event source, AWS Lambda may retry the failed Lambda function. For example, if Kinesis is the event source, AWS Lambda will retry the failed invocation until the Lambda function succeeds or the records in the stream expire.

### To test the preceding Python code (console)

- In the console, create a Lambda function using the hello-world blueprint. In **runtime**, choose either **Python 3.6** or **Python 2.7**. In **Handler**, replace `lambda_function.lambda_handler` with `lambda_function.always_failed_handler`. For instructions on how to do this, see [Create a Simple Lambda Function \(p. 9\)](#).
- Replace the template code with the code provided in this section.
- Test the Lambda function using the **Sample event template** called **Hello World** provided in the Lambda console.

### Function Error Handling

You can create custom error handling to raise an exception directly from your Lambda function and handle it directly (Retry or Catch) within an AWS Step Functions State Machine. For more information, see [Handling Error Conditions Using a State Machine](#).

Consider a `CreateAccount` state is a **task** that writes a customer's details to a database using a Lambda function.

- If the task succeeds, an account is created and a welcome email is sent.
- If a user tries to create an account for a username that already exists, the Lambda function raises an error, causing the state machine to suggest a different username and to retry the account-creation process.

The following code samples demonstrate how to do this. Note that custom errors in Python must extend the `Exception` class.

```
class AccountAlreadyExistsException(Exception): pass

def create_account(event, context):
    raise AccountAlreadyExistsException('Account is in use!')
```

You can configure Step Functions to catch the error using a `Catch` rule. Lambda automatically sets the error name to the simple class name of the exception at runtime:

```
{  
    "StartAt": "CreateAccount",  
    "States": {  
        "CreateAccount": {  
            "Type": "Task",  
            "Resource": "arn:aws:lambda:us-east-1:123456789012:function:CreateAccount",  
            "Next": "SendWelcomeEmail",  
            "Catch": [  
                {  
                    "ErrorEquals": ["AccountAlreadyExistsException"],  
                    "Next": "SuggestAccountName"  
                }  
            ]  
        },  
        ...  
    }  
}
```

At runtime, AWS Step Functions catches the error, [transitioning](#) to the `SuggestAccountName` state as specified in the `Next` transition.

Custom error handling makes it easier to create [serverless](#) applications. This feature integrates with all the languages supported by the Lambda [Programming Model \(p. 18\)](#), allowing you to design your application in the programming languages of your choice, mixing and matching as you go.

To learn more about creating your own serverless applications using AWS Step Functions and AWS Lambda, see [AWS Step Functions](#).

## Programming Model for Authoring Lambda Functions in Go

The following sections explain how [common programming patterns and core concepts](#) apply when authoring Lambda function code in [Go](#).

### Topics

- [Lambda Function Handler \(Go\) \(p. 58\)](#)
- [The Context Object \(Go\) \(p. 62\)](#)
- [Logging \(Go\) \(p. 64\)](#)
- [Function Errors \(Go\) \(p. 65\)](#)
- [Using Environment Variables \(Go\) \(p. 67\)](#)

Additionally, note that AWS Lambda provides the following:

- [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 [Lambda Function Handler \(Go\) \(p. 58\)](#).
- [github.com/aws/aws-lambda-go/lambdacontext](#): Helpers for accessing execution context information from the [The Context Object \(Go\) \(p. 62\)](#).
- [github.com/aws/aws-lambda-go/events](#): This library provides type definitions for common event source integrations.

### Lambda Function Handler (Go)

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:** [The Context Object \(Go\) \(p. 62\)](#).
  - **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 string) (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 [The Context Object \(Go\) \(p. 62\)](#).
  - **name string:** An input type with a variable name of `name` whose value will be returned in the `return` statement.
  - **string error:** Returns standard `error` information. For more information on custom error handling, see [Function Errors \(Go\) \(p. 65\)](#).
  - **return fmt.Sprintf("Hello %s!", name), nil:** Simply returns a formatted "Hello" greeting with the name you supplied in the handler signature. `nil` indicates there were no errors and the function executed successfully.
- **func main():** The entry point that executes your Lambda function code. This is required.

By adding `lambda.Start(HandleRequest)` between `func main() {}` code brackets, your Lambda function will be executed.

**Note**

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!"
}
```

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 [Function Errors \(Go\) \(p. 65\)](#).

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. This means, for example, that you may safely change global state, assured that those changes will require a new Execution Context and will not introduce locking or unstable behavior from function invocations directed at the previous Execution Context. For more information, see the following:

- [AWS Lambda Execution Model \(p. 144\)](#)
- [Best Practices for Working with AWS Lambda Functions \(p. 386\)](#)

```
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 {
    invokeCount = invokeCount + 1
    log.Println(myObjects)
    return invokeCount
}

func main() {
    lambda.Start(LambdaHandler)
}
```

## Next Step

[The Context Object \(Go\) \(p. 62\)](#)

## The Context Object (Go)

While a Lambda function is executing, it can interact with AWS Lambda to get useful runtime information such as:

- How much time is remaining before AWS Lambda terminates your Lambda function (timeout is one of the Lambda function configuration properties).
- The [CloudWatch](#) log group and log stream associated with the Lambda function that is executing.
- The AWS request ID returned to the client that invoked the Lambda function. You can use the request ID for any follow up inquiry with AWS support.
- If the Lambda function is invoked through AWS Mobile SDK, you can learn more about the mobile application calling the Lambda function.
- In addition to the options listed below, you can also use the AWS X-Ray SDK for [Go \(p. 330\)](#) to identify critical code paths, trace their performance and capture the data for analysis.

AWS Lambda provides this information via the `context.Context` object that the service passes as a parameter to your Lambda function handler. For more information, see [Valid Handler Signatures \(p. 60\)](#).

The following sections provide an example Lambda function that uses the `context` object, and then lists all of the available methods and attributes.

### 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.CognitoPoolID)
}

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.CognitoPoolID)` prints that information, in this case, the `CognitoPoolID`.

### Monitoring Execution Time of a Function

The following example introduces how to use the context object to monitor how long it takes to execute your Lambda function. 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.Println("hello!")
            time.Sleep(50 * time.Millisecond)
        }
    }
}

func main() {
    lambda.Start(LongRunningHandler)
}

```

The Lambda context library provides the following global variables:

- **MemoryLimitInMB**: Memory limit, in MB, you configured for the Lambda function.
- **FunctionName**: Name of the Lambda function that is running.
- **FunctionVersion**: The Lambda function version that is executing. If an alias is used to invoke the function, then **FunctionVersion** will be the version the alias points to.
- **LogStreamName**: The CloudWatch log stream name for the particular Lambda function execution. It can be null if the IAM user provided does not have permission for CloudWatch actions.
- **LogGroupName**: The CloudWatch log group name associated with the Lambda function invoked. It can be null if the IAM user provided does not have permission for CloudWatch actions.

The Lambda context object also includes the following properties:

- **AwsRequestId**: AWS request ID associated with the request. This is the ID returned to the client that invoked this Lambda function. You can use the request ID for any follow up inquiry with AWS support. Note that if AWS Lambda retries the function (for example, in a situation where the Lambda function processing Kinesis records throw an exception), the request ID remains the same.
- **ClientContext**: Information about the client application and device when invoked through the AWS Mobile SDK. It can be null. Client context provides client information such as client ID, application title, version name, version code, and the application package name.
- **Identity**: Noted in the preceding example. Information about the Amazon Cognito identity provider when invoked through the AWS Mobile SDK. It can be null.

- **InvokedFunctionArn:** The ARN used to invoke this function. It can be function ARN or alias ARN. An unqualified ARN executes the \$LATEST version and aliases execute the function version it is pointing to.

## Next Step

[Logging \(Go\) \(p. 64\)](#)

## Logging (Go)

Your Lambda function can contain logging statements. AWS Lambda writes these logs to CloudWatch. If you use the Lambda console to invoke your Lambda function, the console displays the same logs.

For example, consider the following example.

```
package main

import (
    "log"
    "github.com/aws/aws-lambda-go/lambda"
)

func HandleRequest() {
    log.Println("Hello from Lambda")
}

func main() {
    lambda.Start(HandleRequest)
}
```

By importing the `log` module, Lambda will write additional logging information such as the time stamp.

You can also analyze the logs in CloudWatch. For more information, see [Accessing Amazon CloudWatch Logs for AWS Lambda \(p. 318\)](#).

Instead of using the `log` module, you can use `print` statements in your code as shown below:

```
package main

import (
    "fmt"
    "github.com/aws/aws-lambda-go/lambda"
)

func HandleRequest() {
    fmt.Println("Hello from Lambda")
}

func main() {
    lambda.Start(HandleRequest)
}
```

In this case only the text passed to the `print` method is sent to CloudWatch. The log entries will not have additional information that the `log.Println` function returns. In addition, any logger that writes to `stdout` or `stderr` will seamlessly integrate with a Go function and those logs will automatically be sent to CloudWatch logs.

The console uses the `RequestResponse` invocation type (synchronous invocation) when invoking the function. And therefore it gets the return value ("Hello from Lambda!") back from AWS Lambda.

## Finding Logs

You can find the logs that your Lambda function writes, as follows:

- **In the AWS Lambda console** – The **Log output** section in the AWS Lambda console shows the logs.
- **In the response header, when you invoke a Lambda function programmatically** – If you invoke a Lambda function programmatically, you can add the `LogType` parameter to retrieve the last 4 KB of log data that is written to CloudWatch Logs. AWS Lambda returns this log information in the `x-amz-log-results` header in the response. For more information, see [Invoke \(p. 450\)](#).

If you use AWS CLI to invoke the function, you can specify the `--log-type` parameter with value `Tail` to retrieve the same information.

- **In CloudWatch Logs** – To find your logs in CloudWatch you need to know the log group name and log stream name. You can use the `context.logGroupName`, and `context.logStreamName` global variables in [The Context Object \(Go\) \(p. 64\)](#) library to get this information. When you run your Lambda function, the resulting logs in the console or CLI will show you the log group name and log stream name.

## Next Step

[Function Errors \(Go\) \(p. 65\)](#)

## Function Errors (Go)

You can create custom error handling to raise an exception directly from your Lambda function and handle it directly.

The following code samples demonstrate how to do this. 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 will return:

```
{ "errorMessage": "something went wrong!" }
```

## Function Error Handling

You can create custom error handling to raise an exception directly from your Lambda function and handle it directly (Retry or Catch) within an AWS Step Functions State Machine. For more information, see [Handling Error Conditions Using a State Machine](#).

Consider a `CreateAccount` state is a `task` that writes a customer's details to a database using a Lambda function.

- If the task succeeds, an account is created and a welcome email is sent.

- If a user tries to create an account for a username that already exists, the Lambda function raises an error, causing the state machine to suggest a different username and to retry the account-creation process.

The following code samples demonstrate how to do this.

```
package main

type CustomError struct {}

func (e *CustomError) Error() string {
    return "bad stuff happened..."
}

func MyHandler() (string, error) {
    return "", &CustomError{}
}
```

At runtime, AWS Step Functions catches the error, [transitioning](#) to the `SuggestAccountName` state as specified in the `Next` transition.

Custom error handling makes it easier to create [serverless](#) applications. This feature integrates with all the languages supported by the Lambda [Programming Model \(p. 18\)](#), allowing you to design your application in the programming languages of your choice, mixing and matching as you go.

To learn more about creating your own serverless applications using AWS Step Functions and AWS Lambda, see [AWS Step Functions](#).

### Handling Unexpected Errors

Lambda functions can fail for reasons beyond your control, such as network outages. These are exceptional circumstances. In Go, [panic](#) addresses these issues. If your code panics, Lambda will attempt to capture the error and serialize it into the standard error json format. Lambda will also attempt to insert the value of the panic into the function's CloudWatch logs. After returning the response, Lambda will re-create the function automatically. If you find it necessary, you can include the [panic](#) function in your code to customize the error response.

```
package main

import (
    "errors"

    "github.com/aws/aws-lambda-go/lambda"
)

func handler(string) (string, error) {
    panic(errors.New("Something went wrong"))
}

func main() {
    lambda.Start(handler)
}
```

Which would return the following stack in json:

```
{  
    "errorMessage": "Something went wrong",
```

```
        "errorType": "errorString",
        "stackTrace": [
            {
                "path": "github.com/aws/aws-lambda-go/lambda/function.go",
                "line": 27,
                "label": "(*Function).Invoke.function"
            },
            ...
        ]
    }
```

## Using Environment Variables (Go)

To access [Environment Variables \(p. 377\)](#) 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 %. years old\n", os.Getenv("NAME"), os.Getenv("AGE"))
}
```

Lambda configures the following environment variables by default: [Environment Variables Available to Lambda Functions \(p. 392\)](#).

## Programming Model for Authoring Lambda Functions in C#

The following sections explain how [common programming patterns and core concepts](#) apply when authoring Lambda function code in C#.

### Topics

- [Lambda Function Handler \(C#\) \(p. 68\)](#)
- [The Context Object \(C#\) \(p. 72\)](#)
- [Logging \(C#\) \(p. 73\)](#)
- [Function Errors \(C#\) \(p. 74\)](#)

Additionally, note that AWS Lambda provides the following:

- **Amazon.Lambda.Core** – This library provides a static Lambda logger, serialization interfaces and a context object. The Context object ([The Context Object \(C#\) \(p. 72\)](#)) 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.SNSEvents**

These packages are available at [Nuget Packages](#).

## Lambda Function Handler (C#)

When you create a Lambda function, you specify a handler that AWS Lambda can invoke when the service executes the function on your behalf.

You define a Lambda function handler as an instance or static method in a class. If you want access to the Lambda context object, it is available by defining a method parameter of type *ILambdaContext*, an interface you can use to access information about the current execution, such as the name of the current function, the memory limit, execution time remaining, 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, which can be event data (published by an event source) 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 will be 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 AWS Lambda with event sources such as Amazon S3 or Amazon SNS, these event sources invoke the Lambda function using the `Event` invocation type.

## Handling Streams

Only the `System.IO.Stream` type is supported as an input parameter by default.

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`), which can be event data (published by an event source such as Amazon S3) or custom input 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 other types, as listed below, 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 the return-type will be ignored by Lambda. The return type may be set to `void` in such cases.
- 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 AWS Lambda \(p. 71\)](#).

Unless your function input and output parameters are of type `System.IO.Stream`, you will need to serialize them. AWS Lambda provides a default serializer 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 [Creating a Deployment Package \(C#\) \(p. 79\)](#).

To add the default serializer attribute to a method, first add a dependency on `Amazon.Lambda.Serialization.Json` in your `project.json` file.

```
{
  "version": "1.0.0-*",
  "dependencies": {
    "Microsoft.NETCore.App": {
      "type": "platform",
      "version": "1.0.1"
    },
    "Amazon.Lambda.Serialization.Json": "1.0.0"
  },
  "frameworks": {
    "netcoreapp1.0": {
      "imports": "dnxcore50"
    }
  }
}
```

The example below illustrates the flexibility you can leverage by specifying the default Json.NET serializer on one method and another of your choosing on a different method:

```
public class ProductService{
    [LambdaSerializer(typeof(Amazon.Lambda.Serialization.Json.JsonSerializer))]
    public Product DescribeProduct(DescribeProductRequest request)
    {
        return catalogService.DescribeProduct(request.Id);
    }
}
```

```
[LambdaSerializer(typeof(MyJsonSerializer))]
public Customer DescribeCustomer(DescribeCustomerRequest request)
{
    return customerService.DescribeCustomer(request.Id);
}
```

## Handler Signatures

When creating Lambda functions, you have to provide a handler string that tells AWS 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 `buildOptions.outputName` setting in `project.json`, the **ASSEMBLY** name will be the name of the folder that contains your `project.json` file. For more information, see [.NET Core CLI \(p. 80\)](#). In this case, let's assume the folder name is `HelloWorldApp`.
- **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 will be of this format: **Assembly::Namespace.ClassName::MethodName**

Again, 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 Lambda should invoke. AWS Lambda will reject an otherwise valid signature if the resolution would require selecting among multiple (overloaded) signatures.

## 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 `unsafe` context can be used inside the handler method and its dependencies. For more information, see [unsafe \(C# Reference\)](#).
- It may not pass a variable number of parameters using the `params` keyword, or use `ArgIterator` as an input or return parameter which is used to support variable number of parameters.
- The handler may not be a generic method (e.g. `IList<T> Sort<T>(IList<T> input)`).

- Async handlers with signature `async void` are not supported.

## Using Async in C# Functions with AWS Lambda

If you know 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 DynamoDB, you can take advantage of the `async/await` pattern. By creating a handler with this signature, Lambda will execute the function synchronously and wait a maximum of 5 minutes for execution to complete before returning or timing out. For example:

```
public async Task<Response> ProcessS3ImageResizeAsync(SimpleS3Event input)
{
    var response = await client.DoAsyncWork(input);
    return response;
}
```

If you use this pattern, there are some considerations you must take into account:

- AWS Lambda will 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 execute while others won't. Or some `async` actions won't complete before the function execution is complete.

```
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 example below, 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 only waiting for one to
    finish.
```

```
    await Task.WhenAny(task1, task2, task3);
}
```

## The Context Object (C#)

You can gain useful information on how your Lambda function is interacting with the AWS Lambda runtime by adding the `ILambdaContext` parameter to your method. In return, AWS Lambda provides runtime details such as the CloudWatch log stream associated with the function or the id of the client that called your functions, which you access via the properties provided by the context object.

To do this, create a method with the following signature:

```
public void Handler(string Input, ILambdaContext context)
```

The context object properties are:

- `MemoryLimitInMB`: Memory limit, in MB, you configured for the Lambda function.
- `FunctionName`: Name of the Lambda function that is running.
- `FunctionVersion`: The Lambda function version that is executing. If an alias is used to invoke the function, then `FunctionVersion` will be the version the alias points to.
- `InvokedFunctionArn`: The ARN used to invoke this function. It can be function ARN or alias ARN. An unqualified ARN executes the `$LATEST` version and aliases execute the function version it is pointing to.
- `AwsRequestId`: AWS request ID associated with the request. This is the ID returned to the client that invoked this Lambda function. You can use the request ID for any follow up enquiry with AWS support. Note that if AWS Lambda retries the function (for example, in a situation where the Lambda function processing Kinesis records throw an exception), the request ID remains the same.
- `LogStreamName`: The CloudWatch log stream name for the particular Lambda function execution. It can be null if the IAM user provided does not have permission for CloudWatch actions.
- `LogGroupName`: The CloudWatch log group name associated with the Lambda function invoked. It can be null if the IAM user provided does not have permission for CloudWatch actions.
- `ClientContext`: Information about the client application and device when invoked through the AWS Mobile SDK. It can be null. Client context provides client information such as client ID, application title, version name, version code, and the application package name.
- `Identity`: Information about the Amazon Cognito identity provider when invoked through the AWS Mobile SDK. It can be null.
- `RemainingTime`: Remaining execution time till the function will be terminated. At the time you create the Lambda function you set maximum time limit, at which time AWS Lambda will terminate the function execution. Information about the remaining time of function execution can be used to specify function behavior when nearing the timeout. This is a  `TimeSpan` field.
- `Logger`: The Lambda logger associated with the `ILambdaContext` object. For more information, see [Logging \(C#\) \(p. 73\)](#).

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);
}
```

## Logging (C#)

Your Lambda function can contain logging statements and, in turn, AWS Lambda writes these logs to CloudWatch Logs.

In the C# programming model, there are three ways to log data in your function:

- Use the static `Write` or `WriteLine` methods provided by the C# `Console` class. Anything written to standard out or standard error - using `Console.Write` or a similar method - will be logged in CloudWatch Logs.

```
public class ProductService
{
    public async Task<Product> DescribeProduct(DescribeProductRequest request)
    {
        Console.WriteLine("DescribeProduct invoked with Id " + request.Id);
        return await catalogService.DescribeProduct(request.Id);
    }
}
```

- Use the `Log` method on the `Amazon.Lambda.Core.LambdaLogger` class. This is a static class that can be used anywhere in your application. To use this, you must include the `Amazon.Lambda.Core` library.

```
using Amazon.Lambda.Core;

public class ProductService
{
    public async Task<Product> DescribeProduct(DescribeProductRequest request)
    {
        LambdaLogger.Log("DescribeProduct invoked with Id " + request.Id);
        return await catalogService.DescribeProduct(request.Id);
    }
}
```

Each call to `LambdaLogger.Log` results in a CloudWatch Logs event, provided the event size is within the allowed limits. For information about CloudWatch Logs limits, see [CloudWatch Logs Limits](#) in the [Amazon CloudWatch User Guide](#).

- Use the logger in `ILambdaContext`. The `ILambdaContext` object (if specified) in your method contains a `Logger` property that represents a `LambdaLogger`. The following is an example of using this method:

```
public class ProductService
{
    public async Task<Product> DescribeProduct(DescribeProductRequest request,
        ILambdaContext context)
    {
        context.Logger.Log("DescribeProduct invoked with Id " + request.Id);
        return await catalogService.DescribeProduct(request.Id);
    }
}
```

## How to Find Logs

You can find the logs that your Lambda function writes, as follows:

- Find logs in CloudWatch Logs. The `ILambdaContext` object provides the `LogStreamName` and the `LogGroupName` properties. Using these properties, you can find the specific log stream where logs are written.

- If you invoke a Lambda function via the console, the invocation type is always RequestResponse (that is, synchronous execution) and the console displays the logs that the Lambda function writes using the `LambdaLogger` object. AWS Lambda also returns logs from `Console.WriteLine` and `Console.WriteLine` methods.
- If you invoke a Lambda function programmatically, you can add the `LogType` parameter to retrieve the last 4 KB of log data that is written to CloudWatch Logs. For more information, see [Invoke \(p. 450\)](#). AWS Lambda returns this log information in the `x-amz-log-results` header in the response. If you use the AWS Command Line Interface to invoke the function, you can specify the `--log-type` parameter with value `Tail`.

## Function Errors (C#)

When an exception occurs in your Lambda function, Lambda will report the exception information back to you. Exceptions can occur in two different places:

- Initialization (Lambda loading your code, validating the handler string, and creating an instance of your class if it is non-static).
- The Lambda function invocation.

The serialized exception information is returned as the payload as a modeled JSON object and outputted to CloudWatch logs.

In the initialization phase, exceptions can be thrown for invalid handler strings, a rule-breaking type or method (see [Lambda Function Handler Restrictions \(p. 70\)](#)), 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": "AritheticException",
      "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.ThrowIfCURLError(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.

Depending on the event source, AWS Lambda may retry the failed Lambda function. For more information, see [Understanding Retry Behavior \(p. 152\)](#).

## Function Error Handling

You can create custom error handling to raise an exception directly from your Lambda function and handle it directly (Retry or Catch) within an AWS Step Functions State Machine. For more information, see [Handling Error Conditions Using a State Machine](#).

Consider a CreateAccount [state](#) is a [task](#) that writes a customer's details to a database using a Lambda function.

- If the task succeeds, an account is created and a welcome email is sent.
  - If a user tries to create an account for a username that already exists, the Lambda function raises an error, causing the state machine to suggest a different username and to retry the account-creation process.

The following code samples demonstrate how to do this. Note that custom errors in C# must extend the `Exception` class.

```
namespace Example {
    public class AccountAlreadyExistsException : Exception {
        public AccountAlreadyExistsException(String message) :
            base(message)
        }
    }
}
```

```
namespace Example {
    public class Handler {
        public static void CreateAccount() {
            throw new AccountAlreadyExistsException("Account is in use!");
        }
    }
}
```

You can configure Step Functions to catch the error using a [Catch rule](#). Lambda automatically sets the error name to the simple class name of the exception at runtime:

```
{
    "StartAt": "CreateAccount",
    "States": {
        "CreateAccount": {
            "Type": "Task",
            "Resource": "arn:aws:lambda:us-east-1:123456789012:function:CreateAccount",
            "Next": "SendWelcomeEmail",
            "Catch": [
                {
                    "ErrorEquals": ["AccountAlreadyExistsException"],
                    "Next": "SuggestAccountName"
                }
            ],
            ...
        }
    }
}
```

At runtime, AWS Step Functions catches the error, [transitioning](#) to the `SuggestAccountName` state as specified in the `Next` transition.

Custom error handling makes it easier to create [serverless](#) applications. This feature integrates with all the languages supported by the Lambda [Programming Model \(p. 18\)](#), allowing you to design your application in the programming languages of your choice, mixing and matching as you go.

To learn more about creating your own serverless applications using AWS Step Functions and AWS Lambda, see [AWS Step Functions](#).

## Creating a Deployment Package

To create a Lambda function you first create a Lambda function deployment package, a `.zip` or `.jar` file consisting of your code and any dependencies. When creating the zip, include only the code and its dependencies, not the containing folder. You will then need to set the appropriate security permissions for the zip package.

## Permissions Policies on Lambda Deployment Packages

Zip packages uploaded with incorrect permissions may cause execution failure. AWS Lambda requires global read permissions on code files and any dependent libraries that comprise your deployment package. To ensure permissions are not restricted to your user account, you can check using the following samples:

- Linux/Unix/OSX environments:** Use `zipinfo` as shown in the sample below:

```
$ zipinfo test.zip
Archive: test.zip
Zip file size: 473 bytes, number of entries: 2
-r----- 3.0 unix      0 bx stor 17-Aug-10 09:37 exlib.py
```

```
-r----- 3.0 unx 234 tx defN 17-Aug-10 09:37 index.py  
2 files, 234 bytes uncompressed, 163 bytes compressed: 30.3%
```

The `-r-----` indicates that only the file owner has read permissions, which can cause Lambda function execution failures. The following indicates what you would see if there are requisite global read permissions:

```
$ zipinfo test.zip  
Archive: test.zip  
Zip file size: 473 bytes, number of entries: 2  
-r--r--r-- 3.0 unx 0 bx stor 17-Aug-10 09:37 exlib.py  
-r--r--r-- 3.0 unx 234 tx defN 17-Aug-10 09:37 index.py  
2 files, 234 bytes uncompressed, 163 bytes compressed: 30.3%
```

To fix this recursively, run the following command:

```
$ chmod 644 $(find /tmp/package_contents -type f)  
$ chmod 755 $(find /tmp/package_contents -type d)
```

- The first command changes all files in `/tmp/package_contents` to have read/write permissions to owners, read to group and global.
- The second command cascades the same permissions for directories.

Once you have done that, set the requisite IAM permissions on the package. For more information, see [Authentication and Access Control for AWS Lambda \(p. 340\)](#) policies.

- [Creating a Deployment Package \(Node.js\) \(p. 78\)](#)
- [Creating a Deployment Package \(C#\) \(p. 79\)](#)
- [Creating a Deployment Package \(Go\) \(p. 88\)](#)
- [Creating a Deployment Package \(Java\) \(p. 89\)](#)
- [Creating a Deployment Package \(Python\) \(p. 96\)](#)

## Creating a Deployment Package (Node.js)

To create a Lambda function you first create a Lambda function deployment package, a `.zip` file consisting of your code and any dependencies. As noted previously, you need to set the appropriate security permissions for the zip package. For more information, see [Authentication and Access Control for AWS Lambda \(p. 340\)](#) policies.

You can create a deployment package yourself or write your code directly in the Lambda console, in which case the console creates the deployment package for you and uploads it, creating your Lambda function. Note the following to determine if you can use the console to create your Lambda function:

- **Simple scenario** – If your custom code requires only the AWS SDK library, then you can use the inline editor in the AWS Lambda console. Using the console, you can edit and upload your code to AWS Lambda. The console will zip up your code with the relevant configuration information into a deployment package that the Lambda service can run.

You can also test your code in the console by manually invoking it using sample event data.

### Note

The Lambda service has preinstalled the AWS SDK for Node.js.

- **Advanced scenario** – If you are writing code that uses other resources, such as a graphics library for image processing, or you want to use the AWS CLI instead of the console, you need to first create the Lambda function deployment package, and then use the console or the CLI to upload the package.

**Note**

After you create a deployment package, you may either upload it directly or upload the .zip file first to an Amazon S3 bucket in the same AWS region where you want to create the Lambda function, and then specify the bucket name and object key name when you create the Lambda function using the console or the AWS CLI.

The following is an example procedure to create a deployment package (outside the console). Suppose you want to create a deployment package that includes a `filename.js` code file and your code uses the `async` library.

1. Open a text editor, and write your code. Save the file (for example, `filename.js`).

You will use the file name to specify the handler at the time of creating the Lambda function.

2. In the same directory, use `npm` to install the libraries that your code depends on. For example, if your code uses the `async` library, use the following `npm` command.

```
npm install async
```

3. Your directory will then have the following structure:

```
filename.js
node_modules/async
node_modules/async/lib
node_modules/async/lib/async.js
node_modules/async/package.json
```

4. Zip the content of the folder, that is your deployment package (for example, `sample.zip`).

Then, specify the .zip file name as your deployment package at the time you create your Lambda function.

If you want to include your own binaries, including native ones, just package them in the Zip file you upload and then reference them (including the relative path within the Zip file you created) when you call them from Node.js or from other processes that you've previously started. Ensure that you include the following at the start of your function code: `process.env['PATH'] = process.env['PATH'] + ':' + process.env['LAMBDA_TASK_ROOT']`

For more information on including native binaries in your Lambda function package, see [Running Executables in AWS Lambda](#). Also note that you need to supply the requisite permissions to the contents of the Zip file. For more information, see [Permissions Policies on Lambda Deployment Packages \(p. 77\)](#).

## Creating a Deployment Package (C#)

A .NET Core Lambda deployment package is a zip file of 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 .NET Core runtime. The .NET CLI's `publish` command can create a folder with all of these files, but by default the `proj.runtimeconfig.json` will not be 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.

**Note**

Although it is possible to create the deployment package with the `dotnet publish` command, we suggest you create the deployment package with either the [AWS Toolkit for Visual Studio](#)

Studio (p. 86) or the .NET Core CLI (p. 80). These are tools optimized specifically for Lambda to ensure 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 \(p. 80\)](#)
- [AWS Toolkit for Visual Studio \(p. 86\)](#)

## .NET Core CLI

The .NET Core CLI offers a cross-platform way for you to create .NET-based Lambda applications. This section assumes you have installed the .NET Core CLI. If you haven't, do so [here](#).

In the .NET CLI, you use the new command to create .NET projects from a command line. This is particularly useful if you want to create a platform-independent project outside of Visual Studio. To view a list of the available project types, open a command line and navigate to where you installed the .NET Core runtime and enter the following:

```
dotnet new -all
```

You should see the following:

```
dotnet new -all
Usage: new [options]

Options:
  -h, --help           Displays help for this command.
  -l, --list            Lists templates containing the specified name. If no name is
                        specified, lists all templates.
  -n, --name            The name for the output being created. If no name is specified, the
                        name of the current directory is used.
  -o, --output          Location to place the generated output.
  -i, --install         Installs a source or a template pack.
  -u, --uninstall       Uninstalls a source or a template pack.
  --type                Filters templates based on available types. Predefined values are
                        "project", "item" or "other".
  --force               Forces content to be generated even if it would change existing
                        files.
  -lang, --language     Specifies the language of the template to create.

Templates
Language      Tags           Short Name
-----
```

Language	Tags	Short Name
Console Application	F#, VB	console
Class library	F#, VB	classlib
Unit Test Project	F#, VB	mstest
xUnit Test Project	F#, VB	xunit
ASP.NET Core Empty	F#	web
ASP.NET Core Web App (Model-View-Controller)	F#	mvc
ASP.NET Core Web App	F#	razor
ASP.NET Core with Angular	Web/MVC/SPA	angular
ASP.NET Core with React.js	Web/MVC/SPA	react

ASP.NET Core with React.js and Redux Web/MVC/SPA	reactredux	[C#]
ASP.NET Core Web API F# global.json file Config	webapi	[C#],
NuGet Config Config	globaljson	
Web Config Config	nugetconfig	
Solution File Solution	webconfig	
Razor Page Web/ASP.NET	sln	
MVC ViewImports Web/ASP.NET	page	
MVC ViewStart Web/ASP.NET	viewimports	
	viewstart	

**Examples:**

```
dotnet new mvc --auth None --framework netcoreapp1.1
```

```
dotnet new mvc --framework netcoreapp1.1
dotnet new --help
```

So, for example, if you wanted to create a console project, you would do the following:

1. Make a directory where your project will be created using the following command: `mkdir example`
2. Navigate to that directory using the following command: `cd example`
3. Enter the following command: `dotnet new console -o myproject`

This will create the following files in your `example` directory:

- `Program.cs`, which is where you write your Lambda function code.
- `MyProject.csproj`, an XML file that lists the files and dependencies that comprise your .NET application.

AWS 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::*
```

The trailing `::*` in the command signals to install the latest version. Once the install is complete, the Lambda templates show up as part of `dotnet new`. To verify this, again run the following command:

`dotnet new -all`

```
dotnet new -all
Usage: new [options]

Options:
  -h, --help           Displays help for this command.
  -l, --list            Lists templates containing the specified name. If no name is
                        specified, lists all templates.
  -n, --name            The name for the output being created. If no name is specified, the
                        name of the current directory is used.
  -o, --output          Location to place the generated output.
  -i, --install         Installs a source or a template pack.
  -u, --uninstall       Uninstalls a source or a template pack.
```

```
--type          Filters templates based on available types. Predefined values are
"project", "item" or "other".
--force         Forces content to be generated even if it would change existing
files.
--lang, --language   Specifies the language of the template to create.
```

Templates		Short Name	
Language	Tags		
Lambda Detect Image Labels	AWS/Lambda/Function	lambda.DetectImageLabels	[ C# ]
Lambda Empty Function	AWS/Lambda/Function	lambda.EmptyFunction	[ C# ]
Lex Book Trip Sample	AWS/Lambda/Function	lambda.LexBookTripSample	[ C# ]
Lambda Simple DynamoDB Function	AWS/Lambda/Function	lambda.DynamoDB	[ C# ]
Lambda Simple Kinesis Firehose Function	AWS/Lambda/Function	lambda.KinesisFirehose	[ C# ]
Lambda Simple Kinesis Function	AWS/Lambda/Function	lambda.Kinesis	[ C# ]
Lambda Simple S3 Function	AWS/Lambda/Function	lambda.S3	[ C# ]
Lambda ASP.NET Core Web API	AWS/Lambda/Serverless	lambda.AspNetCoreWebAPI	[ C# ]
Lambda DynamoDB Blog API	AWS/Lambda/Serverless	lambda.DynamoDBBlogAPI	[ C# ]
Lambda Empty Serverless	AWS/Lambda/Serverless	lambda.EmptyServerless	[ C# ]
Step Functions Hello World	AWS/Lambda/Serverless	lambda.StepFunctionsHelloWorld	[ C# ]
Console Application	F#, VB Common/Console	console	[ C# ], [ F# ], [ VB ]
Class library	F#, VB Common/Library	classlib	[ C# ], [ F# ], [ VB ]
Unit Test Project	F#, VB Test/MSTest	mstest	[ C# ], [ F# ], [ VB ]
xUnit Test Project	F#, VB Test/xUnit	xunit	[ C# ], [ F# ], [ VB ]
ASP.NET Core Empty	F# Web/Empty	web	[ C# ], [ F# ]
ASP.NET Core Web App (Model-View-Controller)	F# Web/MVC	mvc	[ C# ], [ F# ]
ASP.NET Core Web App	Web/MVC/Razor Pages	razor	[ C# ]
ASP.NET Core with Angular	Web/MVC/SPA	angular	[ C# ]
ASP.NET Core with React.js	Web/MVC/SPA	react	[ C# ]
ASP.NET Core with React.js and Redux	Web/MVC/SPA	reactredux	[ C# ]
ASP.NET Core Web API	F# Web/WebAPI	webapi	[ C# ], [ F# ]
global.json file	Config	globaljson	
NuGet Config	Config	nugetconfig	
Web Config	Config	webconfig	
Solution File	Solution	sln	
Razor Page	Web/ASP.NET	page	
MVC ViewImports	Web/ASP.NET	viewimports	

MVC ViewStart  
Web/ASP.NET

viewstart

**Examples:**

```
dotnet new mvc --auth Individual  
dotnet new console  
dotnet new --help
```

To examine details about a particular template, use the following command:  
`dotnet new lambda.EmptyFunction --help`

Note the following:

```
-p|--profile  The AWS credentials profile set in aws-lambda-tools-defaults.json and used  
as the default profile when interacting with AWS.  
string - Optional  
  
-r|--region   The AWS region set in aws-lambda-tools-defaults.json and used as the default  
region when interacting with AWS.  
string - Optional
```

These are optional values you can set when you create your Lambda function and will then be automatically written to the `aws-lambda-tools-defaults.json` file, which is built as part of the function-creation process. The following explains what they mean:

- **--profile:** Your execution role.

To create an IAM role (execution role):

1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
2. Follow the steps in **IAM Roles** in the *IAM User Guide* to create an IAM role (execution role). As you follow the steps to create a role, note the following:
  - In **Select Role Type**, choose **AWS Service Roles**, and then choose **AWS Lambda**.
  - In **Attach Policy**, choose the policy that best fits your Lambda function's requirements. If it's not interacting with any other AWS services, you would choose **AWSLambdaBasicExecutionRole**. However, say your Lambda function is interacting with Kinesis, then you would choose the **AWSLambdaKinesisExecutionRole**.
- **--region:** The Amazon Region in which your function will reside.

For example, to create a Lambda function, run the following command, substituting the values of the `--region` parameter with the region of your choice and `--profile` with your IAM profile:

**Note**

For more information on Lambda function requirements, see [CreateFunction \(p. 412\)](#)

```
dotnet new lambda.EmptyFunction --name MyFunction --profile default --region region
```

This should create a directory structure similar to the following:

```
<dir>myfunction  
  /src/myfunction  
  /test/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": "iam profile",
"region" : "region",
"configuration" : "Release",
"framework" : "netcoreapp2.0",
"function-runtime": "dotnetcore2.0",
"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 \(p. 86\)](#). 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.Json.JsonSerializer))]

namespace MyFunction
{
    public class Function
    {

        public string FunctionHandler1(string input, ILambdaContext context)
        {
            return input?.ToUpper();
        }
    }
}
```

- **MyFunction.csproj:** An [MSBuild](#) file that lists the files and assemblies that comprise your application. Note specifically that it includes the `Amazon.Lambda.Tools` package, the extension that makes available the Lambda templates described previously.

```
<Project Sdk="Microsoft.NET.Sdk">

<PropertyGroup>
    <TargetFramework>netcoreapp2.0</TargetFramework>
</PropertyGroup>

<ItemGroup>
    <PackageReference Include="Amazon.Lambda.Core" Version="2.0.0" />
    <PackageReference Include="Amazon.Lambda.Serialization.Json" Version="1.1.0" />
</ItemGroup>

<ItemGroup>
    <DotNetCliToolReference Include="Amazon.Lambda.Tools" Version="2.0.0" />
</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 above, 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, allowing you to seamlessly integrate any Lambda templates required to test your function.

```
<Project Sdk="Microsoft.NET.Sdk">
  ...
  <PackageReference Include="Amazon.Lambda.Core" Version="2.0.0" />
  ...

```

- **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 it by running the following commands from the parent `example` directory:

```
dotnet restore
dotnet lambda deploy-function MyFunction --function-role role
```

After deployment, you can re-test it in a production environment with 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"
```

Presuming everything was successful, you should 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: 100 ms      Memory Size:
256 MB     Max Memory Used: 12 MB
```

## Serializing Lambda Functions

For any Lambda functions that use input or output types other than a `Stream` object, you will need to add a serialization library to your application. You can do this in the following ways:

- Use Json.NET. Lambda will provide an implementation for JSON serializer using JSON.NET as a [NuGet](#) package.
- 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 is returned by the `Invoke` API.

You use whichever serializer you wish by adding it as a dependency to your `MyProject.csproj` file.

```
...
<ItemGroup>
  <PackageReference Include="Amazon.Lambda.Core" Version="2.0.0" />
  <PackageReference Include="Amazon.Lambda.Serialization.Json" Version="1.0.1" />
</ItemGroup>
```

You then add it to your `AssemblyInfo.cs` file. For example, if you are using the default Json.NET serializer, this is what you would add:

```
[assembly:LambdaSerializer(typeof(Amazon.Lambda.Serialization.Json.JsonSerializer))]
```

### Note

You can define a custom serialization attribute at the method level, which will override the default serializer specified at the assembly level. For more information, see [Handling Standard Data Types \(p. 69\)](#).

## AWS Toolkit for Visual Studio

You can build .NET-based Lambda applications using the Lambda plugin to the [AWS Toolkit for Visual Studio](#). The plugin is available as part of a [Nuget](#) package.

### Step 1: Create and Build a Project

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 **AWS Lambda Project (.NET Core)** and then choose **OK**.
  - c. In the **Select Blueprint** window, you will be presented with the option of selecting from a list of sample applications that will provide you with sample code to get started with creating a .NET-based Lambda application.
  - d. To create a Lambda application from scratch, choose **Blank Function** and then choose **Finish**.
2. Examine the `aws-lambda-tools-defaults.json` file, which is created as part of your project. You can set the options in this file, which is read by the Lambda tooling by default. The project templates created in Visual Studio set many of these fields with default values. Note the following fields:
- **profile:** The IAM role required for your Lambda function's execution. If you have not yet created an execution role, do the following:
    1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
    2. Follow the steps in [Creating a Role to Delegate Permissions to an AWS Service](#) in the *IAM User Guide* to create an IAM role (execution role). As you follow the steps to create a role, note the following:
      - In **Role Name**, use a name that is unique within your AWS account.
      - In **Select Role Type**, choose **AWS Service Roles**, and then choose a service role that grants that service permissions to assume the role.
      - In **Attach Policy**, choose a permissions policy that is suitable to execute your Lambda function.
  - **function-handler:** This is where the `function_handler` is specified, which 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 will need to update the corresponding fields in the `aws-lambda-tools-defaults.json` file.

```
{  
    "profile": "iam-execution-profile",  
    "region" : "region",  
    "configuration" : "Release",  
    "framework" : "netcoreapp2.0",  
    "function-runtime": "dotnetcore2.0",  
    "function-memory-size" : 256,  
    "function-timeout" : 30,  
    "function-handler" : "Assembly::Namespace.Class::Function"  
}
```

3. Open the **Function.cs** file. You will be provided with a template to implement your Lambda function handler code.

```

using System;
using Amazon.Lambda.Core;
using Amazon.Lambda.Serialization;

// Assembly attribute to enable the Lambda function's JSON input to be converted into a .NET class.
[assembly: LambdaSerializerAttribute(typeof(Amazon.Lambda.Serialization.Json.JsonSerializer))]

namespace AWSLambda
{
    public class LambdaFunction
    {

        /// <summary>
        /// A simple function that takes a string and does a ToUpper
        /// </summary>
        /// <param name="input"></param>
        /// <param name="context"></param>
        /// <returns></returns>
        public string FunctionHandler(string input, ILambdaContext context)
        {
            return input?.ToUpper();
        }
    }
}

```

4. Once you have written the code that represents your Lambda function, you can upload it by right-clicking the **Project** node in your application and then choosing **Publish to AWS Lambda**.
5. In the **Upload Lambda Function** window, type a name for the function or select a previously published function to republish. Then choose **Next**
6. In the **Advanced Function Details** window, do the following:
  - Specify the **Role Name**; the IAM role mentioned previously.
  - (Optional) In **Environment**: specify any environment variables you wish to use. For more information, see [Environment Variables \(p. 377\)](#).
  - (Optional) Specify the **Memory (MB)** or **Timeout (Secs)** configurations.
  - (Optional) Specify any **VPC**: configurations if your Lambda function needs to access resources running inside a VPC. For more information, see [Configuring a Lambda Function to Access Resources in an Amazon VPC \(p. 133\)](#).
  - Choose **Next** and then choose **Upload** to deploy your application.

For more information, see [Deploying an AWS Lambda Project with the .NET Core CLI](#).

## Creating a Deployment Package (Go)

To create a Lambda function you first create a Lambda function deployment package, a .zip file consisting of your code and any dependencies.

After you create a deployment package, you may either upload it directly or upload the .zip file first to an Amazon S3 bucket in the same AWS region where you want to create the Lambda function, and then specify the bucket name and object key name when you create the Lambda function using the console or the AWS CLI.

For Lambda functions written in Go, download the Lambda library for Go by navigating to the Go runtime directory and enter the following command:

```
go get github.com/aws/aws-lambda-go/lambda
```

Then use following command to build, package and deploy a Go Lambda function via the CLI. Note that your *function-name* must match the name of your *Lambda handler* name.

```

GOOS=linux go build lambda_handler.go
zip handler.zip ./lambda_handler
# --handler is the path to the executable inside the .zip

```

```
aws lambda create-function \
--region region \
--function-name lambda-handler \
--memory 128 \
--role arn:aws:iam::account-id:role/execution_role \
--runtime go1.x \
--zip-file fileb://path-to-your-zip-file/handler.zip \
--handler lambda-handler
```

**Note**

If you are using a non-Linux environment, such as Windows or macOS, ensure that your handler function is compatible with the Lambda [Execution Context](#) by setting the `GOOS` (Go Operating System) environment variable to 'linux' when compiling your handler function code.

## Creating a Deployment Package on Windows

To create a .zip that will work on AWS Lambda using Windows, we recommend installing the [build-lambda-zip](#) tool.

**Note**

If you have not already done so, you will need to install [git](#) and then add the `git` executable to your Windows `%PATH%` environment variable.

To download the tool, run the following command:

```
go.exe get -u github.com/aws/aws-lambda-go/cmd/build-lambda-zip
```

Use the tool from your `GOPATH`. If you have a default installation of Go, the tool will typically be in `%USERPROFILE%\Go\bin`. Otherwise, navigate to where you installed the Go runtime and do the following:

In cmd.exe, run the following:

```
set GOOS=linux
go build -o main main.go
%USERPROFILE%\Go\bin\build-lambda-zip.exe -o main.zip main
```

In Powershell, run the following:

```
$env:GOOS = "linux"
go build -o main main.go
~\Go\Bin\build-lambda-zip.exe -o main.zip main
```

## Creating a Deployment Package (Java)

Your deployment package can be a .zip file or a standalone jar; it is your choice. You can use any build and packaging tool you are familiar with to create a deployment package.

We provide examples of using Maven to create standalone jars and using Gradle to create a .zip file. For more information, see the following topics:

**Topics**

- [Creating a .jar Deployment Package Using Maven without any IDE \(Java\) \(p. 90\)](#)
- [Creating a .jar Deployment Package Using Maven and Eclipse IDE \(Java\) \(p. 92\)](#)
- [Creating a .zip Deployment Package \(Java\) \(p. 94\)](#)

- [Authoring Lambda Functions Using Eclipse IDE and AWS SDK Plugin \(Java\) \(p. 96\)](#)

## Creating a .jar Deployment Package Using Maven without any IDE (Java)

This section shows how to package your Java code into a deployment package using Maven at the command line.

### Topics

- [Before You Begin \(p. 90\)](#)
- [Project Structure Overview \(p. 90\)](#)
- [Step 1: Create Project \(p. 90\)](#)
- [Step 2: Build Project \(Create Deployment Package\) \(p. 92\)](#)

### Before You Begin

You will need to install the Maven command-line build tool. For more information, go to [Maven](#). If you are using Linux, check your package manager.

```
sudo apt-get install mvn
```

if you are using Homebrew

```
brew install maven
```

### Project Structure Overview

After you set up the project, you should have the following folder structure:

```
project-dir/pom.xml  
project-dir/src/main/java/ (your code goes here)
```

Your code will then be in the /java folder. For example, if your package name is `example` and you have a `Hello.java` class in it, the structure will be:

```
project-dir/src/main/java/example/Hello.java
```

After you build the project, the resulting .jar file (that is, your deployment package), will be in the `project-dir/target` subdirectory.

### Step 1: Create Project

Follow the steps in this section to create a Java project.

1. Create a project directory (`project-dir`).
2. In the `project-dir` directory, create the following:
  - Project Object Model file, `pom.xml`. Add the following project information and configuration details for Maven to build the project.

```
<project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"  
        xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/maven-v4_0_0.xsd">
```

```

<modelVersion>4.0.0</modelVersion>

<groupId>doc-examples</groupId>
<artifactId>lambda-java-example</artifactId>
<packaging>jar</packaging>
<version>1.0-SNAPSHOT</version>
<name>lambda-java-example</name>

<dependencies>
    <dependency>
        <groupId>com.amazonaws</groupId>
        <artifactId>aws-lambda-java-core</artifactId>
        <version>1.1.0</version>
    </dependency>
</dependencies>

<build>
    <plugins>
        <plugin>
            <groupId>org.apache.maven.plugins</groupId>
            <artifactId>maven-shade-plugin</artifactId>
            <version>2.3</version>
            <configuration>
                <createDependencyReducedPom>false</createDependencyReducedPom>
            </configuration>
            <executions>
                <execution>
                    <phase>package</phase>
                    <goals>
                        <goal>shade</goal>
                    </goals>
                </execution>
            </executions>
        </plugin>
    </plugins>
</build>
</project>

```

### Note

- In the dependencies section, the groupId (that is, com.amazonaws) is the Amazon AWS group ID for Maven artifacts in the Maven Central Repository. The artifactId (that is, aws-lambda-java-core) is the AWS Lambda core library that provides definitions of the RequestHandler, RequestStreamHandler, and the Context AWS Lambda interfaces for use in your Java application. At the build time Maven resolves these dependencies.
- In the plugins section, the Apache maven-shade-plugin is a plugin that Maven will download and use during your build process. This plugin is used for packaging jars to create a standalone .jar (a .zip file), your deployment package.
- 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. In the *project-dir*, create the following structure:

```
project-dir/src/main/java
```

4. Under the /java subdirectory you add your Java files and folder structure, if any. For example, if your Java package name is example, and source code is Hello.java, your directory structure looks like this:

```
project-dir/src/main/java/example/Hello.java
```

## Step 2: Build Project (Create Deployment Package)

Now you can build the project using Maven at the command line.

1. At a command prompt, change directory to the project directory (*project-dir*).
2. Run the following `mvn` command to build the project:

```
$ mvn package
```

The resulting .jar is saved as *project-dir*/target/lambda-java-example-1.0-SNAPSHOT.jar. The .jar name is created by concatenating the artifactId and version in the pom.xml file.

The build creates this resulting .jar, using information in the pom.xml to do the necessary transforms. This is a standalone .jar (.zip file) that includes all the dependencies. This is your deployment package that you can upload to AWS Lambda to create a Lambda function.

## Creating a .jar Deployment Package Using Maven and Eclipse IDE (Java)

This section shows how to package your Java code into a deployment package using Eclipse IDE and Maven plugin for Eclipse.

### Topics

- [Before You Begin \(p. 92\)](#)
- [Step 1: Create and Build a Project \(p. 92\)](#)

### Before You Begin

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.

### Step 1: 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** window, type the following values:

**Group Id:** com.amazonaws

**Artifact Id:** aws-lambda-java-core

**Version:** 1.1.0

**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 create 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:** 2.3
- 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`.

## Creating a .zip Deployment Package (Java)

This section provides examples of creating .zip file as your deployment package. You can use any build and packaging tool you like to create this zip. Regardless of the tools you use, the resulting .zip file must have the following structure:

- All compiled class files and resource files at the root level.
- All required jars to run the code in the `/lib` directory.

### Note

You can also build a standalone .jar (also a zipped file) as your deployment package. For examples of creating standalone .jar using Maven, see [Creating a Deployment Package \(Java\) \(p. 89\)](#).

The following examples use Gradle build and deployment tool to create the .zip.

### Important

Gradle version 2.0 or later is required.

## Before You Begin

You will need to download Gradle. For instructions, go to the gradle website, <https://gradle.org/>.

## Example 1: Creating .zip Using Gradle and the Maven Central Repository

At the end of this walkthrough, you will have a project directory (`project-dir`) with content having the following structure:

```
project-dir/build.gradle
project-dir/src/main/java/
```

The `/java` folder will contain your code. For example, if your package name is `example`, and you have a `Hello.java` class in it, the structure will be:

```
project-dir/src/main/java/example/Hello.java
```

After you build the project, the resulting .zip file (that is, your deployment package), will be in the `project-dir/build/distributions` subdirectory.

1. Create a project directory (`project-dir`).

2. In the *project-dir*, create build.gradle file and add the following content:

```
apply plugin: 'java'

repositories {
    mavenCentral()
}

dependencies {
    compile (
        'com.amazonaws:aws-lambda-java-core:1.1.0',
        'com.amazonaws:aws-lambda-java-events:1.1.0'
    )
}

task buildZip(type: Zip) {
    from compileJava
    from processResources
    into('lib') {
        from configurations.compile Classpath
    }
}

build.dependsOn buildzip
```

#### Note

- The repositories section refers to Maven Central Repository. At the build time, it fetches the dependencies (that is, the two AWS Lambda libraries) from Maven Central.
- The buildZip task describes how to create the deployment package .zip file.

For example, if you unzip the resulting .zip file you should find any of the compiled class files and resource files at the root level. You should also find a /lib directory with the required jars for running the code.

- 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. In the *project-dir*, create the following structure:

```
project-dir/src/main/java/
```

4. Under the /java subdirectory you add your Java files and folder structure, if any. For example, if you Java package name is example, and source code is Hello.java, then your directory structure looks like this:

```
project-dir/src/main/java/example/Hello.java
```

5. Run the following gradle command to build and package the project in a .zip file.

```
project-dir> gradle build
```

6. Verify the resulting *project-dir.zip* file in the *project-dir/build/distributions* subdirectory.
7. Now you can upload the .zip file, your deployment package to AWS Lambda to create a Lambda function and test it by manually invoking it using sample event data. For instruction, see [\(Optional\) Create a Lambda Function Authored in Java \(p. 49\)](#).

## Example 2: Creating .zip Using Gradle Using Local Jars

You may choose not to use the Maven Central repository. Instead have all the dependencies in the project folder. In this case your project folder (*project-dir*) will have the following structure:

```
project-dir/jars/          (all jars go here)
project-dir/build.gradle
project-dir/src/main/java/ (your code goes here)
```

So if your Java code has example package and Hello.java class, the code will be in the following subdirectory:

```
project-dir/src/main/java/example>Hello.java
```

Your build.gradle file should be as follows:

```
apply plugin: 'java'

dependencies {
    compile fileTree(dir: 'jars', include: '*.jar')
}

task buildZip(type: Zip) {
    from compileJava
    from processResources
    into('lib') {
        from configurations.runtime
    }
}

build.dependsOn buildZip
```

Note that the dependencies specify fileTree which identifies *project-dir*/jars as the subdirectory that will include all the required jars.

Now you build the package. Run the following gradle command to build and package the project in a .zip file.

```
project-dir> gradle build
```

## Authoring Lambda Functions Using Eclipse IDE and AWS SDK Plugin (Java)

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 AWS Lambda with the AWS Toolkit for Eclipse](#).

## Creating a Deployment Package (Python)

To create a Lambda function you first create a Lambda function deployment package, a .zip file consisting of your code and any dependencies. You will then need to set the appropriate security permissions for the zip package. For more information, see [Authentication and Access Control for AWS Lambda \(p. 340\)](#) policies.

You can create a deployment package yourself or write your code directly in the Lambda console, in which case the console creates the deployment package for you and uploads it, creating your Lambda function. Note the following to determine if you can use the console to create your Lambda function:

- **Simple scenario** – If your custom code requires only the AWS SDK library, then you can use the inline editor in the AWS Lambda console. Using the console, you can edit and upload your code to AWS Lambda. The console will zip up your code with the relevant configuration information into a deployment package that the Lambda service can run.

You can also test your code in the console by manually invoking it using sample event data.

**Note**

The Lambda service has preinstalled the AWS SDK for Python.

- **Advanced scenario** – If you are writing code that uses other resources, such as a graphics library for image processing, or you want to use the AWS CLI instead of the console, you need to first create the Lambda function deployment package, and then use the console or the CLI to upload the package.

**Note**

After you create a deployment package, you may either upload it directly or upload the .zip file first to an Amazon S3 bucket in the same AWS region where you want to create the Lambda function, and then specify the bucket name and object key name when you create the Lambda function using the console or the AWS CLI.

The following is an example procedure to create a deployment package (outside the console).

**Note**

This should work for most standard installations of Python and pip when using pure Python modules in your Lambda function. If you are including modules that have native dependencies or have Python installed with Homebrew on OS X, you should see the next section which provides instructions to create a deployment package when using Virtualenv. For more information, see [Create Deployment Package Using a Python Environment Created with Virtualenv \(p. 98\)](#) and the [Virtualenv](#) website.

You will use pip to install dependencies/libraries. For information to install pip, go to [Installation](#).

1. You create a directory, for example `project-dir`.
2. Save all of your Python source files (the .py files) at the root level of this directory.
3. Install any libraries using `pip`. Again, you install these libraries at the root level of the directory.

```
pip install module-name -t /path/to/project-dir
```

For example, the following command installs the `requests` HTTP library in the `project-dir` directory.

```
pip install requests -t /path/to/project-dir
```

If using Mac OS X and you have Python installed using Homebrew (see [Homebrew](#)), the preceding command will not work. A simple workaround is to add a `setup.cfg` file in your `/path/to/project-dir` with the following content.

```
[install]
prefix=
```

4. Zip the content of the `project-dir` directory, which is your deployment package.

**Important**

Zip the directory `content` contained within the directory, not the directory itself. The contents of the Zip file are available as the current working directory of the Lambda function. For example: `/project-dir/codefile.py/lib/yourlibraries`. In this case, you zip the content contained within `/project-dir`.

**Note**

AWS Lambda includes the AWS SDK for Python (Boto 3), so you don't need to include it in your deployment package. However, if you want to use a version of Boto3 other than the one included by default, you can include it in your deployment package.

## Create Deployment Package Using a Python Environment Created with Virtualenv

This section explains how to create a deployment package if you are using a Python environment that you created with the Virtualenv tool. Consider the following example:

- Created the following isolated Python environment using the Virtualenv tool and activated the environment:

```
virtualenv path/to/my/virtual-env
```

You can activate the environment on Windows, OS X, and Linux as follows:

- On Windows, you activate using the `activate.bat`:

```
path\to\my\virtual-env\Scripts\activate.bat
```

- On OS X and Linux, you source the `activate` script:

```
source path/to/my/virtual-env/bin/activate
```

- Also, to install the `requests` package in the activated environment, do the following:

```
pip install requests
```

Now, to create a deployment package you do the following:

1. First, create .zip file with your Python code you want to upload to AWS Lambda.
2. Add the libraries from preceding activated virtual environment to the .zip file. That is, you add the content of the following directory to the .zip file (note again that you add the content of the directory and not the directory itself).

For Windows the directory is:

```
%VIRTUAL_ENV%\Lib\site-packages
```

For OS X, Linux, the directory is:

```
$VIRTUAL_ENV/lib/python3.6/site-packages
```

**Note**

If you don't find the packages in the `site-packages` directory in your virtual environment, you might find it in the `dist-packages` directory.

For an example of creating a Python deployment package, see [Python \(p. 183\)](#).

# Test Your Serverless Applications Locally Using SAM CLI (Public Beta)

## Note

This feature is available as part of a public beta and is subject to change at any time.

**AWS SAM** is a fast and easy way of deploying your serverless applications, allowing you to write simple templates to describe your functions and their event sources (Amazon API Gateway, Amazon S3, Kinesis, and so on).

Based on AWS SAM, SAM CLI is a tool that provides an environment for you to develop, test, and analyze your serverless applications locally before uploading them to the Lambda runtime. Whether you're developing on Linux, Mac, or Microsoft Windows, you can use SAM CLI to create a local testing environment that simulates the AWS runtime environment. The SAM CLI also allows faster, iterative development of your Lambda function code. For more information, see [Building a Simple Application Using SAM CLI \(p. 102\)](#).

SAM CLI works with [AWS SAM](#), allowing you to invoke functions defined in SAM templates, whether directly or through API Gateway endpoints. By using SAM CLI features, you can analyze your serverless application's performance in your own testing environment and update accordingly.

SAM CLI also offers the `sam-init` command, which, when run, provides a fully-functional SAM application that you can use to further your understanding of the SAM application model or enhance your application to meet production needs. For more information, see [Create a Simple App \(sam init\) \(p. 302\)](#).

The following examples outline additional advantages of using SAM CLI with sample operation code. For instance, you can do the following:

- Generate sample function payloads (for example, an Amazon S3 event).

```
$ sam local generate-event s3 --bucket bucket-name --key key-name  
      > event_file.json
```

- Test a sample function payload locally with your Lambda functions.

```
$ sam local invoke function-name -e event_file.json
```

- Spawn a local API Gateway to test HTTP request and response functionality. By using the hot reloading feature, you can test and iterate your functions without having to restart or reload them to the AWS runtime.

```
$ sam local start-api
```

SAM CLI will automatically find any functions within your SAM template that have API event sources defined, and mount them at the defined HTTP paths. In the example below, the `Ratings` function would mount `ratings.py:handler()` at `/ratings` for GET requests.

```
Ratings:  
  Type: AWS::Serverless::Function  
  Properties:  
    Handler: ratings.handler  
    Runtime: python3.6  
    Events:  
      Api:  
        Type: Api  
        Properties:
```

Path: /ratings  
Method: get

By default, SAM CLI uses [Proxy Integration](#) and expects the response from your Lambda function to include one or more of the following: statusCode, headers and/or body. For example:

```
// Example of a Proxy Integration response
exports.handler = (event, context, callback) => {
  callback(null, {
    statusCode: 200,
    headers: { "x-custom-header" : "my custom header value" },
    body: "hello world"
  });
}
```

If your Lambda function does not return a valid [Proxy Integration](#) response, you will receive an HTTP 500 (Internal Server Error) response when accessing your function. SAM CLI will also print the following error log message to help you diagnose the problem:

```
ERROR: Function ExampleFunction returned an invalid response (must include one of: body,
       headers
           or statusCode in the response object)
```

- Validate that any runtime constraints, such as maximum memory use or timeout limits of your Lambda function invocations, are honored.
- Inspect AWS Lambda runtime logs, and also any customized logging output specified in your Lambda function code (for example, `console.log`). SAM CLI automatically displays this output. The following shows an example.

```
START RequestId: 2137da9a-c79c-1d43-5716-406b4e6b5c0a Version: $LATEST
2017-05-18T13:18:57.852Z      2137da9a-c79c-1d43-5716-406b4e6b5c0a
Error: any error information
END RequestId: 2137da9a-c79c-1d43-5716-406b4e6b5c0a
REPORT RequestId: 2137da9a-c79c-1d43-5716-406b4e6b5c0a
Duration: 12.78 ms      Billed Duration: 100 ms Memory Size: 128 MB
Max Memory Used: 29 MB
```

- Honor security credentials that you've established by using the AWS CLI. Doing so means your Lambda function can make remote calls to the AWS services that make up your serverless application. If you have not installed the AWS CLI, see [Installing the AWS Command Line Interface](#).

As with the AWS CLI and SDKs, SAM CLI looks for credentials in the following order:

- Environment variables (`AWS_ACCESS_KEY_ID`, `AWS_SECRET_ACCESS_KEY`)
- The AWS credentials file, located at `~/.aws/credentials` on Linux, MacOS, or Unix, or at `C:\Users\USERNAME\.aws\credentials` on Windows)
- Instance profile credentials, if running on an Amazon EC2 instance with an assigned instance role

## Supported Runtimes

SAM CLI supports the following AWS runtimes:

- node.js 4.3
- node.js 6.10
- node.js 8.10
- python 2.7

- python 3.6
- java8
- go 1.x

If you have not already installed SAM CLI, see [Install SAM CLI \(p. 7\)](#).

## Getting Started Using SAM CLI

SAM CLI consists of the following CLI operations:

- **start-api**: Creates a local HTTP server hosting all of your Lambda functions. When accessed by using a browser or the CLI, this operation launches a Docker container locally to invoke your function. It reads the `CodeUri` property of the `AWS::Serverless::Function` resource to find the path in your file system containing the Lambda function code. This path can be the project's root directory for interpreted languages like Node.js or Python, a build directory that stores your compiled artifacts, or for Java, a `.jar` file.

If you use an interpreted language, local changes are made available within the same Docker container. This approach means you can reinvoke your Lambda function with no need for redeployment. For compiled languages or projects requiring complex packing support, we recommend that you run your own build solution and point AWS SAM to the directory that contains the build dependency files needed.

- **invoke**: Invokes a local Lambda function once and terminates after invocation completes.

```
# Invoking function with event file
$ sam local invoke "Ratings" -e event.json

# Invoking function with event via stdin
$ echo '{"message": "Hey, are you there?" }' | sam local invoke "Ratings"

# For more options
$ sam local invoke --help
```

- **generate-event**: Generates mock serverless events. Using these, you can develop and test locally on functions that respond to asynchronous events such as those from Amazon S3, Kinesis, and DynamoDB. The following displays the command options available to the `generate-event` operation.

```
sam local generate-event
NAME:
  sam local generate-event - Generates Lambda events (e.g. for S3/Kinesis etc) that can
  be piped to 'sam local invoke'

USAGE:
  sam local generate-event command [command options] [arguments...]

COMMANDS:
  s3      Generates a sample Amazon S3 event
  sns     Generates a sample Amazon SNS event
  kinesis Generates a sample Amazon Kinesis event
  dynamodb Generates a sample Amazon DynamoDB event
  api     Generates a sample Amazon API Gateway event
  schedule Generates a sample scheduled event

OPTIONS:
  --help, -h  show help
```

- **validate**: Validates your template against the official [AWS Serverless Application Model specification](#). The following is an example.

```
$ sam validate
ERROR: Resource "HelloWorld", property "Runtime": Invalid value node.
Valid values are "nodejs4.3", "nodejs6.10", "nodejs8.10", "java8", "python2.7",
"python3.6"(line: 11; col: 6)

# Let's fix that error...
$ sed -i 's/node/nodejs6.10/g' template.yaml

$ sam validate
Valid!
```

- **package** and **deploy**: `sam package` and `sam deploy` implicitly call AWS CloudFormation's [package](#) and [deploy](#) commands. For more information on packaging and deployment of SAM applications, see [Packaging and Deployment \(p. 304\)](#).

The following demonstrates how to use the `package` and `deploy` commands in SAM CLI.

```
# Package SAM template
$ sam package --template-file sam.yaml --s3-bucket mybucket --output-template-file
packaged.yaml

# Deploy packaged SAM template
$ sam deploy --template-file ./packaged.yaml --stack-name mystack --capabilities
CAPABILITY_IAM
```

## Building a Simple Application Using SAM CLI

Suppose you want to build a simple RESTful API operation that creates, reads, updates, and deletes a list of products. You begin by creating the following directory structure:

`dir/products.js`

`dir/template.yaml`

The `template.yaml` file is the AWS SAM template that describes a single Lambda function that handles all the API requests.

### Note

By default, the `start-api` and `invoke` commands search your working directory for the `template.yaml` file. If you reference a `template.yaml` file that is in a different directory, add the `-t` or `--template` parameter to these operations and pass an absolute or relative path to that file.

Copy and paste the following into the `template.yaml` file.

```
AWSTemplateFormatVersion : '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Description: My first serverless application.

Resources:

  Products:
    Type: AWS::Serverless::Function
    Properties:
      Handler: products.handler
      Runtime: nodejs6.10
      Events:
        ListProducts:
          Type: Api
```

```
Properties:  
  Path: /products  
  Method: get  
CreateProduct:  
  Type: Api  
  Properties:  
    Path: /products  
    Method: post  
Product:  
  Type: Api  
  Properties:  
    Path: /products/{product}  
    Method: any
```

The preceding example configures the following RESTful API endpoints:

- Create a new product with a POST request to /products.
- List all products with a GET request to /products.
- Read, update, or delete a product with GET, POST or DELETE request to /products/{product}.

Next, copy and paste the following code into the *products.js* file.

```
'use strict';

exports.handler = (event, context, callback) => {

  let id = (event.pathParameters || {}).product || false;
  switch(event.httpMethod){

    case "GET":

      if(id) {
        callback(null, {body: "This is a READ operation on product ID " + id});
        return;
      }

      callback(null, {body: "This is a LIST operation, return all products"});
      break;

    case "POST":
      callback(null, {body: "This is a CREATE operation"});
      break;

    case "PUT":
      callback(null, {body: "This is an UPDATE operation on product ID " + id});
      break;

    case "DELETE":
      callback(null, {body:"This is a DELETE operation on product ID " + id});
      break;

    default:
      // Send HTTP 501: Not Implemented
      console.log("Error: unsupported HTTP method (" + event.httpMethod + ")");
      callback(null, { statusCode: 501 })

  }
}
```

Start a local copy of your API operations by calling the `start-api` command.

```
$ sam local start-api

2017/05/18 14:03:01 Successfully parsed template.yaml (AWS::Serverless-2016-10-31)
2017/05/18 14:03:01 Found 1 AWS::Serverless::Function
2017/05/18 14:03:01 Mounting products.handler (nodejs6.10) at /products [POST]
2017/05/18 14:03:01 Mounting products.handler (nodejs6.10) at /products/{product} [OPTIONS
GET HEAD POST PUT DELETE TRACE CONNECT]
2017/05/18 14:03:01 Mounting products.handler (nodejs6.10) at /products [GET]
2017/05/18 14:03:01 Listening on http://localhost:3000

You can now browse to the above endpoints to invoke your functions.
You do not need to restart/reload while working on your functions,
changes will be reflected instantly/automatically. You only need to restart
if you update your AWS SAM template.
```

You can then test your API endpoint locally using either a browser or the CLI.

```
$ curl http://localhost:3000/products
"This is a LIST operation, return all products"

$ curl -XDELETE http://localhost:3000/products/1
"This is a DELETE operation on product ID 1"
```

## Local Logging

Using the `invoke` and `start-api` commands, you can pipe logs from your Lambda function's invocation into a file. This approach is useful if you run automated tests against SAM CLI and want to capture logs for analysis. The following is an example.

```
$ sam local invoke --log-file ./output.log
```

## Using an Environment Variables File

If your Lambda function uses [Environment Variables \(p. 377\)](#), SAM CLI provides an `--env-vars` argument for both the `invoke` and `start-api` commands. With this argument, you can use a JSON file that contains values for environment variables defined in your function. The JSON file's structure should be similar to the following.

```
{
  "MyFunction1": {
    "TABLE_NAME": "localtable",
    "BUCKET_NAME": "testBucket"
  },
  "MyFunction2": {
    "TABLE_NAME": "localtable",
    "STAGE": "dev"
  }
}
```

You then access the JSON file using the following command:

```
$ sam local start-api --env-vars env.json
```

## Using a Shell Environment

Variables defined in your shell environment are passed to the Docker container if they map to a variable in your Lambda function. Shell variables are globally accessible to functions. For example, suppose

you have two functions, *MyFunction1* and *MyFunction2*, which have a variable called *TABLE\_NAME*. In this case, the value for *TABLE\_NAME* provided through your shell's environment is available to both functions.

The following command sets the value of *TABLE\_NAME* to *myTable* for both functions.

```
$ TABLE_NAME=mytable sam local start-api
```

#### Note

For greater flexibility, you can use a combination of shell variables and an external JSON file that holds environment variables. If a variable is defined in both places, the one from the external file overrides the shell version. Following is the order of priority, highest to lowest:

- Environment variable file
- Shell environment
- Hard-coded values contained in the SAM template

## Debugging With SAM CLI

Both `sam local invoke` and `sam local start-api` support local debugging of your functions. To run SAM CLI with debugging support enabled, specify `--debug-port` or `-d` on the command line.

```
# Invoke a function locally in debug mode on port 5858
$ sam local invoke -d 5858 function logical id

# Start local API Gateway in debug mode on port 5858
$ sam local start-api -d 5858
```

#### Note

If you use `sam local start-api`, the local API Gateway exposes all of your Lambda functions. But because you can specify only one debug port, you can only debug one function at a time.

For compiled languages or projects requiring complex packaging support, we recommend that you run your own build solution and point AWS SAM to the directory that contains the build dependency files needed. You can use one of the following IDEs or another of your choosing:

- [AWS Cloud9](#)
- [Eclipse](#)
- [Visual Studio Code](#)

## Debugging Functions Written in Python

Unlike Node.js, .NET or Java, Python requires you to enable remote debugging in your Lambda function code. If you enable debugging (using the `--debug-port` or `-d` options mentioned above) for a function that uses one of the Python runtimes (2.7 or 3.6), SAM CLI maps through that port from your host machine to the Lambda container. To enable remote debugging, use a Python package such as [remote-pdb](#).

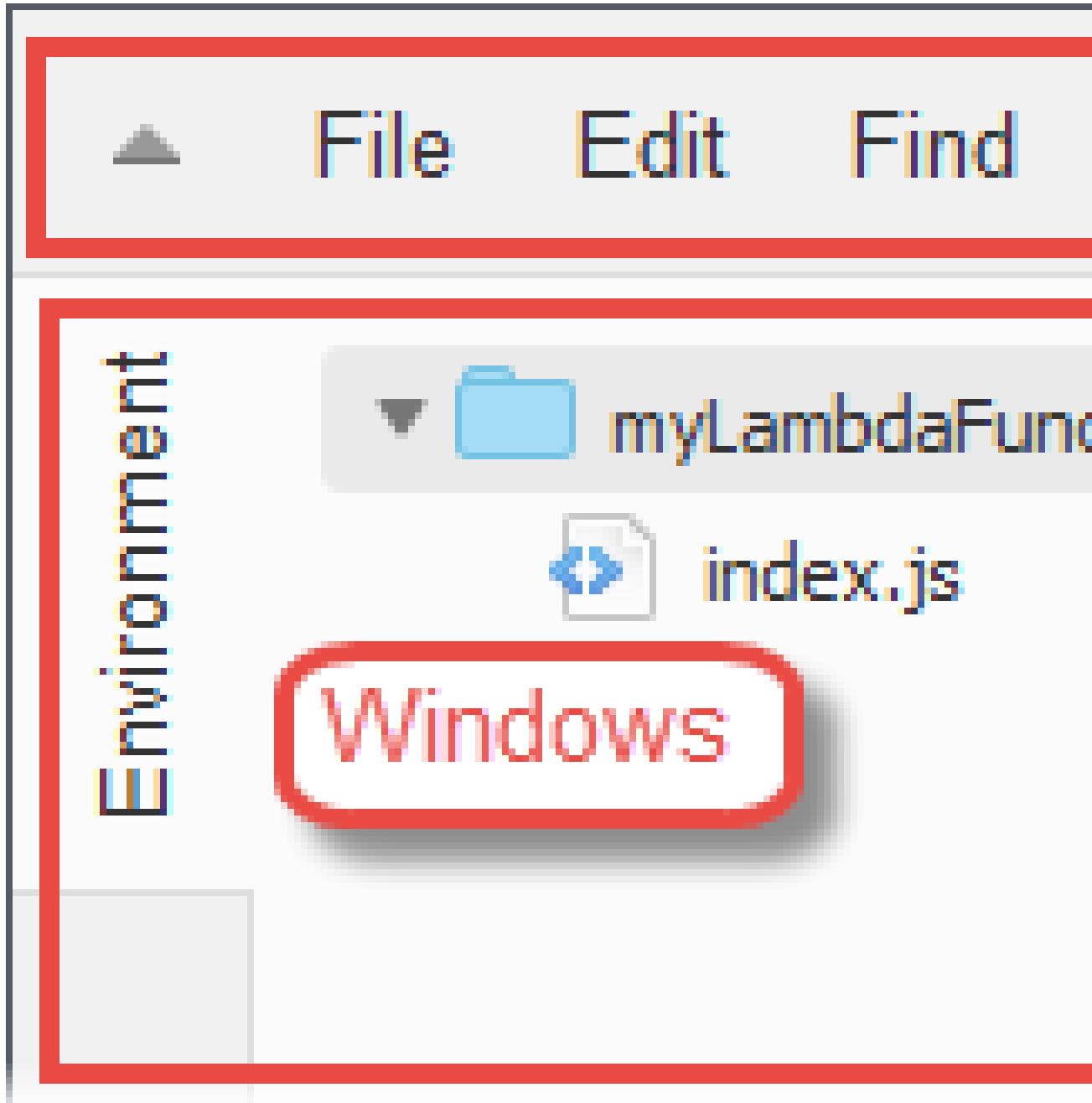
#### Important

When configuring the host, the debugger listens in on your code, so make sure to use `0.0.0.0` and not `127.0.0.1`.

## Creating Functions Using the AWS Lambda Console Editor

The code editor in the AWS Lambda console enables you to write, test, and view the execution results of your Lambda function code.

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



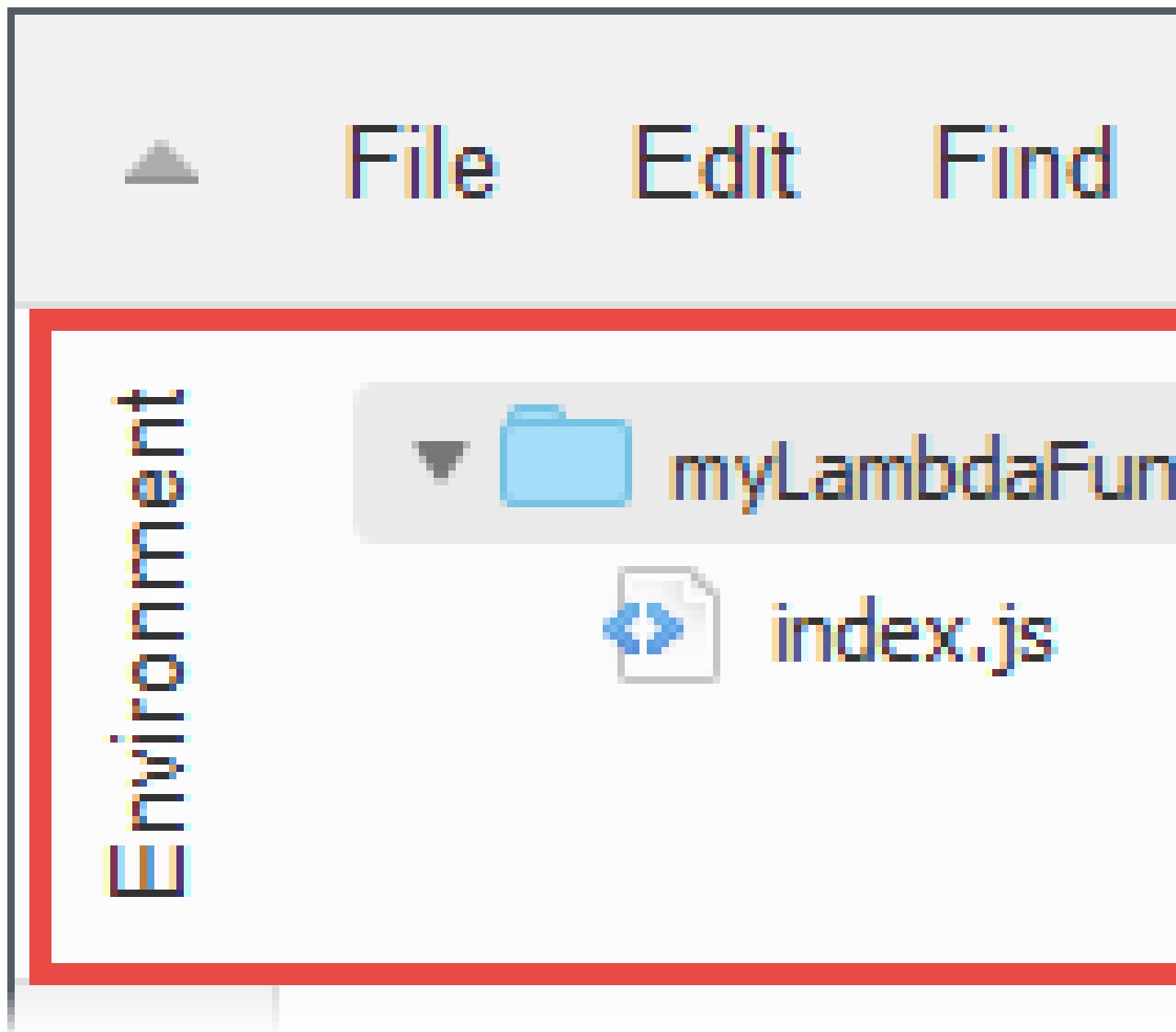
You use the menu bar to run common commands. For more information, see [Using the Menu Bar \(p. 125\)](#).

You use windows to work with files, folders, and other commands. For more information, see [Working with Files and Folders \(p. 107\)](#) and [Working with Commands \(p. 127\)](#).

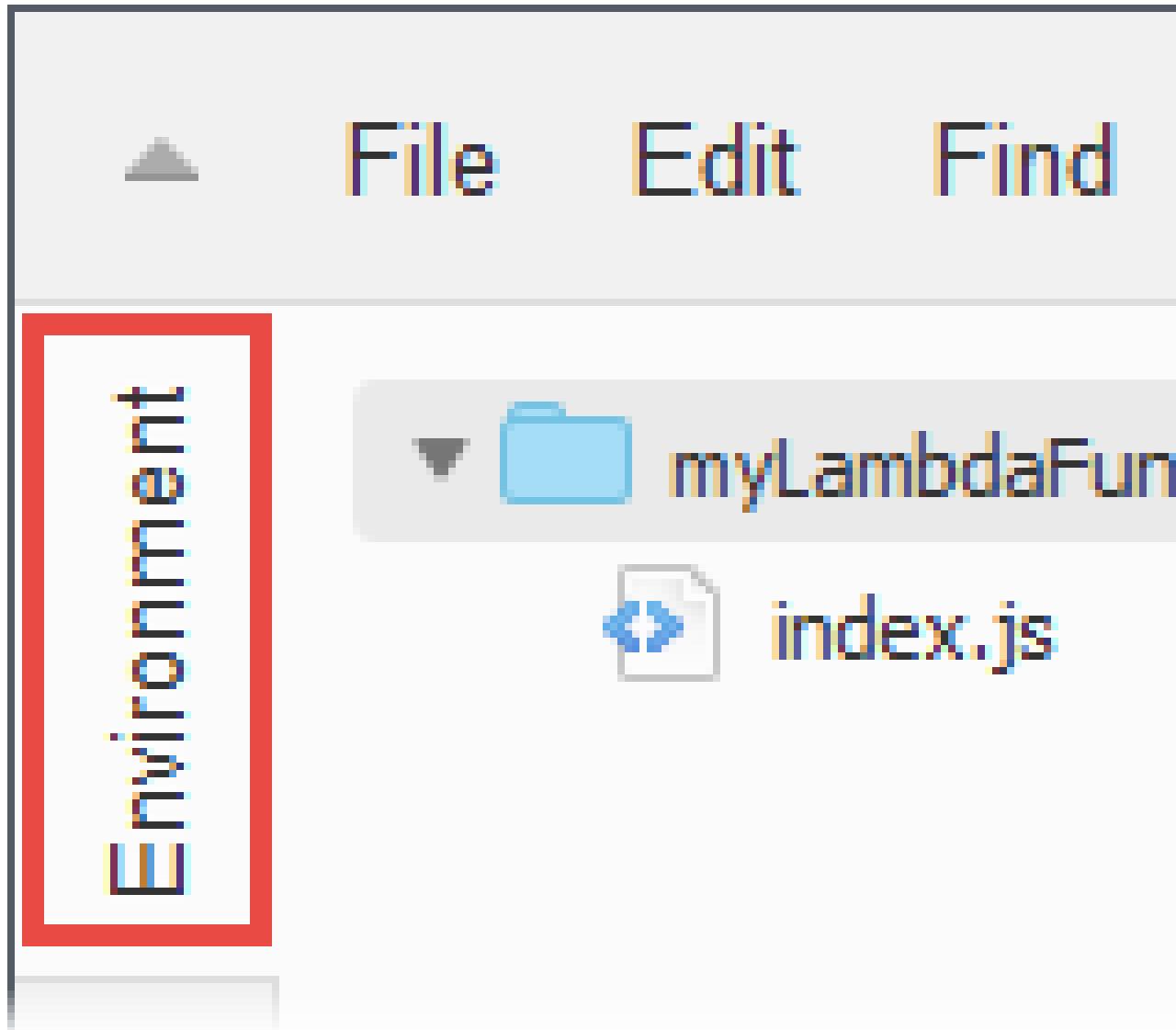
You use the editor pane to write code. For more information, see [Working with Code \(p. 114\)](#).

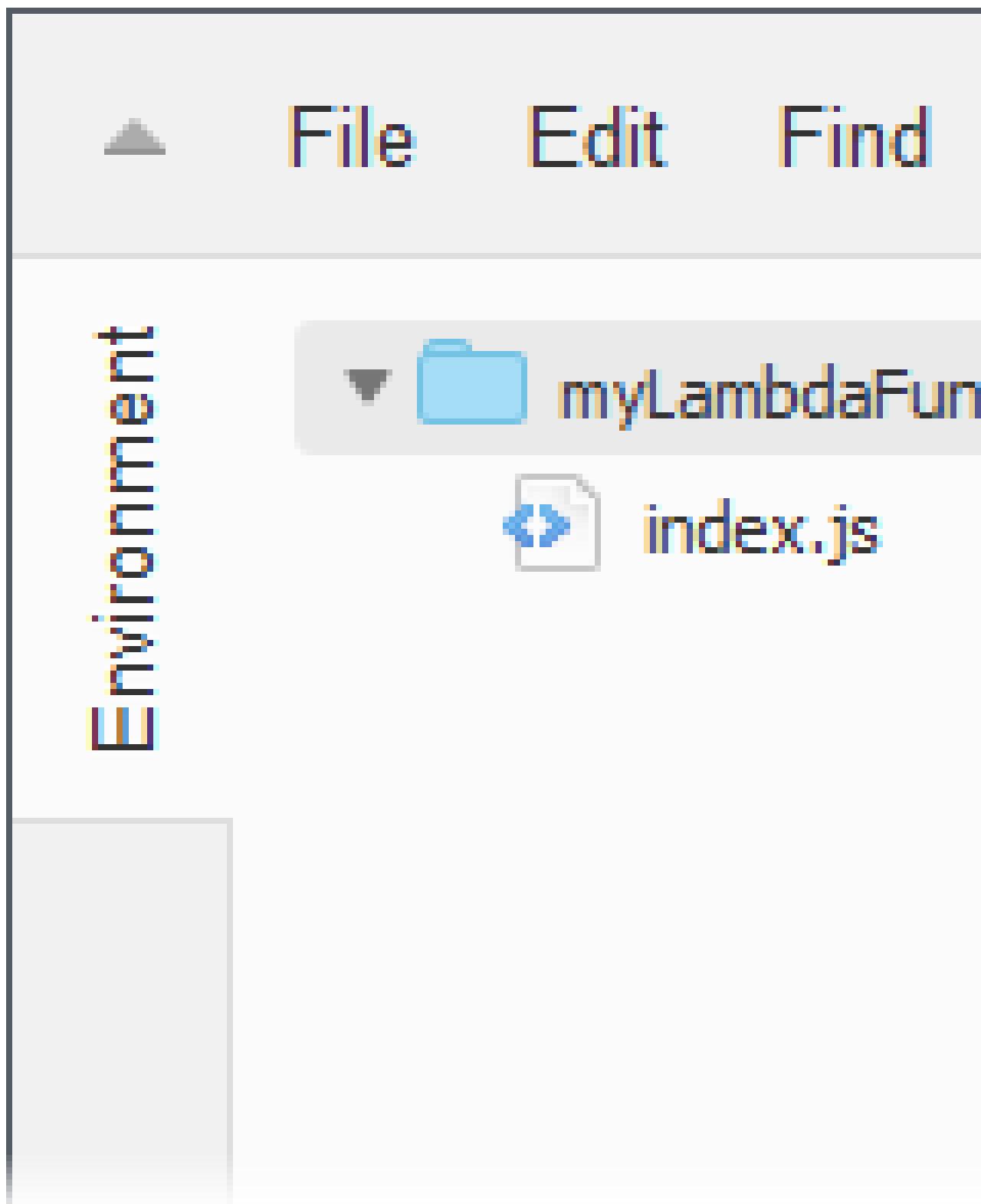
## Working with Files and Folders

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.



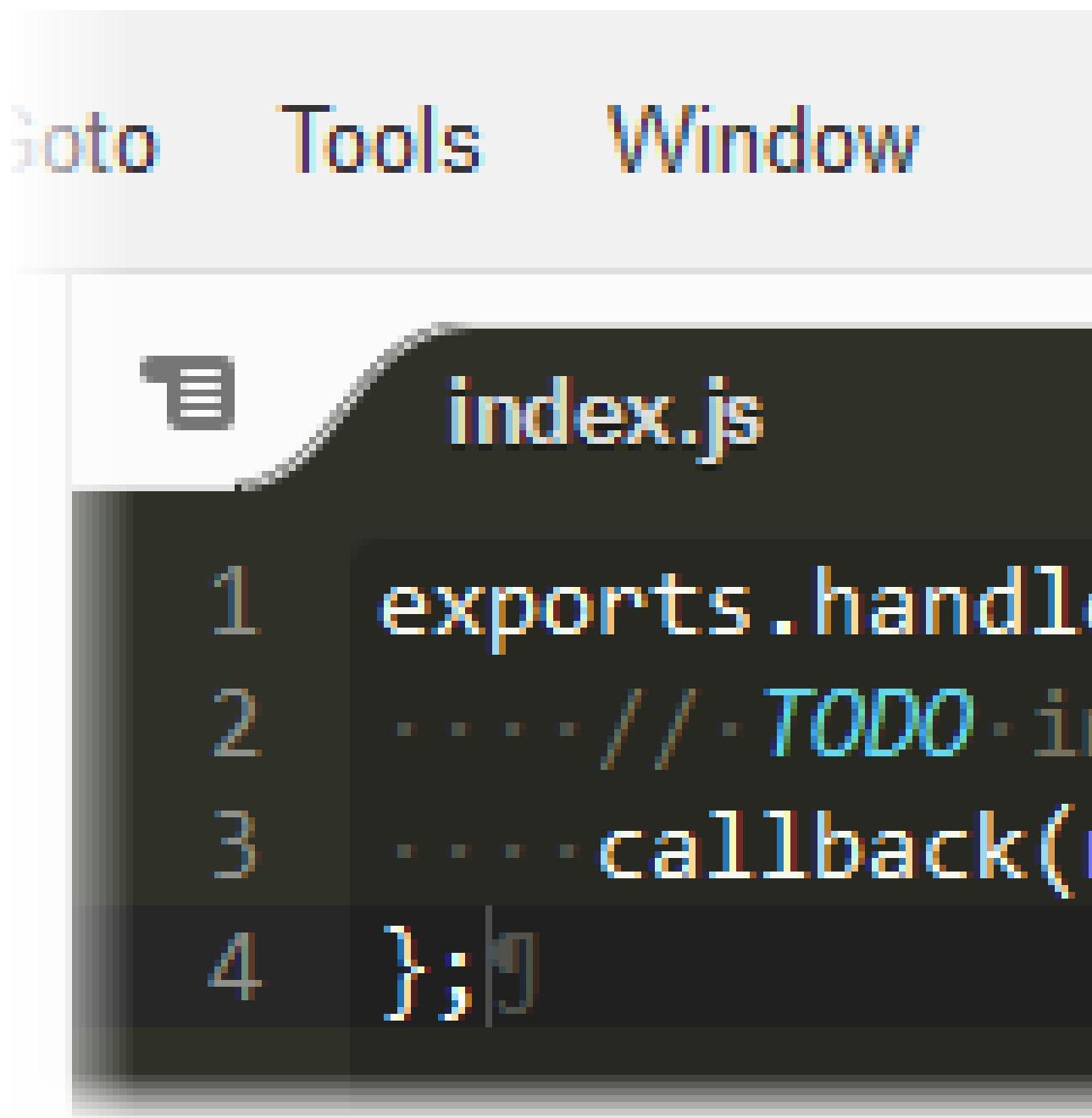


**To open a single file and show its contents in the editor pane**, double-click the file in the **Environment** window.

**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**.

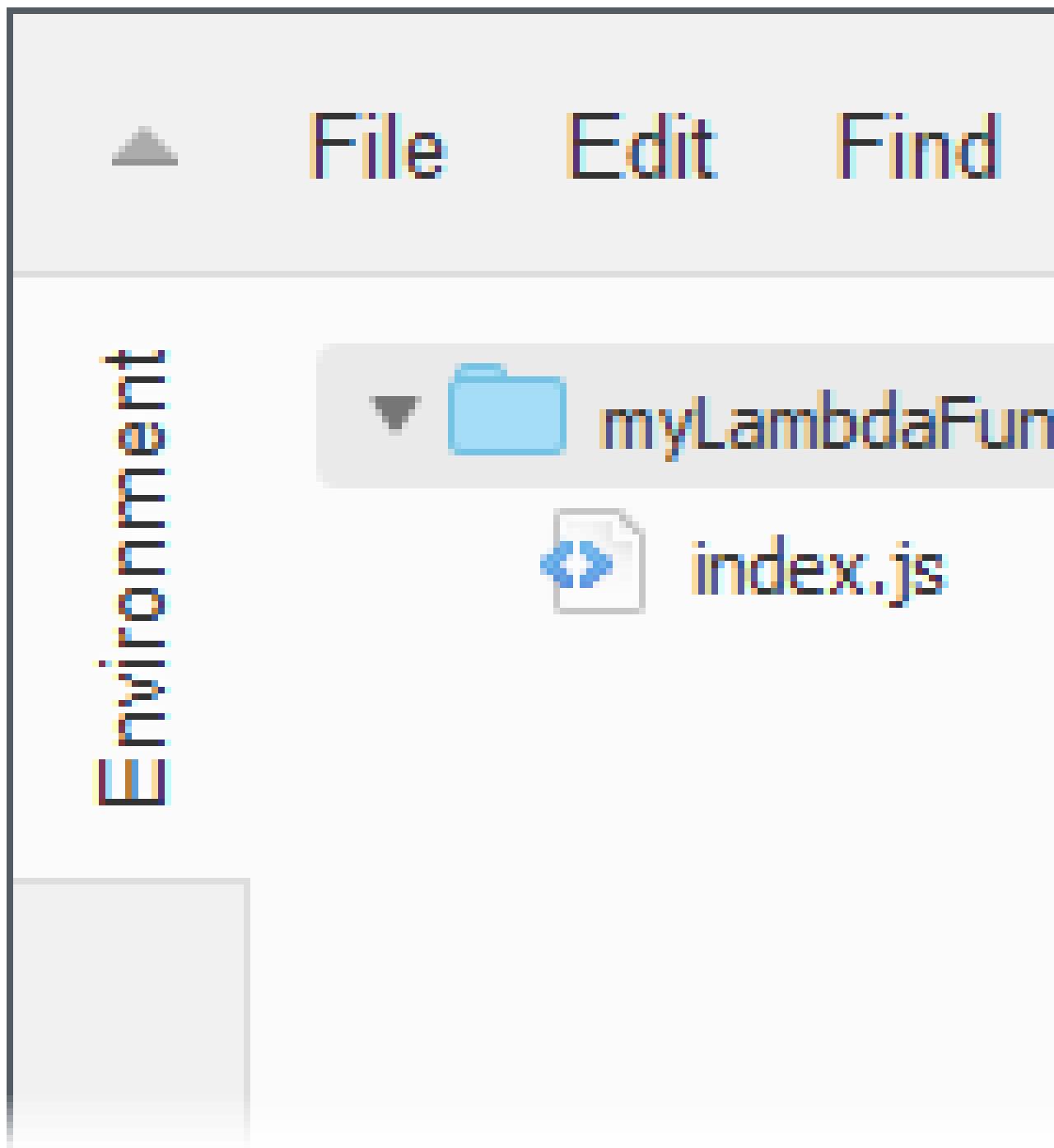
**To save a file**, with the file open and its contents visible in the editor pane, choose **File, Save** on the menu bar.

**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**.

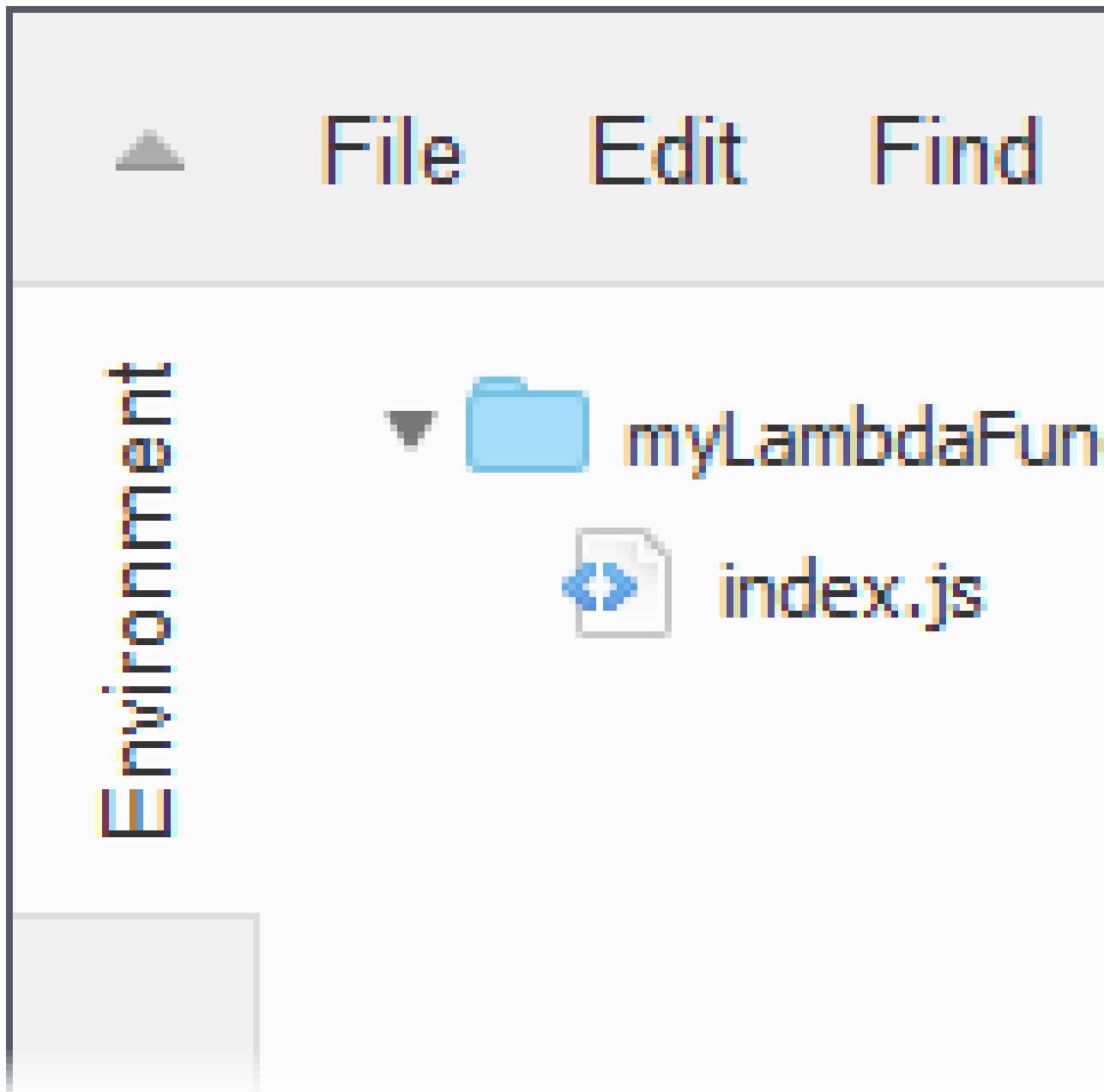


To show or hide hidden files, choose the gear icon in the **Environment** window, and then choose **Show Hidden Files**.

You can also create, open, and manage files by using the **Commands** window. For more information, see [Working with Commands \(p. 127\)](#).

## Working with Code

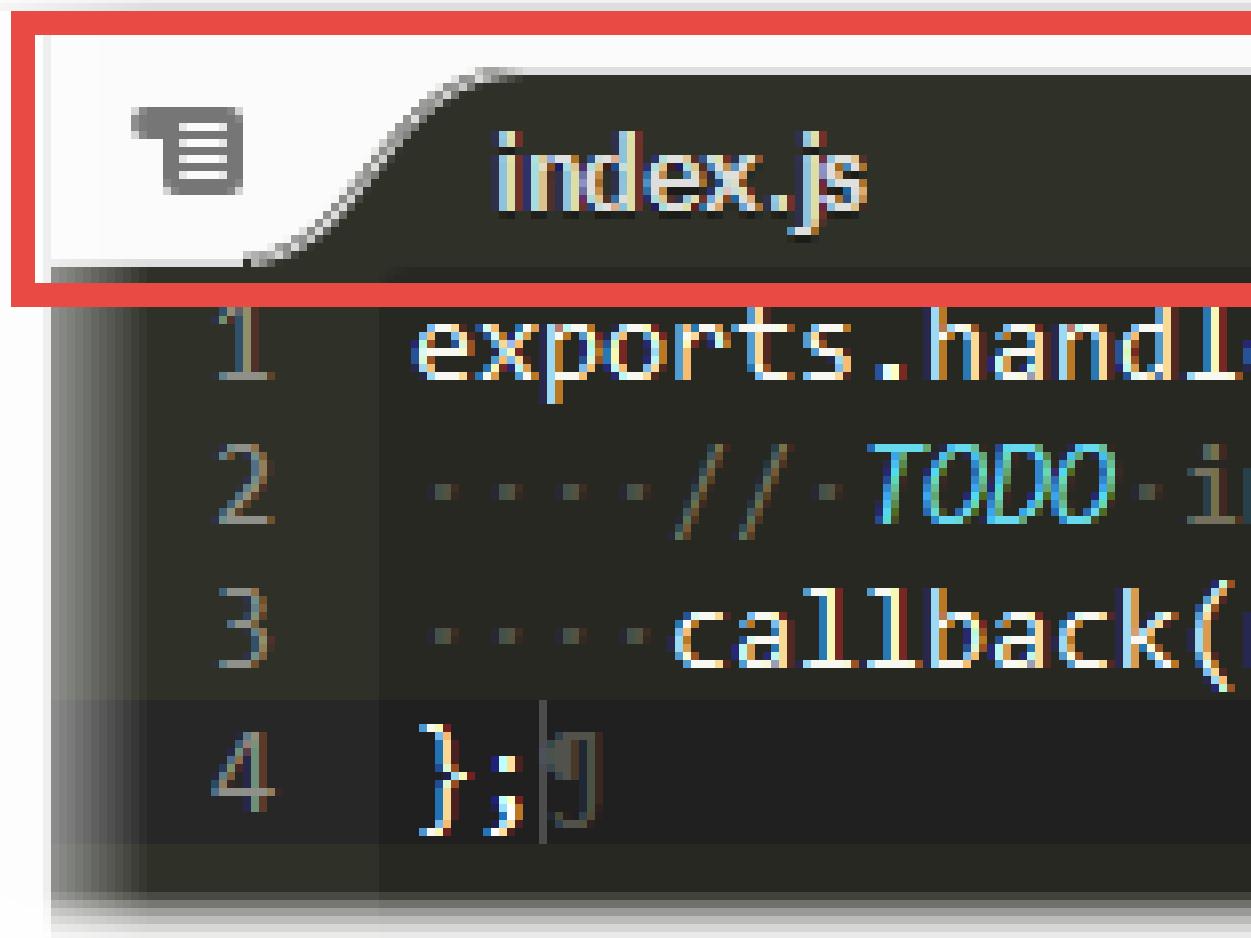
Use the editor pane in the code editor to view and write code.



## Working with Tab Buttons

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

## oto Tools Window



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.

Goto Tools Window

1



index.js

Close Pane

Close All Tabs In All

Close All But Current

2

index.js

Split Pane in Two Rows

Split Pane in Two Col

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

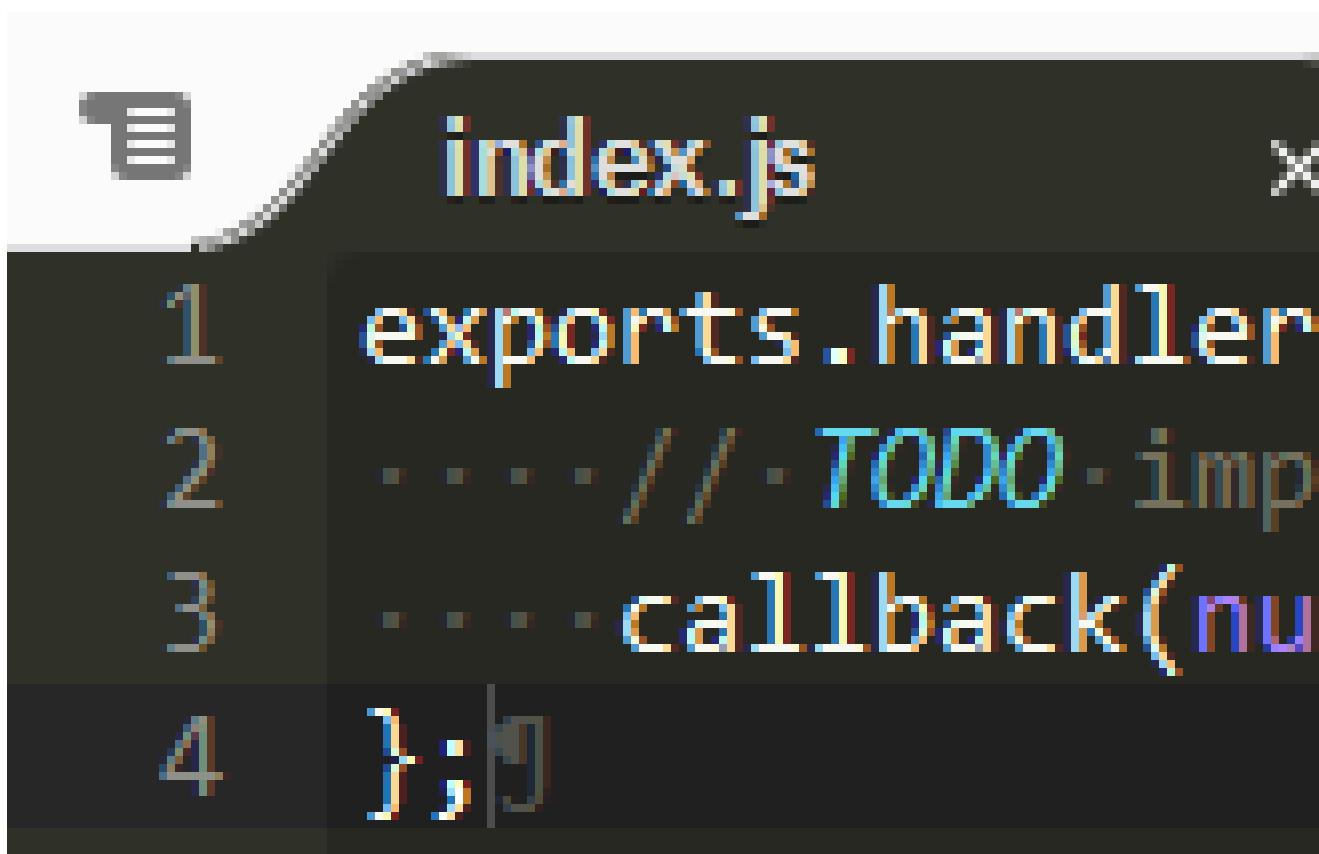
- Choose the X icon in the file's tab.
- Choose the file's tab. Then choose the drop-down menu button in the tab buttons bar, and choose **Close Pane**.

**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.



The screenshot shows a dark-themed code editor window for a Lambda function named "index.js". The code is as follows:

```
1 exports.handler
2     ... // - TODO - imp
3     ... callback(nu
4 };
```

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.

• **JavaScript**

**JSON**

**LESS**

**Lua**

**Perl**

**PHP**

**Python**

**Ruby**

**Scala**

**SCSS**

**SH**

**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.

## ✓ Soft Tabs (*spaces*)

### Tab Size

2

3

4

8

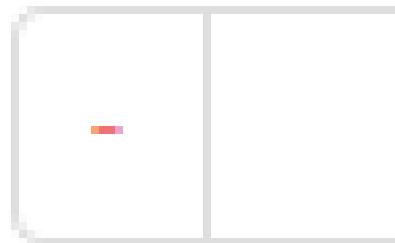
Other

-	4
---	---

**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.

- Show Invisibles**
- Show Gutter**
- Auto-pair Brackets, Quot**
- Wrap Lines**
- ↳ to Print Margin**

**Font Size**



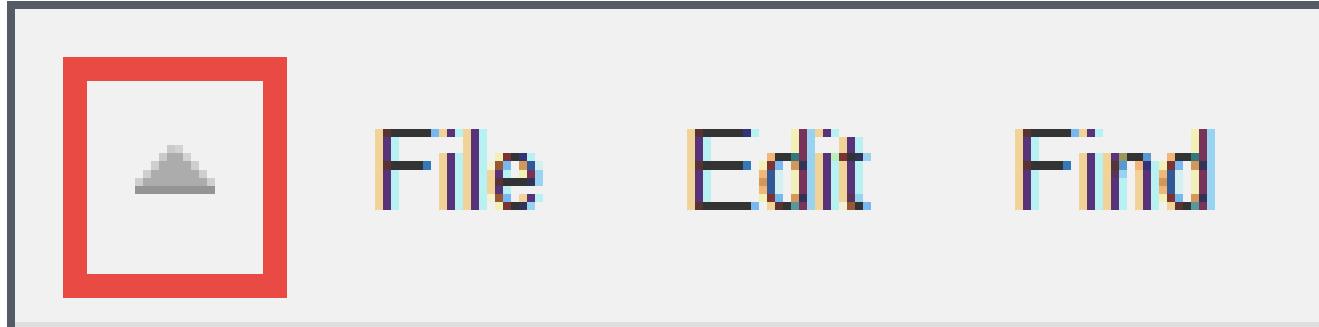
43    **JavaScript**    5

## Using the Menu Bar

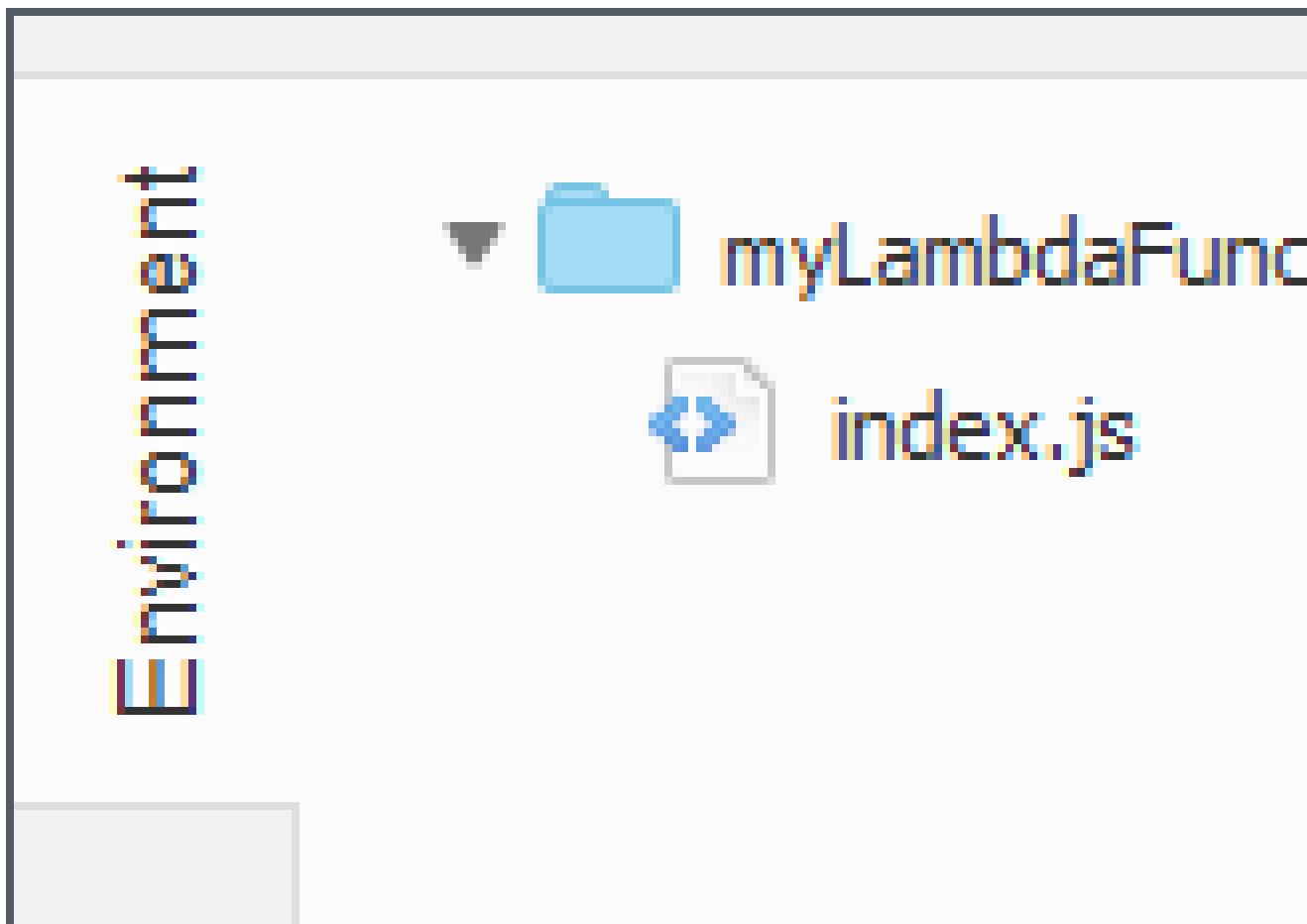
You can use the menu bar to run common commands.



To hide the menu bar, choose the up arrow in the menu bar.



To show the menu bar if it is hidden, choose the down arrow in the menu bar.



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.

You can also run commands by using the **Commands** window. For more information, see [Working with Commands \(p. 127\)](#).

## 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, an additional menu 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*.

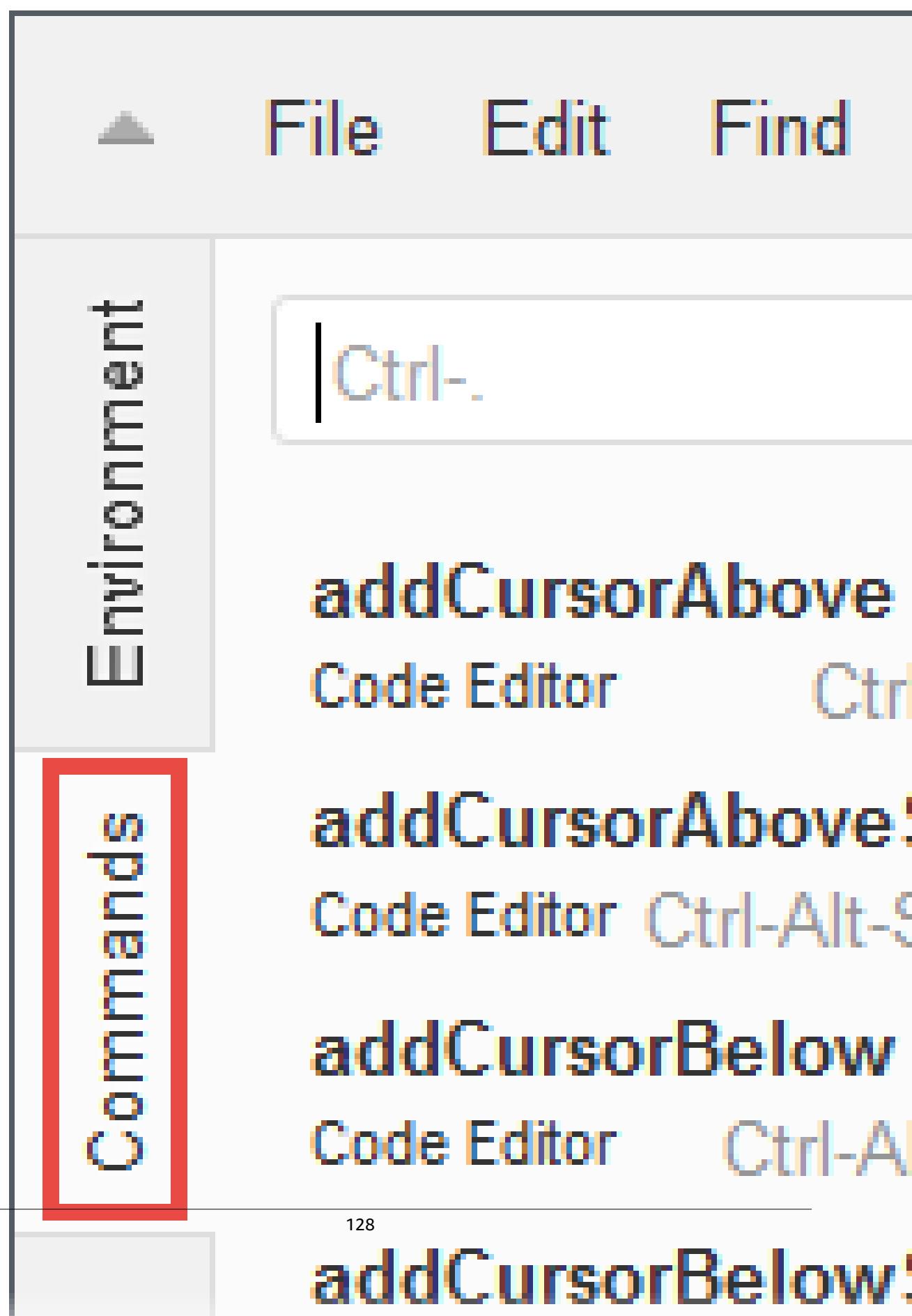
- [Project Setting Changes You Can Make](#)
- [User Setting Changes You Can Make](#)

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

## Working with Commands

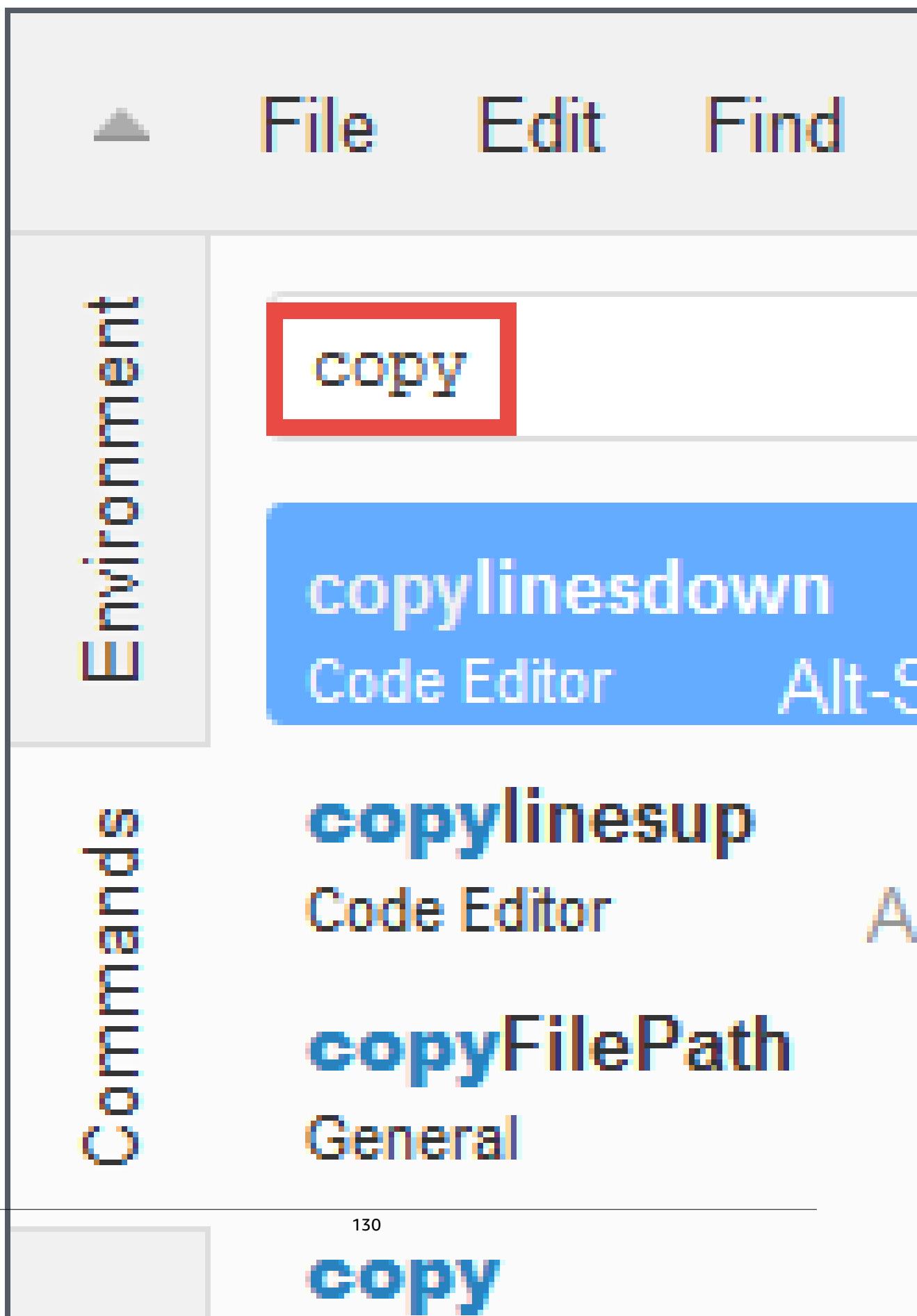
You can use the **Commands** window to run various commands such as those found on the menu bar, in the **Environment** window, in the editor pane.

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



To run a command, choose it in the **Commands** window.

To find a command, type some or all of the command's name in the search box.



For a list of what the commands do, see the [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.

Other topics in the section include:

- [Configuring Lambda Functions \(p. 131\)](#)
- [Accessing Resources from a Lambda Function \(p. 132\)](#)
- [AWS Lambda Execution Model \(p. 144\)](#)

## Configuring Lambda Functions

A Lambda function consists of code and any associated dependencies. In addition, a Lambda function also has configuration information associated with it. Initially, you specify the configuration information when you create a Lambda function. Lambda provides an API for you to update some of the configuration data. Lambda function configuration information includes the following key elements:

- **Compute resources that you need** – You only specify the amount of memory you want to allocate for your Lambda function. AWS Lambda allocates CPU power proportional to the memory by using the same ratio as a general purpose Amazon EC2 instance type, such as an M3 type. For example, if you allocate 256 MB memory, your Lambda function will receive twice the CPU share than if you allocated only 128 MB.

You can update the configuration and request additional memory in 64 MB increments from 128MB to 3008 MB. For information about relevant limits, see [AWS Lambda Limits \(p. 394\)](#).

To change the amount of memory your Lambda function requires, do the following:

1. Sign in to the AWS Management Console and navigate to the AWS Lambda console.
2. Choose the function whose memory size you wish to change.
3. Click the **Configuration** tab and then expand **Advanced settings**.
4. In the **Memory (MB)** list, choose your desired amount.

Optionally, you can update the memory size of your functions using the following AWS CLI command (using valid 64 MB increments):

```
$ aws lambda update-function-configuration \
  --function-name your function name \
  --region region where your function resides \
  --memory-size memory amount \
  --profile adminuser
```

For information on setting up and using the AWS CLI, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#).

- **Maximum execution time (timeout)** – You pay for the AWS resources that are used to run your Lambda function. To prevent your Lambda function from running indefinitely, you specify a timeout. When the specified timeout is reached, AWS Lambda terminates execution of your Lambda function. We recommend you set this value based on your expected execution time. The default is 3 seconds.

### Note

You can invoke a Lambda function synchronously either by calling the `Invoke` operation or by using an AWS SDK in your preferred runtime. If you anticipate a long-running Lambda function, your client may time out before function execution completes. To avoid this, update the client timeout or your SDK configuration. For more information, see [Invoke \(p. 450\)](#).

- **IAM role (execution role)** – This is the role that AWS Lambda assumes when it executes the Lambda function on your behalf. For more information, see [AWS Lambda Permissions Model \(p. 361\)](#).
- **Handler name** – The handler method is the entry point that executes your Lambda function code and any event source dependencies that you have included as part of your Lambda function.

## Accessing Resources from a Lambda Function

Lambda does not enforce any restrictions on your function logic – if you can code for it, you can run it within a Lambda function. As part of your function, you may need to call other APIs, or access other AWS services like databases.

### Accessing AWS Services

To access other AWS services, you can use the AWS SDK ([Node.js](#), [Java](#), [Python](#), [C#](#)) or [Go](#), AWS Lambda will automatically set the credentials required by the SDK to those of the IAM role associated with your function – you do not need to take any additional steps. For example, here's sample code using the Python SDK for accessing an S3 object.:

```
import boto3
import botocore

BUCKET_NAME = 'my-bucket' # replace with your bucket name
KEY = 'my_image_in_s3.jpg' # replace with your object key

s3 = boto3.resource('s3')

try:
    s3.Bucket(BUCKET_NAME).download_file(KEY, 'my_local_image.jpg')
except botocore.exceptions.ClientError as e:
    if e.response['Error']['Code'] == "404":
        print("The object does not exist.")
    else:
        raise
```

#### Note

For convenience, AWS Lambda includes versions of the AWS SDK as part of the execution environment so you don't have to include it. See [Lambda Execution Environment and Available Libraries \(p. 391\)](#) for the version of the included SDK. We recommend including your own copy of the AWS SDK for production applications so you can control your dependencies.

### Accessing non AWS Services

You can include any SDK to access any service as part of your Lambda function. For example, you can include the [SDK for Twilio](#) to access information from your Twilio account. You can use [Environment Variables \(p. 377\)](#) for storing the credential information for the SDKs after encrypting the credentials.

### Accessing Private Services or Resources

By default, your service or API must be accessible over the public internet for AWS Lambda to access it. However, you may have APIs or services that are not exposed this way. Typically, you create these

resources inside Amazon Virtual Private Cloud (Amazon VPC) so that they cannot be accessed over the public Internet. These resources could be AWS service resources, such as Amazon Redshift data warehouses, Amazon ElastiCache clusters, or Amazon RDS instances. They could also be your own services running on your own EC2 instances. By default, resources within a VPC are not accessible from within a Lambda function.

AWS Lambda runs your function code securely within a VPC by default. However, to enable your Lambda function to access resources inside your private VPC, you must provide additional VPC-specific configuration information that includes VPC subnet IDs and security group IDs. AWS Lambda uses this information to set up elastic network interfaces (ENIs) that enable your function to connect securely to other resources within your private VPC.

**Important**

AWS Lambda does not support connecting to resources within Dedicated Tenancy VPCs. For more information, see [Dedicated VPCs](#).

To learn how to configure a Lambda function to access resources within a VPC, see [Configuring a Lambda Function to Access Resources in an Amazon VPC \(p. 133\)](#)

## Configuring a Lambda Function to Access Resources in an Amazon VPC

Typically, you create resources inside Amazon Virtual Private Cloud (Amazon VPC) so that they cannot be accessed over the public Internet. These resources could be AWS service resources, such as Amazon Redshift data warehouses, Amazon ElastiCache clusters, or Amazon RDS instances. They could also be your own services running on your own EC2 instances. By default, resources within a VPC are not accessible from within a Lambda function.

AWS Lambda runs your function code securely within a VPC by default. However, to enable your Lambda function to access resources inside your private VPC, you must provide additional VPC-specific configuration information that includes VPC subnet IDs and security group IDs. AWS Lambda uses this information to set up elastic network interfaces ([ENIs](#)) that enable your function to connect securely to other resources within your private VPC.

**Important**

AWS Lambda does not support connecting to resources within Dedicated Tenancy VPCs. For more information, see [Dedicated VPCs](#).

## Configuring a Lambda Function for Amazon VPC Access

You add VPC information to your Lambda function configuration using the `VpcConfig` parameter, either at the time you create a Lambda function (see [CreateFunction \(p. 412\)](#)), or you can add it to the existing Lambda function configuration (see [UpdateFunctionConfiguration \(p. 502\)](#)). Following are AWS CLI examples:

- The `create-function` CLI command specifies the `--vpc-config` parameter to provide VPC information at the time you create a Lambda function. Note that the `--runtime` parameter specifies `python3.6`. You can also use `python2.7`.

```
$ aws lambda create-function \
--function-name ExampleFunction \
--runtime python3.6 \
--role execution-role-arn \
--zip-file fileb://path/app.zip \
--handler app.handler \
--vpc-config SubnetIds=comma-separated-vpc-subnet-ids,SecurityGroupIds=comma-separated-security-group-ids \
```

```
--memory-size 1024
```

#### Note

The Lambda function execution role must have permissions to create, describe and delete ENIs. AWS Lambda provides a permissions policy, `AWSLambdaVPCAccessExecutionRole`, with permissions for the necessary EC2 actions (`ec2:CreateNetworkInterface`, `ec2:DescribeNetworkInterfaces`, and `ec2:DeleteNetworkInterface`) that you can use when creating a role. You can review the policy in the IAM console. Do not delete this role immediately after your Lambda function execution. There is a delay between the time your Lambda function executes and ENI deletion. If you do delete the role immediately after function execution, you are responsible for deleting the ENIs.

- The `update-function-configuration` CLI command specifies the `--vpc-config` parameter to add VPC information to an existing Lambda function configuration.

```
$ aws lambda update-function-configuration \
--function-name ExampleFunction \
--vpc-config SubnetIds=comma-separated-vpc-subnet-ids,SecurityGroupIds=security-group-ids
```

To remove VPC-related information from your Lambda function configuration, use the `UpdateFunctionConfiguration` API by providing an empty list of subnet IDs and security group IDs as shown in the following example CLI command.

```
$ aws lambda update-function-configuration \
--function-name ExampleFunction \
--vpc-config SubnetIds=[ ],SecurityGroupIds=[ ]
```

Note the following additional considerations:

- When you add VPC configuration to a Lambda function, it can only access resources in that VPC. If a Lambda function needs to access both VPC resources and the public Internet, the VPC needs to have a Network Address Translation (NAT) instance inside the VPC.
- When a Lambda function is configured to run within a VPC, it incurs an additional ENI start-up penalty. This means address resolution may be delayed when trying to connect to network resources.

## Internet Access for Lambda Functions

AWS Lambda uses the VPC information you provide to set up `ENIs` that allow your Lambda function to access VPC resources. Each ENI is assigned a private IP address from the IP address range within the Subnets you specify, but is not assigned any public IP addresses. *Therefore, if your Lambda function requires Internet access (for example, to access AWS services that don't have VPC endpoints), you can configure a NAT instance inside your VPC or you can use the Amazon VPC NAT gateway.* For more information, see [NAT Gateways](#) in the [Amazon VPC User Guide](#). You cannot use an Internet gateway attached to your VPC, since that requires the ENI to have public IP addresses.

#### Important

If your Lambda function needs Internet access, do not attach it to a public subnet or to a private subnet without Internet access. Instead, attach it only to private subnets with Internet access through a NAT instance or an Amazon VPC NAT gateway.

## Guidelines for Setting Up VPC-Enabled Lambda Functions

Your Lambda function automatically scales based on the number of events it processes. The following are general guidelines for setting up VPC-enabled Lambda functions to support the scaling behavior.

- If your Lambda function accesses a VPC, you must make sure that your VPC has sufficient ENI capacity to support the scale requirements of your Lambda function. You can use the following formula to approximately determine the ENI capacity.

Projected peak concurrent executions \* (Memory in GB / 3GB)

Where:

- **Projected peak concurrent execution** – Use the information in [Managing Concurrency \(p. 373\)](#) to determine this value.
- **Memory** – The amount of memory you configured for your Lambda function.
- The subnets you specify should have sufficient available IP addresses to match the number of ENIs.

We also recommend that you specify at least one subnet in each Availability Zone in your Lambda function configuration. By specifying subnets in each of the Availability Zones, your Lambda function can run in another Availability Zone if one goes down or runs out of IP addresses.

**Note**

If your VPC does not have sufficient ENIs or subnet IPs, your Lambda function will not scale as requests increase, and you will see an increase in function failures. AWS Lambda currently does not log errors to CloudWatch Logs that are caused by insufficient ENIs or IP addresses. If you see an increase in errors without corresponding CloudWatch Logs, you can invoke the Lambda function synchronously to get the error responses (for example, test your Lambda function in the AWS Lambda console because the console invokes your Lambda function synchronously and displays errors).

## Tutorials: Configuring a Lambda Function to Access Resources in an Amazon VPC

This section provides end-to-end example tutorials where you create and configure a Lambda function to access resources in an Amazon VPC, such as an Amazon ElastiCache cluster or an Amazon RDS database instance.

### Topics

- [Tutorial: Configuring a Lambda Function to Access Amazon ElastiCache in an Amazon VPC \(p. 135\)](#)
- [Tutorial: Configuring a Lambda Function to Access Amazon RDS in an Amazon VPC \(p. 139\)](#)

### 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 (Amazon VPC) in the us-east-1 region. 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 manually and verify that it accessed the ElastiCache cluster in your VPC.

## Important

This tutorial uses the default Amazon VPC in the us-east-1 region in your account. For more information about Amazon VPC, see [How to Get Started with Amazon VPC](#) in the *Amazon VPC User Guide*.

## Next Step

### [Step 1: Create an ElastiCache Cluster \(p. 136\)](#)

#### [Step 1: Create an ElastiCache Cluster](#)

In this step, you create an ElastiCache cluster in the default Amazon VPC in us-east-1 region in your account.

1. Run the following AWS CLI command to create a Memcached cluster in the default VPC in the us-east-1 region in your account.

```
aws elasticache create-cache-cluster \
    --cache-cluster-id ClusterForLambdaTest \
    --cache-node-type cache.m3.medium \
    --engine memcached \
    --security-group-ids your-default-vpc-security-group \
    --num-cache-nodes 1
```

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.

You can also launch a cache cluster using the Amazon ElastiCache console. For instructions, see [Getting Started with Amazon ElastiCache](#) in the *Amazon ElastiCache User Guide*.

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.

## Next Step

### [Step 2: Create a Lambda Function \(p. 136\)](#)

#### [Step 2: Create a Lambda Function](#)

In this step, you do the following:

- Create a Lambda function deployment package using the sample code provided.
- Create an IAM role (execution role). At the time you upload the deployment package, you need to specify this role so that Lambda can assume the role and then execute the function on your behalf.

The permissions policy grants AWS Lambda permissions to set up elastic network interfaces (ENIs) to enable your Lambda function to access resources in the VPC. In this example, your Lambda function accesses an ElastiCache cluster in the VPC.

- Create the Lambda function by uploading the deployment package.

## Topics

- [Step 2.1: Create a Deployment Package \(p. 137\)](#)
- [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 138\)](#)
- [Step 2.3: Create the Lambda Function \(Upload the Deployment Package\) \(p. 138\)](#)

## Step 2.1: Create a Deployment Package

### Note

At this time, example code for the Lambda function is provided only in Python.

### Python

The following example Python code reads and writes an item to your ElastiCache cluster.

1. Open a text editor, and then copy the following code.

### Note

The `from __future__` statement enables you to write code that is compatible with Python 2 or 3. If you are using runtime version 3.6, it is not necessary to include it.

```
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-elasticacluster-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 = str(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") == str(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, str(uuid_obtained)))

    return "Fetched value from memcache: " + str(uuid_obtained)
```

2. Save the file as `app.py`.
3. Install the following library dependencies using `pip`:
  - `pymemcache` – The Lambda function code uses this library to create a `HashClient` object to set and get items from memcache (see [pymemcache](#)).
  - `elasticache-auto-discovery` – The Lambda function uses this library to get the nodes in your Amazon ElastiCache cluster (see [elasticache-auto-discovery](#)).
4. Zip all of these files into a file named `app.zip` to create your deployment package. For step-by-step instructions, see [Creating a Deployment Package \(Python\) \(p. 96\)](#).

### Next Step

### [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 138\)](#)

#### [Step 2.2: Create the Execution Role \(IAM Role\)](#)

In this step, you create an AWS Identity and Access Management (IAM) role using the following predefined role type and access permissions policy:

- **AWS Lambda** (AWS service role) – This role grants AWS Lambda permissions to assume the role.
- **AWSLambdaVPCAccessExecutionRole** (access permissions policy) – This is the policy that you attach to the role. The policy grants permissions for the EC2 actions that AWS Lambda needs to manage ENIs. You can view this AWS managed policy in IAM console.

For more information about IAM roles, see [IAM Roles](#) in the *IAM User Guide*. Use the following procedure to create the IAM role.

#### **To create an IAM role (execution role)**

1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
2. Follow the steps in [Creating a Role to Delegate Permissions to an AWS Service](#) in the *IAM User Guide* to create an IAM role (execution role). As you follow the steps to create a role, note the following:
  - In **Role Name**, use a name that is unique within your AWS account (for example, `lambda-vpc-execution-role`).
  - In **Select Role Type**, choose **AWS Service Roles**, and then choose **AWS Lambda**. This grants the AWS Lambda service permissions to assume the role.
  - In **Attach Policy**, choose **AWSLambdaVPCAccessExecutionRole**. The permissions in this policy are sufficient for the Lambda function in this tutorial.
3. Write down the role ARN. You will need it in the next step when you create your Lambda function.

#### **Next Step**

### [Step 2.3: Create the Lambda Function \(Upload the Deployment Package\) \(p. 138\)](#)

#### [Step 2.3: Create the Lambda Function \(Upload the Deployment Package\)](#)

In this step, you create the Lambda function (`AccessMemCache`) using the `create-function` AWS CLI command.

At the command prompt, run the following Lambda CLI `create-function` command using the `adminuser` profile.

You need to update the following `create-function` command by providing the .zip file path and the execution role ARN. The `--runtime` parameter value can be `python3.6`, `python2.7`, `nodejs` and `java8`, depending on the language you used to author your code.

#### **Note**

At this time, example code for the Lambda function is provided only in Python.

```
$ aws lambda create-function \
--function-name AccessMemCache \
--region us-east-1 \
--zip-file fileb://path-to/app.zip \
--role execution-role-arn \
--handler app.handler \
--runtime python3.6 \
--timeout 30 \
--vpc-config SubnetIds=comma-separated-vpc-subnet-ids,SecurityGroupIds=default-security-group-id \
```

```
--memory-size 1024
```

You can find the subnet IDs and the default security group ID of your VPC from the VPC console.

Optionally, you can upload the .zip file to an Amazon S3 bucket in the same AWS region, and then specify the bucket and object name in the preceding command. You need to replace the --zip-file parameter by the --code parameter, as shown following:

```
--code S3Bucket=bucket-name,S3Key=zip-file-object-key
```

#### Note

You can also create the Lambda function using the AWS Lambda console. When creating the function, choose a VPC for the Lambda and then select the subnets and security groups from the provided fields.

#### Next Step

[Step 3: Test the Lambda Function \(Invoke Manually\) \(p. 139\)](#)

#### Step 3: Test the Lambda Function (Invoke Manually)

In this step, you invoke the Lambda function manually using the `invoke` command. When the Lambda function executes, 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 (`AccessMemCache`) using the AWS Lambda `invoke` command.

```
$ aws lambda invoke \
--function-name AccessMemCache \
--region us-east-1 \
--profile adminuser \
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.

#### What Next?

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 [Use Cases \(p. 173\)](#).

## 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 manually 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.

**Important**

This tutorial uses the default Amazon VPC in the us-east-1 region in your account. For more information about Amazon VPC, see [How to Get Started with Amazon VPC](#) in the *Amazon VPC User Guide*.

**Next Step**

[Step 1: Create an Amazon RDS MySQL Instance and ExampleDB Database \(p. 140\)](#)

[Step 1: Create an Amazon RDS MySQL Instance and ExampleDB Database](#)

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.

**Important**

This tutorial uses the RDS MySQL DB engine launched in the default VPC in the us-east-1 region.

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-instance-identifier MySQLForLambdaTest \
--db-instance-class db.t2.micro \
--engine MySQL \
--allocated-storage 5 \
--no-publicly-accessible \
--db-name ExampleDB \
--master-username username \
--master-user-password password \
--backup-retention-period 3
```

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).

**Next Step**

[Step 2: Create a Lambda Function \(p. 140\)](#)

[Step 2: Create a Lambda Function](#)

In this step, you do the following:

- Create a Lambda function deployment package using the sample code provided.
- Create an IAM role (execution role) that you specify at the time of creating your Lambda function. This is the role AWS Lambda assumes when executing the Lambda function.

The permissions policy associated with this role grants AWS Lambda permissions to set up elastic network interfaces (ENIs) to enable your Lambda function to access resources in the VPC.

- Create the Lambda function by uploading the deployment package.

### Topics

- [Step 2.1: Create a Deployment Package \(p. 141\)](#)
- [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 142\)](#)
- [Step 2.3: Create the Lambda Function \(Upload the Deployment Package\) \(p. 143\)](#)

## Step 2.1: Create a Deployment Package

### Note

At this time, example code for the Lambda function is provided only in Python.

### Python

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.

1. Open a text editor, and then copy the following code.

```
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(rds_host, user=name, passwd=password, db=db_name,
                           connect_timeout=5)
except:
    logger.error("ERROR: Unexpected error: Could not connect to MySql instance.")
    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 Employee3 ( EmpID int NOT NULL, Name varchar(255)
NOT NULL, PRIMARY KEY (EmpID))")
        cur.execute('insert into Employee3 (EmpID, Name) values(1, "Joe")')
        cur.execute('insert into Employee3 (EmpID, Name) values(2, "Bob")')
        cur.execute('insert into Employee3 (EmpID, Name) values(3, "Mary")')
        conn.commit()
        cur.execute("select * from Employee3")
```

```
for row in cur:  
    item_count += 1  
    logger.info(row)  
    #print(row)  
  
return "Added %d items from RDS MySQL table" %(item_count)
```

**Note**

We recommend that `pymysql.connect()` is executed outside the handler, as shown, for better performance.

2. Save the file as `app.py`.
3. Install the following library dependencies using `pip`:
  - `pymysql` – The Lambda function code uses this library to access your MySQL instance (see [PyMySQL](#)).
4. Create a config file that contains the following information and save it as `rds_config.py`:

```
#config file containing credentials for rds mysql instance  
db_username = "username"  
db_password = "password"  
db_name = "databasename"
```

5. Zip all of these files into a file named `app.zip` to create your deployment package. For step-by-step instructions, see [Creating a Deployment Package \(Python\) \(p. 96\)](#).

## Next Step

[Step 2.2: Create the Execution Role \(IAM Role\) \(p. 142\)](#)

### Step 2.2: Create the Execution Role (IAM Role)

In this step, you create an execution role (IAM role) for your Lambda function using the following predefined role type and access permissions policy:

- **AWS Lambda** (AWS service role) – This role grants AWS Lambda permissions to assume the role.
- **AWSLambdaVPCAccessExecutionRole** (access permissions policy) – This role grants AWS Lambda permissions for EC2 actions to create ENIs and your Lambda function can access VPC resources and CloudWatch Logs actions to write logs.

For more information about IAM roles, see [IAM Roles](#) in the *IAM User Guide*. Use the following procedure to create the IAM role.

#### To create an IAM role (execution role)

1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
2. Follow the steps in [Creating a Role to Delegate Permissions to an AWS Service](#) in the *IAM User Guide* to create an IAM role (execution role). As you follow the steps to create a role, note the following:
  - In **Role Name**, use a name that is unique within your AWS account (for example, `lambda-vpc-execution-role`).
  - In **Select Role Type**, choose **AWS Service Roles**, and then choose **AWS Lambda**. This grants the AWS Lambda service permissions to assume the role.
  - In **Attach Policy**, choose **AWSLambdaVPCAccessExecutionRole**. The permissions in this policy are sufficient for the Lambda function in this tutorial.

3. Write down the role ARN. You will need it in the next step when you create your Lambda function.

### Next Step

[Step 2.3: Create the Lambda Function \(Upload the Deployment Package\) \(p. 143\)](#)

#### Step 2.3: Create the Lambda Function (Upload the Deployment Package)

In this step, you create the Lambda function (`ReadMySqlTable`) using the `create-function` AWS CLI command.

At the command prompt, run the following Lambda CLI `create-function` command using the **adminuser** profile.

You need to update the following `create-function` command by providing the .zip file path and the execution role ARN. The `--runtime` parameter value can be `python2.7`, `nodejs`, or `java8`, depending on the language you used to author your code.

#### Note

At this time, example code for the Lambda function is provided only in Python. You can use either `python3.6` or `python2.7` for the `--runtime` parameter.

```
$ aws lambda create-function \
--region us-east-1 \
--function-name CreateTableAddRecordsAndRead \
--zip-file fileb://file-path/app.zip \
--role execution-role-arn \
--handler app.handler \
--runtime python3.6 \
--vpc-config SubnetIds=comma-separated-subnet-ids,SecurityGroupIds=default-vpc-security-
group-id \
--profile adminuser
```

Optionally, you can upload the .zip file to an Amazon S3 bucket in the same AWS region, and then specify the bucket and object name in the preceding command. You need to replace the `--zip-file` parameter by the `--code` parameter, as shown following:

```
--code S3Bucket=bucket-name,S3Key=zip-file-object-key
```

#### Note

You can also create the Lambda function using the AWS Lambda console (use the parameter values shown in the preceding CLI command).

### Next Step

[Step 3: Test the Lambda Function \(Invoke Manually\) \(p. 143\)](#)

#### Step 3: Test the Lambda Function (Invoke Manually)

In this step, you invoke the Lambda function manually using the `invoke` command. When the Lambda function executes, it runs the `SELECT` query against the `Employee` table in the RDS MySQL instance and prints the results (these results also go to the CloudWatch Logs).

1. Invoke the Lambda function (`ReadMySqlTable`) using the AWS Lambda `invoke` command.

```
$ aws lambda invoke \
--function-name CreateTableAddRecordsAndRead \
--region us-east-1 \
--profile adminuser \
```

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.

## AWS Lambda Execution Model

When AWS Lambda executes your Lambda function on your behalf, it takes care of provisioning and managing resources needed to run your Lambda function. When you create a Lambda function, you specify configuration information, such as the amount of memory and maximum execution time that you want to allow for your Lambda function. When a Lambda function is invoked, AWS Lambda launches an Execution Context based on the configuration settings you provide. Execution Context is a temporary runtime environment that initializes any external dependencies of your Lambda function code, such as database connections or HTTP endpoints. This affords subsequent invocations better performance because there is no need to "cold-start" or initialize those external dependencies, as explained below.

**Note**

The content of this section is for information only. AWS Lambda manages Execution Context creations and deletion, there is no AWS Lambda API for you to manage Execution Context.

It takes time to set up an Execution Context and do the necessary "bootstrapping", which adds some latency each time the Lambda function is invoked. You typically see this latency when a Lambda function is invoked for the first time or after it has been updated because AWS Lambda tries to reuse the Execution Context for subsequent invocations of the Lambda function.

After a Lambda function is executed, AWS Lambda maintains the Execution Context for some time in anticipation of another Lambda function invocation. In effect, the service freezes the Execution Context after a Lambda function completes, and thaws the context for reuse, if AWS Lambda chooses to reuse the context when the Lambda function is invoked again. This Execution Context reuse approach has the following implications:

- Any declarations in your Lambda function code (outside the handler code, see [Programming Model \(p. 18\)](#)) remains 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 suggest adding logic in your code to check if a connection exists before creating one.
- Each Execution Context provides 500MB of additional disk space in the /tmp directory. The directory content remains when the Execution Context is frozen, providing 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 information on deployment limits, see [AWS Lambda Limits \(p. 394\)](#).
- Background processes or callbacks initiated by your Lambda function that did not complete when the function ended resume if AWS Lambda chooses to reuse the Execution Context. You should make sure any background processes or callbacks (in case of Node.js) in your code are complete before the code exits.

**Note**

When you write your Lambda function code, do not assume that AWS Lambda automatically reuses the Execution Context for subsequent function invocations. Other factors may dictate a

need for AWS Lambda to create a new Execution Context, which can lead to unexpected results, such as database connection failures. As mentioned previously, add logic to your Lambda function code to check for the existence of an Execution Context.

# Invoking Lambda Functions

When building applications on AWS Lambda, including [serverless](#) applications, the core components are Lambda functions and event sources. An *event source* is the AWS service or custom application that publishes events, and a *Lambda function* is the custom code that processes the events. 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, in this scenario you can configure a Lambda function to process the clicks within your custom mobile application.

Each of these event sources uses a specific format for the event data. For more information, see [Sample Events Published by Event Sources \(p. 162\)](#). When a Lambda function is invoked, it receives the event as a parameter for the Lambda function.

AWS Lambda supports many AWS services as event sources. For more information, see [Supported Event Sources \(p. 155\)](#). 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.

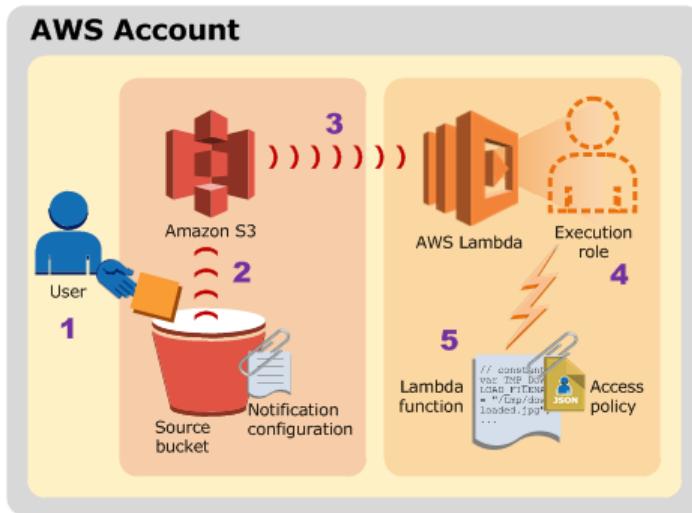
In addition to the supported AWS services, user applications can also generate events—you can build your own custom event sources. Custom event sources invoke a Lambda function using the AWS Lambda [Invoke \(p. 450\)](#) operation. User applications, such as client, mobile, or web applications, can publish events and invoke Lambda functions on demand using the AWS SDKs or AWS Mobile SDKs, such as the AWS Mobile SDK for Android.

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, as shown in the following illustration.



The diagram illustrates the following 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. For more information on execution roles, see [Authentication and Access Control for AWS Lambda \(p. 340\)](#). Amazon S3 knows which Lambda function to invoke based on the event source mapping that is stored in the bucket notification configuration.
4. AWS Lambda executes the Lambda function, specifying the event as a parameter.

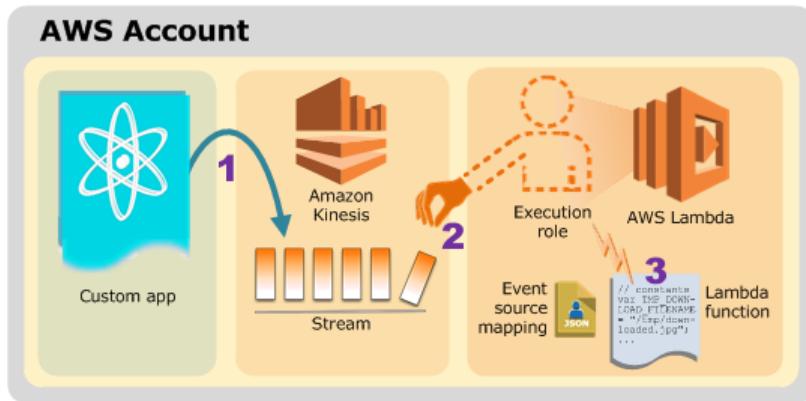
Note the following:

- The event source mapping is maintained within the event source service, Amazon S3 in this scenario. This is true for all supported AWS event sources except the stream-based sources (Kinesis and DynamoDB streams). The next example explains stream-based event sources.
- The event source (Amazon S3) invokes the Lambda function (referred to as the *push model*). Again, this is true for all supported AWS services except the stream-based event sources.
- In order for the event source (Amazon S3) to invoke your Lambda function, you must grant permissions using the permissions policy attached to the Lambda function.

## Example 2: AWS Lambda Pulls Events from an Kinesis Stream and Invokes a Lambda Function

For stream-based event sources, AWS Lambda polls the stream and invokes the Lambda function when records are detected on the stream. These stream sources are special in that event source mapping information is stored in Lambda. AWS Lambda provides an API for you to create and manage these event source mappings.

The following diagram shows how a custom application writes records to a Kinesis stream.



The diagram illustrates the following sequence:

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.

Note the following:

- When working with stream-based event sources, the following is true:
  - You create event source mappings in AWS Lambda.
  - AWS Lambda invokes the Lambda function (referred to as the *pull model*).
- AWS Lambda does not need permission to invoke your Lambda function, therefore you don't need to add any permissions to the permissions policy attached to your Lambda function.
- Your Lambda role needs permission to read from the stream.

## Invocation Types

AWS Lambda supports synchronous and asynchronous invocation of a Lambda function. You can control the invocation type only when you invoke a Lambda function (referred to as *on-demand invocation*). The following examples illustrate on-demand invocations:

- Your custom application invokes a Lambda function.
- You manually invoke a Lambda function (for example, using the AWS CLI) for testing purposes.

In both cases, you invoke your Lambda function using the [Invoke \(p. 450\)](#) operation, and you can specify the invocation type as synchronous or asynchronous.

However, when you are using AWS services as event sources, the invocation type is predetermined for each of these services. You don't have any control over the invocation type that these event sources use when they invoke your Lambda function. For example, Amazon S3 always invokes a Lambda function asynchronously and Amazon Cognito always invokes a Lambda function synchronously. For stream-based AWS services (Amazon Kinesis Streams and Amazon DynamoDB Streams), AWS Lambda polls the stream and invokes your Lambda function synchronously.

## Event Source Mapping

In AWS Lambda, Lambda functions and event sources are the core components in AWS Lambda. An event source is the entity that publishes events, and a Lambda function is the custom code that processes the events. Supported event sources refer to those AWS services that can be preconfigured to work with AWS Lambda. The configuration is referred to as *event source mapping*, which maps an event source to a Lambda function. It enables automatic invocation of your Lambda function when events occur.

Each event source mapping identifies the type of events to publish and the Lambda function to invoke when events occur. The specific Lambda function then receives the event information as a parameter, your Lambda function code can then process the event.

Note the following about the event sources. These event sources can be any of the following:

- **AWS services** – These are the supported AWS services that can be preconfigured to work with AWS Lambda. You can group these services as regular AWS services or stream-based services. Amazon Kinesis Data Streams and Amazon DynamoDB Streams are stream-based event sources, all others AWS services do not use stream-based event sources. Where you maintain the event source mapping and how the Lambda function is invoked depends on whether or not you're using a stream-based event source.
- **Custom applications** – You can have your custom applications publish events and invoke a Lambda function.

You may be wondering—where do I keep the event mapping information? Do I keep it within the event source or within AWS Lambda? The following sections explain event source mapping for each of these event source categories. These sections also explain how the Lambda function is invoked and how you manage permissions to allow invocation of your Lambda function.

### Topics

- [Event Source Mapping for AWS Services \(p. 149\)](#)
- [Event Source Mapping for AWS Stream-Based Services \(p. 150\)](#)
- [Event Source Mapping for Custom Applications \(p. 151\)](#)

## Event Source Mapping for AWS Services

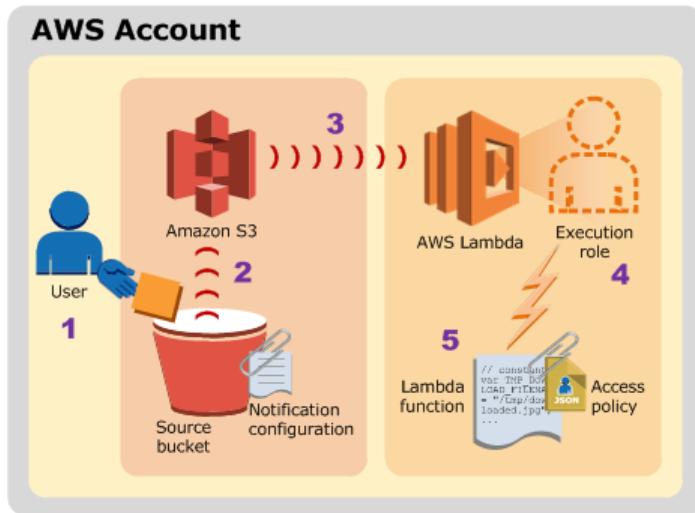
Except for the stream-based AWS services (Amazon Kinesis Data Streams and DynamoDB streams), other supported AWS services publish events and can also invoke your Lambda function (referred to as the *push model*). In the push model, note the following:

- Event source mappings are maintained within the event source. Relevant API support in the event sources enables you to create and manage event source mappings. For example, Amazon S3 provides the bucket notification configuration API. Using this API, you can configure an event source mapping that identifies the bucket events to publish and the Lambda function to invoke.
- Because the event sources invoke your Lambda function, you need to grant the event source the necessary permissions using a resource-based policy (referred to as the *Lambda function policy*). For more information, see [AWS Lambda Permissions Model \(p. 361\)](#).

The following example illustrates how this model works.

### Example – Amazon S3 Pushes Events and Invokes a Lambda Function

Suppose that you want your AWS Lambda function invoked for each *object created* bucket event. You add the necessary event source mapping in the bucket notification configuration.



The diagram illustrates the flow:

1. The user creates an object in a bucket.
2. Amazon S3 detects the object created event.
3. Amazon S3 invokes your Lambda function according to the event source mapping described in the bucket notification configuration.
4. AWS Lambda verifies the permissions policy attached to the Lambda function to ensure that Amazon S3 has the necessary permissions. For more information on permissions policies, see [Authentication and Access Control for AWS Lambda \(p. 340\)](#)
5. Once AWS Lambda verifies the attached permissions policy, it executes the Lambda function. Remember that your Lambda function receives the event as a parameter.

## Event Source Mapping for AWS Stream-Based Services

The Amazon Kinesis Data Streams and DynamoDB streams are the stream-based services that you can preconfigure to use with AWS Lambda. After you do the necessary event source mapping, AWS Lambda polls the streams and invokes your Lambda function (referred to as the *pull model*). In the pull model, note the following:

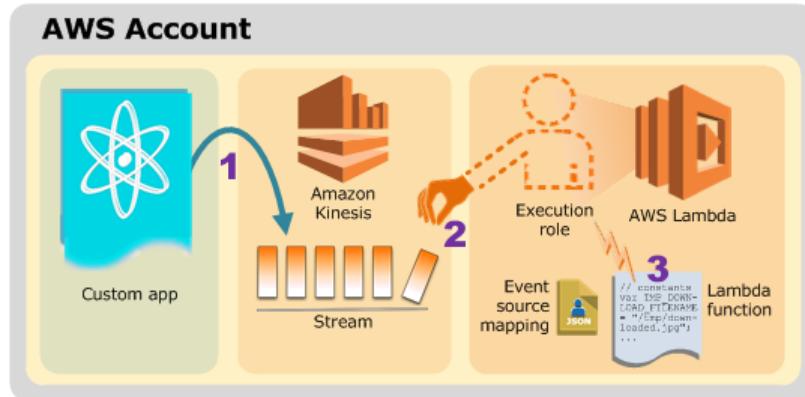
- The event source mappings are maintained within the AWS Lambda. AWS Lambda provides the relevant APIs to create and manage event source mappings. For more information, see [CreateEventSourceMapping \(p. 407\)](#).
- AWS Lambda needs your permission to poll the stream and read records. You grant these permissions via the execution role, using the permissions policy associated with role that you specify when you create your Lambda function. AWS Lambda does not need any permissions to invoke your Lambda function.

The following example illustrates how this model works.

### Example – AWS Lambda Pulls Events from an Kinesis Stream and Invokes a Lambda Function

The following diagram shows a custom application that writes records to an Kinesis stream and how AWS Lambda polls the stream. When AWS Lambda detects a new record on the stream, it invokes your Lambda function.

Suppose you have a custom application that writes records to a Kinesis stream. You want to invoke a Lambda function when new records are detected on the stream. You create a Lambda function and the necessary event source mapping in AWS Lambda.



The diagram illustrates the following sequence:

1. The custom application writes records to an 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 AWS Lambda.
3. Assuming the attached permission policy, which allows AWS Lambda to poll the stream, is verified, AWS Lambda then executes the Lambda function. For more information on permissions policies, see [Authentication and Access Control for AWS Lambda \(p. 340\)](#)

The example uses a Kinesis stream but the same applies when working with a DynamoDB stream.

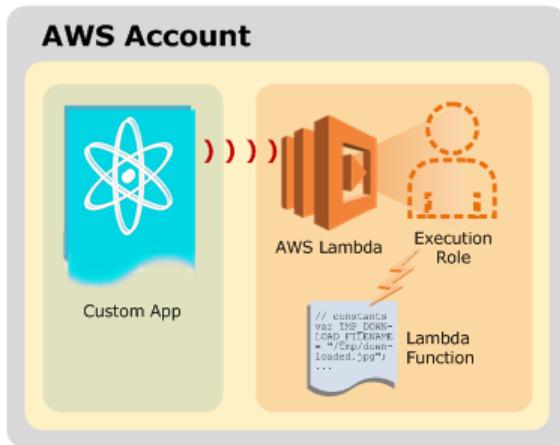
## Event Source Mapping for Custom Applications

If you have custom applications that publish and process events, you can create a Lambda function to process these events. In this case, there is no preconfiguration required—you don't have to set up an event source mapping. Instead, the event source uses the AWS Lambda Invoke API. If the application and Lambda function are owned by different AWS accounts, the AWS account that owns the Lambda function must allow cross-account permissions in the permissions policy associated with the Lambda function.

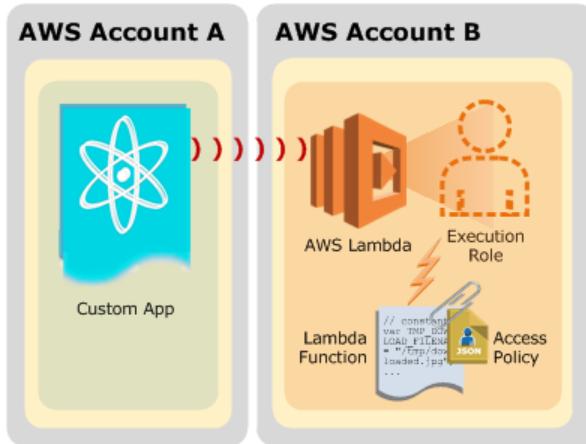
The following example illustrates how this works.

### Example – Custom Application Publishes Events and Invokes a Lambda Function

The following diagram shows how a custom application in your account can invoke a Lambda function. In this example, the custom application is using the same account credentials as the account that owns the Lambda function, and, therefore, does not require additional permissions to invoke the function.



In the following example, the user application and Lambda function are owned by different AWS accounts. In this case, the AWS account that owns the Lambda function must have cross-account permissions in the permissions policy associated with the Lambda function. For more information, see [AWS Lambda Permissions Model \(p. 361\)](#).



# Understanding Retry Behavior

A Lambda function can fail for any of the following reasons:

- The function times out while trying to reach an endpoint.
  - The function fails to successfully parse input data.
  - The function experiences resource constraints, such as out-of-memory errors or other timeouts.

If any of these failures occur, your function will throw an exception. How the exception is handled depends upon how the Lambda function was invoked:

- **Event sources that aren't stream-based** – Some of these event sources are set up to invoke a Lambda function synchronously and others invoke it asynchronously. Accordingly, exceptions are handled as follows:

- **Synchronous invocation** – The invoking application receives a 429 error and is responsible for retries. For a list of supported event sources and the invocation types they use, see [Supported Event Sources](#). These event sources may have additional retries built into the integration.

If you invoked the Lambda function directly through AWS SDKs, your client receives the error and can choose to retry.

- **Asynchronous invocation** – Asynchronous events are queued before being used to invoke the Lambda function. If AWS Lambda is unable to fully process the event, it will automatically retry the invocation twice, with delays between retries. If you have specified a Dead Letter Queue for your function, then the failed event is sent to the specified Amazon SQS queue or Amazon SNS topic. If you don't specify a Dead Letter Queue (DLQ), which is not required and is the default setting, then the event will be discarded. For more information, see [Dead Letter Queues \(p. 385\)](#).
- **Stream-based event sources** – For stream-based event sources (Amazon Kinesis Data Streams and DynamoDB streams), AWS Lambda polls your stream and invokes your Lambda function. Therefore, if a Lambda function fails, AWS Lambda attempts to process the erring batch of records until the time the data expires, which can be up to seven days for Amazon Kinesis Data Streams. The exception is treated as blocking, and AWS Lambda will not read any new records from the stream until the failed batch of records either expires or processed successfully. This ensures that AWS Lambda processes the stream events in order.

For more information about invocation modes, see [Event Source Mapping \(p. 149\)](#).

## Understanding Scaling Behavior

Concurrent executions refers to the number of executions of your function code that are happening at any given time. You can estimate the concurrent execution count, but the concurrent execution count will differ depending on whether or not your Lambda function is processing events from a stream-based event source.

- **Stream-based event sources** for Lambda functions that process Kinesis or DynamoDB streams the number of shards is the unit of concurrency. If your stream has 100 active shards, there will be at most 100 Lambda function invocations running concurrently. This is because Lambda processes each shard's events in sequence.
- **Event sources that aren't stream-based** – If you create a Lambda function to process events from event sources that aren't stream-based (for example, Lambda can process every event from other sources, like Amazon S3 or API Gateway), each published event is a unit of work, in parallel, up to your account limits. Therefore, the number of events (or requests) these event sources publish influences the concurrency. You can use the this formula to estimate your concurrent Lambda function invocations:

```
events (or requests) per second * function duration
```

For example, consider a Lambda function that processes Amazon S3 events. Suppose that the Lambda function takes on average three seconds and Amazon S3 publishes 10 events per second. Then, you will have 30 concurrent executions of your Lambda function.

## Request Rate

Request rate refers to the rate at which your Lambda function is invoked. For all services except the stream-based services, the request rate is the rate at which the event sources generate the events. For stream-based services, AWS Lambda calculates the request rate as follow:

```
request rate = number of concurrent executions / function duration
```

For example, if there are five active shards on a stream (that is, you have five Lambda functions running in parallel) and your Lambda function takes about two seconds, the request rate is 2.5 requests/second.

## Scaling

AWS Lambda will dynamically scale capacity in response to increased traffic, subject to your account's [Account Level Concurrent Execution Limit \(p. 373\)](#). To handle any burst in traffic, Lambda will immediately increase your concurrently executing functions by a predetermined amount, dependent on which region it's executed (see table below).

If the default **Immediate Concurrency Increase** value, as noted in the table below, is not sufficient to accommodate the traffic surge, Lambda will continue to increase the number of concurrent function executions by 500 per minute until your account safety limit has been reached or the number of concurrently executing functions is sufficient to successfully process the increased load.

### Note

Because Lambda depends on Amazon EC2 to provide Elastic Network Interfaces for VPC-enabled Lambda functions, these functions are also subject to Amazon EC2's rate limits as they scale. If your Amazon EC2 rate limits prevent VPC-enabled functions from adding 500 concurrent invocations per minute, please request a limit increase by following the instructions in the preceding section under [To request a limit increase for concurrent executions](#).

Beyond this rate (i.e. for applications taking advantage of the full Immediate concurrency increase), your application should handle Amazon EC2 throttling (502 EC2ThrottledException) through client-side retry and backoff. For more details, see [Error Retries and Exponential Backoff in AWS](#).

The table below outlines the immediate concurrency increase per region:

Region	Immediate Concurrency Increase (function executions)
Asia Pacific (Tokyo)	1000
Asia Pacific (Seoul)	500
Asia Pacific (Mumbai)	500
Asia Pacific (Singapore)	500
Asia Pacific (Sydney)	500
China (Beijing)	500
Canada (Central)	500
EU (Frankfurt)	1000
EU (London)	500

Region	Immediate Concurrency Increase (function executions)
EU (Ireland)	3000
EU (Paris)	500
AWS GovCloud (US)	500
US East (Ohio)	500
US West (N. California)	500
US West (Oregon)	3000
US East (N. Virginia)	3000
South America (São Paulo)	500
AWS GovCloud (US)	500

To learn how to view and manage the concurrent executions for your function, see [Managing Concurrency \(p. 373\)](#)

## Supported Event Sources

This topic lists the supported AWS services that you can configure as event sources for AWS Lambda functions. After you preconfigure the event source mapping, your Lambda function gets invoked automatically when these event sources detect events. For more information about invocation modes, see [Event Source Mapping \(p. 149\)](#).

For all of the event sources listed in this topic, note the following:

- Event sources maintain the event source mapping, except for the stream-based services (Amazon Kinesis Data Streams and Amazon DynamoDB Streams). For the stream-based services, AWS Lambda maintains the event source mapping. AWS Lambda provides the [CreateEventSourceMapping \(p. 407\)](#) operation for you to create and manage the event source mapping. For more information, see [Event Source Mapping \(p. 149\)](#).
- The invocation type that these event sources use when invoking a Lambda function is also preconfigured. For example, Amazon S3 always invokes a Lambda function asynchronously and Amazon Cognito invokes a Lambda function synchronously. The only time you can control the invocation type is when you are invoking the Lambda function yourself using the [Invoke \(p. 450\)](#) operation (for example, invoking a Lambda function on demand from your custom application).
- In order to process AWS events, your Lambda functions may need to include additional libraries, depending on the programming language used to create the function. Functions written in Node.js or Python do not require any additional libraries. For C#, you need to include [AWS Lambda for .NET Core](#). For Java, you need to include [aws-lambda-java-libs](#).

### Important

Each of the included packages should be used without modification. Removing dependencies, adding conflicting dependencies, or selectively including classes from the packages can result in unexpected behavior.

You can also invoke a Lambda function on demand. For details, see [Other Event Sources: Invoking a Lambda Function On Demand \(p. 162\)](#).

For examples of events that are published by these event sources, see [Sample Events Published by Event Sources \(p. 162\)](#).

### Topics

- [Amazon S3 \(p. 156\)](#)
- [Amazon DynamoDB \(p. 156\)](#)
- [Amazon Kinesis Data Streams \(p. 157\)](#)
- [Amazon Simple Notification Service \(p. 157\)](#)
- [Amazon Simple Email Service \(p. 158\)](#)
- [Amazon Cognito \(p. 158\)](#)
- [AWS CloudFormation \(p. 158\)](#)
- [Amazon CloudWatch Logs \(p. 158\)](#)
- [Amazon CloudWatch Events \(p. 159\)](#)
- [AWS CodeCommit \(p. 159\)](#)
- [Scheduled Events \(powered by Amazon CloudWatch Events\) \(p. 159\)](#)
- [AWS Config \(p. 160\)](#)
- [Amazon Alexa \(p. 160\)](#)
- [Amazon Lex \(p. 160\)](#)
- [Amazon API Gateway \(p. 161\)](#)
- [AWS IoT Button \(p. 161\)](#)
- [Amazon CloudFront \(p. 161\)](#)
- [Amazon Kinesis Data Firehose \(p. 162\)](#)
- [Other Event Sources: Invoking a Lambda Function On Demand \(p. 162\)](#)
- [Sample Events Published by Event Sources \(p. 162\)](#)

## Amazon S3

You can write Lambda functions to process S3 bucket events, such as the object-created or object-deleted events. For example, when a user uploads a photo to a bucket, you might want Amazon S3 to invoke your Lambda function so that it reads the image and creates a thumbnail for the photo.

You can use the bucket notification configuration feature in Amazon S3 to configure the event source mapping, identifying the bucket events that you want Amazon S3 to publish and which Lambda function to invoke.

For an example Amazon S3 event, see [Event Message Structure, Amazon S3 Put Sample Event \(p. 168\)](#), and [Amazon S3 Delete Sample Event \(p. 168\)](#). For an example use case, see [Using AWS Lambda with Amazon S3 \(p. 173\)](#).

Error handling for a given event source depends on how Lambda is invoked. Amazon S3 invokes your Lambda function asynchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Amazon DynamoDB

You can use Lambda functions as triggers for your Amazon DynamoDB table. Triggers are custom actions you take in response to updates made to the DynamoDB table. To create a trigger, first you enable

Amazon DynamoDB Streams for your table. AWS Lambda polls the stream and your Lambda function processes any updates published to the stream.

This is a stream-based event source. For stream-based service, you create event source mapping in AWS Lambda, identifying the stream to poll and which Lambda function to invoke.

For an example DynamoDB event, see [Step 2.3.2: Test the Lambda Function \(Invoke Manually\) \(p. 208\)](#) and [Amazon DynamoDB Update Sample Event \(p. 165\)](#). For general format, see [GetRecord](#) in the [Amazon DynamoDB API Reference](#). For an example use case, see [Using AWS Lambda with Amazon DynamoDB \(p. 201\)](#).

Error handling for a given event source depends on how Lambda is invoked. DynamoDB is a stream-based event source. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Amazon Kinesis Data Streams

You can configure AWS Lambda to automatically poll your stream and process any new records such as website click streams, financial transactions, social media feeds, IT logs, and location-tracking events. Then, AWS Lambda polls the stream periodically (once per second) for new records.

For stream-based service, you create event source mapping in AWS Lambda, identifying the stream to poll and which Lambda function to invoke.

For an example event, see [Step 2.3: Create the Lambda Function and Test It Manually \(p. 197\)](#) and [Amazon Kinesis Data Streams Sample Event \(p. 167\)](#). For an example use case, see [Using AWS Lambda with Kinesis \(p. 190\)](#).

Error handling for a given event source depends on how Lambda is invoked. Amazon Kinesis Data Streams is a stream-based event source. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Amazon Simple Notification Service

You can write Lambda functions to process Amazon Simple Notification Service notifications. When a message is published to an Amazon SNS topic, the service can invoke your Lambda function by passing the message payload as parameter. Your Lambda function code can then process the event, for example publish the message to other Amazon SNS topics, or send the message to other AWS services.

This also enables you to trigger a Lambda function in response to Amazon CloudWatch alarms and other AWS services that use Amazon SNS.

You configure the event source mapping in Amazon SNS via topic subscription configuration. For more information, see [Invoking Lambda functions using Amazon SNS notifications](#) in the [Amazon Simple Notification Service Developer Guide](#).

For an example event, see [Appendix: Message and JSON Formats](#) and [Amazon SNS Sample Event \(p. 165\)](#). For an example use case, see [Using AWS Lambda with Amazon SNS from Different Accounts \(p. 228\)](#).

When a user calls the SNS Publish API on a topic that your Lambda function is subscribed to, Amazon SNS will call Lambda to invoke your function asynchronously. Lambda will then return a delivery status. If there was an error calling Lambda, Amazon SNS will retry invoking the Lambda function up to three times. After three tries, if Amazon SNS still could not successfully invoke the Lambda function, then Amazon SNS will send a delivery status failure message to CloudWatch.

Error handling for a given event source depends on how Lambda is invoked. Amazon SNS invokes your Lambda function asynchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Amazon Simple Email Service

Amazon Simple Email Service (Amazon SES) is a cost-effective email service. With Amazon SES, in addition to sending emails, you can also use the service to receive messages. For more information about Amazon SES, see [Amazon Simple Email Service](#). 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. For example scenarios, see [Considering Your Use Case for Amazon SES Email Receiving](#).

You configure event source mapping using the rule configuration in Amazon SES. The following topics provide additional information in the *Amazon Simple Email Service Developer Guide*:

- For sample events, see [Lambda Action](#) and [Amazon SES Email Receiving Sample Event \(p. 163\)](#).
- For Lambda function examples, see [Lambda Function Examples](#).

Error handling for a given event source depends on how Lambda is invoked. Amazon SES invokes your Lambda function asynchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Amazon Cognito

The Amazon Cognito Events feature enables you to run Lambda function 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.

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*. For another example event, see [Amazon Cognito Sync Trigger Sample Event \(p. 167\)](#)

Error handling for a given event source depends on how Lambda is invoked. Amazon Cognito is configured to invoke a Lambda function synchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## AWS CloudFormation

As part of deploying AWS CloudFormation stacks, you can specify a Lambda function as a custom resource to execute any custom commands. Associating a Lambda function with a custom resource enables you to invoke your Lambda function whenever you create, update, or delete AWS CloudFormation stacks.

You configure event source mapping in AWS CloudFormation using stack definition. For more information, see [AWS Lambda-backed Custom Resources](#) in the *AWS CloudFormation User Guide*.

For an example event, see [AWS CloudFormation Create Request Sample Event \(p. 163\)](#). Note that this event is actually a AWS CloudFormation message in an Amazon SNS event.

Error handling for a given event source depends on how Lambda is invoked. AWS CloudFormation invokes your Lambda function synchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Amazon CloudWatch Logs

You can use AWS Lambda functions to perform custom analysis on Amazon CloudWatch Logs using CloudWatch Logs subscriptions. CloudWatch Logs subscriptions provide access to a real-time feed of

log events from CloudWatch Logs and deliver it to your AWS Lambda function for custom processing, analysis, or loading to other systems. For more information about CloudWatch Logs, see [Monitoring Log Files](#).

You maintain event source mapping in Amazon CloudWatch Logs using the log subscription configuration. For more information, see [Real-time Processing of Log Data with Subscriptions \(Example 2: AWS Lambda\)](#) in the *Amazon CloudWatch User Guide*.

For an example event, see [Amazon CloudWatch Logs Sample Event \(p. 165\)](#).

Error handling for a given event source depends on how Lambda is invoked. Amazon CloudWatch Logs invokes your Lambda function asynchronously (invoking a Lambda function does not block write operation into the logs). For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Amazon CloudWatch Events

[Amazon CloudWatch Events](#) help you to respond to state changes in your AWS resources. When your resources change state, they automatically send events into an event stream. 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](#).

You maintain event source mapping in Amazon CloudWatch Events by using a rule target definition. For more information, see the [PutTargets](#) operation in the *Amazon CloudWatch Events API Reference*.

For sample events, see [Supported Event Types](#) in the *Amazon CloudWatch User Guide*.

Error handling for a given event source depends on how Lambda is invoked. Amazon CloudWatch Events invokes your Lambda function asynchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## 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. For more information, see [Manage Triggers for an AWS CodeCommit Repository](#).

You maintain the event source mapping in AWS CodeCommit by using a repository trigger. For more information, see the [PutRepositoryTriggers](#) operation.

Error handling for a given event source depends on how Lambda is invoked. AWS CodeCommit invokes your Lambda function asynchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Scheduled Events (powered by Amazon CloudWatch Events)

You can also set up AWS Lambda to invoke your code on a regular, scheduled basis using the schedule event capability in Amazon CloudWatch Events. To set a schedule you can specify a fixed rate (number of hours, days, or weeks) or specify a cron expression (see [Schedule Expression Syntax for Rules](#) in the *Amazon CloudWatch User Guide*).

You maintain event source mapping in Amazon CloudWatch Events by using a rule target definition. For more information, see the [PutTargets](#) operation in the *Amazon CloudWatch Events API Reference*.

For an example use case, see [Using AWS Lambda with Scheduled Events \(p. 262\)](#).

For an example event, see [Scheduled Event Sample Event \(p. 164\)](#).

Error handling for a given event source depends on how Lambda is invoked. Amazon CloudWatch Events is configured to invoke a Lambda function asynchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## 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.

You maintain event source mapping in AWS Config by using a rule target definition. For more information, see the [PutConfigRule](#) operation in the *AWS Config API reference*.

For more information, see [Evaluating Resources With AWS Config Rules](#). For an example of setting a custom rule, see [Developing a Custom Rule for AWS Config](#). For example Lambda functions, see [Example AWS Lambda Functions for AWS Config Rules \(Node.js\)](#).

Error handling for a given event source depends on how Lambda is invoked. AWS Config is configured to invoke a Lambda function asynchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Amazon 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. For more information, see:

- [Getting Started with Alexa Skills Kit](#).
- [alexa-skills-kit-sdk-for-nodejs](#)
- [alexa-skills-kit-java](#)

Error handling for a given event source depends on how Lambda is invoked. Amazon Echo is configured to invoke a Lambda function synchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Amazon Lex

Amazon Lex is an AWS service for building conversational interfaces into applications using voice and text. Amazon Lex provides pre-build integration with AWS Lambda, allowing you to create Lambda functions for use as code hook with your Amazon Lex bot. In your intent configuration, you can identify your Lambda function to perform initialization/validation, fulfillment, or both.

For more information, see [Using Lambda Functions](#). For an example use case, see [Exercise 1: Create Amazon Lex Bot Using a Blueprint](#).

Error handling for a given event source depends on how Lambda is invoked. Amazon Lex is configured to invoke a Lambda function synchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Amazon API Gateway

You can invoke a Lambda function over HTTPS. You can do this by defining a custom REST API endpoint using Amazon API Gateway. You map individual API operations, such as `GET` and `PUT`, to specific Lambda functions. When you send an HTTPS request to the API endpoint, the Amazon API Gateway service invokes the corresponding Lambda function.

For more information, see [Make Synchronous Calls to Lambda Functions](#). For an example use case, see [Using AWS Lambda with Amazon API Gateway \(On-Demand Over HTTPS\) \(p. 234\)](#).

Error handling for a given event source depends on how Lambda is invoked. Amazon API Gateway is configured to invoke a Lambda function synchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

In addition, you can also use Lambda functions with other AWS services that publish data to one of the supported AWS event sources listed in this topic. For example, you can:

- Trigger Lambda functions in response to CloudTrail updates because it records all API access events to an Amazon S3 bucket.
- Trigger Lambda functions in response to CloudWatch alarms because it publishes alarm events to an Amazon SNS topic.

## AWS IoT Button

The AWS IoT button is a programmable button based on the Amazon Dash Button hardware. This simple Wi-Fi device is easy to configure and designed for developers to get started with AWS Lambda, among many other AWS services, without writing device-specific code.

You can code the button's logic in the cloud to configure button clicks to count or track items, call or alert someone, start or stop something, order services, or even provide feedback. For example, you can click the button to unlock or start a car, open your garage door, call a cab, call your spouse or a customer service representative, track the use of common household chores, medications or products, or remotely control your home appliances.

Error handling for a given event source depends on how Lambda is invoked. AWS IoT is configured to invoke a Lambda function asynchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Amazon CloudFront

Lambda@Edge lets you run Lambda functions at AWS Regions and Amazon CloudFront edge locations 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)

For more information, see [Lambda@Edge \(p. 275\)](#)

Error handling for a given event source depends on how Lambda is invoked. CloudFront is configured to invoke a Lambda function synchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Amazon Kinesis Data Firehose

Amazon Kinesis Data Firehose is the easiest way to load streaming data into AWS. It can capture, transform, and load streaming data into downstream services such as Kinesis Data Analytics or Amazon S3, enabling near real-time analytics with existing business intelligence tools and dashboards you're already using today. You can write Lambda functions to request additional, customized processing of the data before it is sent downstream.

Error handling for a given event source depends on how Lambda is invoked. Kinesis Data Firehose is configured to invoke a Lambda function synchronously. For more information on how errors are retried, see [Understanding Retry Behavior \(p. 152\)](#).

## Other Event Sources: Invoking a Lambda Function On Demand

In addition to invoking Lambda functions using event sources, you can also invoke your Lambda function on demand. You don't need to preconfigure any event source mapping in this case. However, make sure that the custom application has the necessary permissions to invoke your Lambda function.

For example, user applications can also generate events (build your own custom event sources). User applications such as client, mobile, or web applications can publish events and invoke Lambda functions using the AWS SDKs or AWS Mobile SDKs such as the AWS Mobile SDK for Android.

For more information, see [Tools for Amazon Web Services](#). For an example tutorial, see [Using AWS Lambda with Amazon API Gateway \(On-Demand Over HTTPS\) \(p. 234\)](#).

## Sample Events Published by Event Sources

The following is a list of example events published by the supported AWS services. For more information about the supported AWS event sources, see [Supported Event Sources \(p. 155\)](#).

### Sample Events

- [AWS CloudFormation Create Request Sample Event \(p. 163\)](#)
- [Amazon SES Email Receiving Sample Event \(p. 163\)](#)
- [Scheduled Event Sample Event \(p. 164\)](#)
- [Amazon CloudWatch Logs Sample Event \(p. 165\)](#)
- [Amazon SNS Sample Event \(p. 165\)](#)
- [Amazon DynamoDB Update Sample Event \(p. 165\)](#)
- [Amazon Cognito Sync Trigger Sample Event \(p. 167\)](#)
- [Amazon Kinesis Data Streams Sample Event \(p. 167\)](#)
- [Amazon S3 Put Sample Event \(p. 168\)](#)
- [Amazon S3 Delete Sample Event \(p. 168\)](#)
- [Amazon Lex Sample Event \(p. 169\)](#)
- [API Gateway Proxy Request Event \(p. 169\)](#)
- [API Gateway Proxy Response Event \(p. 170\)](#)
- [CloudFront Event \(p. 171\)](#)
- [AWS Config Event \(p. 171\)](#)
- [AWS IoT Button Event \(p. 172\)](#)
- [Kinesis Data Firehose Event \(p. 172\)](#)

## AWS CloudFormation Create Request Sample Event

```
{  
    "StackId": "arn:aws:cloudformation:us-west-2:EXAMPLE/stack-name/guid",  
    "ResponseURL": "http://pre-signed-S3-url-for-response",  
    "ResourceProperties": {  
        "StackName": "stack-name",  
        "List": [  
            "1",  
            "2",  
            "3"  
        ]  
    },  
    "RequestType": "Create",  
    "ResourceType": "Custom::TestResource",  
    "RequestId": "unique id for this create request",  
    "LogicalResourceId": "MyTestResource"  
}
```

## Amazon SES Email Receiving Sample 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"  
                        }  
                    ]  
                }  
            }  
        }  
    ]  
}
```

```

        "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-2:012345678912:function:Example"
    },
    "spfVerdict": {
        "status": "PASS"
    },
    "virusVerdict": {
        "status": "PASS"
    }
},
"eventSource": "aws:ses"
}
]
}
```

### Scheduled Event Sample Event

```
{
    "account": "123456789012",
    "region": "us-east-1",
```

```

    "detail": {},
    "detail-type": "Scheduled Event",
    "source": "aws.events",
    "time": "1970-01-01T00:00:00Z",
    "id": "cdc73f9d-aea9-11e3-9d5a-835b769c0d9c",
    "resources": [
        "arn:aws:events:us-east-1:123456789012:rule/my-schedule"
    ]
}

```

### Amazon CloudWatch Logs Sample Event

```
{
    "awslogs": {
        "data": "H4sIAAAAAAAAHWPwQqCQBCGX0Xm7EFTK
+smZBEUgXoLCdMhFtKV3akI8d0bLYmibvPPN3wz00CJxmQnTO41whwWQRICtmEcB6sQbFC3CjW3XW8kxpOpP
+OC22d1Wml1qZkOGtoMsScxaczKN3plG8zlaHIta5KqWsozoTYw3/djzwhpLwivWFHGpAFe7DL68JlBUk
+17KSN7tCOEJ4M3/qOI49vMHj+zCKdlFqLaU2ZHV2a4Ct/an0/ivdx8oYc1UVX860fQDQiMdxRQEAAA=="
    }
}

```

### Amazon SNS Sample Event

```
{
    "Records": [
        {
            "EventVersion": "1.0",
            "EventSubscriptionArn": eventsubscriptionarn,
            "EventSource": "aws:sns",
            "Sns": {
                "SignatureVersion": "1",
                "Timestamp": "1970-01-01T00:00:00.000Z",
                "Signature": "EXAMPLE",
                "SigningCertUrl": "EXAMPLE",
                "MessageId": "95df01b4-ee98-5cb9-9903-4c221d41eb5e",
                "Message": "Hello from SNS!",
                "MessageAttributes": {
                    "Test": {
                        "Type": "String",
                        "Value": "TestString"
                    },
                    "TestBinary": {
                        "Type": "Binary",
                        "Value": "TestBinary"
                    }
                },
                "Type": "Notification",
                "UnsubscribeUrl": "EXAMPLE",
                "TopicArn": topicarn,
                "Subject": "TestInvoke"
            }
        }
    ]
}

```

### Amazon DynamoDB Update Sample Event

```
{
    "Records": [
        {
            "eventID": "1",
            "eventVersion": "1.0",
            "eventTime": "2015-07-09T12:00:00.000Z",
            "eventName": "aws:lambda:UpdateFunctionCode",
            "invokeIdentity": "arn:aws:lambda:us-east-1:123456789012:function:my-function",
            "region": "us-east-1",
            "resource": "arn:aws:lambda:us-east-1:123456789012:function:my-function",
            "awsRegion": "us-east-1"
        }
    ]
}

```

```

    "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": eventsourcearn,
    "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": sourcearn,
    "eventSource": "aws:dynamodb"
},
{
    "eventID": "3",
    "eventVersion": "1.0",
    "dynamodb": {
        "Keys": {
            "Id": {
                "N": "101"
            }
        },

```

```

        "SizeBytes": 38,
        "SequenceNumber": "333",
        "OldImage": {
            "Message": {
                "S": "This item has changed"
            },
            "Id": {
                "N": "101"
            }
        },
        "StreamViewType": "NEW_AND_OLD_IMAGES"
    },
    "awsRegion": "us-west-2",
    "eventName": "REMOVE",
    "eventSourceARN": sourcearn,
    "eventSource": "aws:dynamodb"
}
]
}

```

### Amazon Cognito Sync Trigger Sample 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
}

```

### Amazon Kinesis Data Streams Sample Event

```

"Records": [
    {
        "eventID": "shardId-000000000000:49545115243490985018280067714973144582180062593244200961",
        "eventVersion": "1.0",
        "kinesis": {
            "partitionKey": "partitionKey-3",
            "data": "SGVsbG8sIHRoaXMgYXNlIDEyMy4=",
            "kinesisSchemaVersion": "1.0",
            "sequenceNumber": "49545115243490985018280067714973144582180062593244200961"
        },
        "invokeIdentityArn": identityarn,
        "eventName": "aws:kinesis:record",
    }
]
}

```

```

        "eventSourceARN": eventsourcarn,
        "eventSource": "aws:kinesis",
        "awsRegion": "us-east-1"
    }
]
}

```

### Amazon S3 Put Sample Event

```
{
  "Records": [
    {
      "eventVersion": "2.0",
      "eventTime": "1970-01-01T00:00:00.000Z",
      "requestParameters": {
        "sourceIPAddress": "127.0.0.1"
      },
      "s3": {
        "configurationId": "testConfigRule",
        "object": {
          "eTag": "0123456789abcdef0123456789abcdef",
          "sequencer": "0A1B2C3D4E5F678901",
          "key": "HappyFace.jpg",
          "size": 1024
        },
        "bucket": {
          "arn": bucketarn,
          "name": "sourcebucket",
          "ownerIdentity": {
            "principalId": "EXAMPLE"
          }
        },
        "s3SchemaVersion": "1.0"
      },
      "responseElements": {
        "x-amz-id-2": "EXAMPLE123/5678abcdefghijklmnaisawesome/mnopqrstuvwxyzABCDEFGH",
        "x-amz-request-id": "EXAMPLE123456789"
      },
      "awsRegion": "us-east-1",
      "eventName": "ObjectCreated:Put",
      "userIdentity": {
        "principalId": "EXAMPLE"
      },
      "eventSource": "aws:s3"
    }
  ]
}
```

### Amazon S3 Delete Sample Event

```
{
  "Records": [
    {
      "eventVersion": "2.0",
      "eventTime": "1970-01-01T00:00:00.000Z",
      "requestParameters": {
        "sourceIPAddress": "127.0.0.1"
      },
      "s3": {
        "configurationId": "testConfigRule",

```

```

    "object": {
        "sequencer": "0A1B2C3D4E5F678901",
        "key": "HappyFace.jpg"
    },
    "bucket": {
        "arn": bucketarn,
        "name": "sourcebucket",
        "ownerIdentity": {
            "principalId": "EXAMPLE"
        }
    },
    "s3SchemaVersion": "1.0"
},
"responseElements": {
    "x-amz-id-2": "EXAMPLE123/5678abcdefghijklmnaisawesome/
mnopqrstuvwxyzABCDEFGHI",
    "x-amz-request-id": "EXAMPLE123456789"
},
"awsRegion": "us-east-1",
"eventName": "ObjectRemoved:Delete",
"userIdentity": {
    "principalId": "EXAMPLE"
},
"eventSource": "aws:s3"
}
]
}
}

```

### Amazon Lex Sample Event

```
{
    "messageVersion": "1.0",
    "invocationSource": "FulfillmentCodeHook or DialogCodeHook",
    "userId": "user-id specified in the POST request to Amazon Lex.",
    "sessionAttributes": {
        "key1": "value1",
        "key2": "value2",
    },
    "bot": {
        "name": "bot-name",
        "alias": "bot-alias",
        "version": "bot-version"
    },
    "outputDialogMode": "Text or Voice, based on ContentType request header in runtime API request",
    "currentIntent": {
        "name": "intent-name",
        "slots": {
            "slot-name": "value",
            "slot-name": "value",
            "slot-name": "value"
        },
        "confirmationStatus": "None, Confirmed, or Denied (intent confirmation, if configured)"
    }
}
```

### API Gateway Proxy Request Event

```
{
    "path": "/test/hello",
```

```

    "headers": {
        "Accept": "text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,*/*;q=0.8",
        "Accept-Encoding": "gzip, deflate, lzma, sdch, br",
        "Accept-Language": "en-US,en;q=0.8",
        "CloudFront-Forwarded-Proto": "https",
        "CloudFront-Is-Desktop-Viewer": "true",
        "CloudFront-Is-Mobile-Viewer": "false",
        "CloudFront-Is-SmartTV-Viewer": "false",
        "CloudFront-Is-Tablet-Viewer": "false",
        "CloudFront-Viewer-Country": "US",
        "Host": "wt6mne2s9k.execute-api.us-west-2.amazonaws.com",
        "Upgrade-Insecure-Requests": "1",
        "User-Agent": "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_11_6) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/52.0.2743.82 Safari/537.36 OPR/39.0.2256.48",
        "Via": "1.1 fb7cca60f0ecd82ce07790c9c5eef16c.cloudfront.net (CloudFront)",
        "X-Amz-Cf-Id": "nBsWBOrSHMgnaROZJK1wGCZ9PcRcSpq_oSXZNQwQ10OTZL4cimZo3g==",
        "X-Forwarded-For": "192.168.100.1, 192.168.1.1",
        "X-Forwarded-Port": "443",
        "X-Forwarded-Proto": "https"
    },
    "pathParameters": {
        "proxy": "hello"
    },
    "requestContext": {
        "accountId": "123456789012",
        "resourceId": "us4z18",
        "stage": "test",
        "requestId": "41b45ea3-70b5-11e6-b7bd-69b5aaebc7d9",
        "identity": {
            "cognitoIdentityPoolId": "",
            "accountId": "",
            "cognitoIdentityId": "",
            "caller": "",
            "apiKey": "",
            "sourceIp": "192.168.100.1",
            "cognitoAuthenticationType": "",
            "cognitoAuthenticationProvider": "",
            "userArn": "",
            "userAgent": "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_11_6) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/52.0.2743.82 Safari/537.36 OPR/39.0.2256.48",
            "user": ""
        },
        "resourcePath": "/{proxy+}",
        "httpMethod": "GET",
        "apiId": "wt6mne2s9k"
    },
    "resource": "/{proxy+}",
    "httpMethod": "GET",
    "queryStringParameters": {
        "name": "me"
    },
    "stageVariables": {
        "stageVarName": "stageVarValue"
    }
}

```

### API Gateway Proxy Response Event

```
{
    "statusCode": 200,
    "headers": {
        "Accept": "text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,*/*;q=0.8",

```

```
"Accept-Encoding": "gzip, deflate, lzma, sdch, br",
"Accept-Language": "en-US,en;q=0.8",
"CloudFront-Forwarded-Proto": "https",
"CloudFront-Is-Desktop-Viewer": "true",
"CloudFront-Is-Mobile-Viewer": "false",
"CloudFront-Is-SmartTV-Viewer": "false",
"CloudFront-Is-Tablet-Viewer": "false",
"CloudFront-Viewer-Country": "US",
"Host": "wt6mne2s9k.execute-api.us-west-2.amazonaws.com",
"Upgrade-Insecure-Requests": "1",
>User-Agent": "Mozilla/5.0 (Macintosh; Intel Mac OS X 10_11_6) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/52.0.2743.82 Safari/537.36 OPR/39.0.2256.48",
"Via": "1.1 fb7cca60f0ecd82ce07790c9c5eef16c.cloudfront.net (CloudFront)",
"X-Amz-Cf-Id": "nBsWBOrSHMgnaROZJK1wGCZ9PcRcSpq_OSXZNQwQ10OTZL4cimZo3g==",
"X-Forwarded-For": "192.168.100.1, 192.168.1.1",
"X-Forwarded-Port": "443",
"X-Forwarded-Proto": "https"
},
"body": "Hello World"
```

## CloudFront 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"
                            }
                        ]
                    }
                }
            }
        }
    ]
}
```

## AWS Config Event

```
{  
    "invokingEvent": "{\"configurationItem\":{\"configurationItemCaptureTime\":\"2016-02-17T01:36:34.043Z\",\"awsAccountId\":\"000000000000\",  
    \"configurationItemStatus\":\"OK\",\"resourceId\":\"i-000000000000\", \"ARN\"  
    \":\"arn:aws:ec2:us-east-1:000000000000:instance/i-000000000000\", \"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\\\"},\n    \"ruleParameters\": \"{\\\"myParameterKey\\\":\\\"myParameterValue\\\"}\",\n    \"resultToken\": \"myResultToken\",\n    \"eventLeftScope\": false,\n    \"executionRoleArn\": \"arn:aws:iam::012345678912:role/config-role\",\n    \"configRuleArn\": \"arn:aws:config:us-east-1:012345678912:config-rule/config-rule-0123456\",\n    \"configRuleName\": \"change-triggered-config-rule\",\n    \"configRuleId\": \"config-rule-0123456\",\n    \"accountId\": \"012345678912\",\n    \"version\": \"1.0\"\n}
```

### AWS IoT Button Event

```
{
    \"serialNumber\": \"ABCDEFG12345\",
    \"clickType\": \"SINGLE\",
    \"batteryVoltage\": \"2000 mV”
}
```

### Kinesis Data Firehose 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\": \"\"
            }
        }
    ]
}
```

# Examples of How to Use AWS Lambda

The use cases for AWS Lambda can be grouped into the following categories:

- **Using AWS Lambda with AWS services as event sources** – *Event sources* publish events that cause the Lambda function to be invoked. These can be AWS services such as Amazon S3. For more information and tutorials, see the following topics:

[Using AWS Lambda with Amazon S3 \(p. 173\)](#)

[Using AWS Lambda with Kinesis \(p. 190\)](#)

[Using AWS Lambda with Amazon DynamoDB \(p. 201\)](#)

[Using AWS Lambda with AWS CloudTrail \(p. 213\)](#)

[Using AWS Lambda with Amazon SNS from Different Accounts \(p. 228\)](#)

- **On-demand Lambda function invocation over HTTPS (Amazon API Gateway)** – In addition to invoking Lambda functions using event sources, you can also invoke your Lambda function over HTTPS. You can do this by defining a custom REST API and endpoint using API Gateway. For more information and a tutorial, see [Using AWS Lambda with Amazon API Gateway \(On-Demand Over HTTPS\) \(p. 234\)](#).
- **On-demand Lambda function invocation (build your own event sources using custom apps)** – User applications such as client, mobile, or web applications can publish events and invoke Lambda functions using the AWS SDKs or AWS Mobile SDKs, such as the AWS Mobile SDK for Android. For more information and a tutorial, see [Getting Started \(p. 3\)](#) and [Using AWS Lambda as Mobile Application Backend \(Custom Event Source: Android\) \(p. 249\)](#).
- **Scheduled events** – You can also set up AWS Lambda to invoke your code on a regular, scheduled basis using the AWS Lambda console. You can specify a fixed rate (number of hours, days, or weeks) or you can specify a cron expression. For more information and a tutorial, see [Using AWS Lambda with Scheduled Events \(p. 262\)](#).

In addition, you also can use a Lambda State Machine. For more information, see [Using a State Machine](#).

## Using AWS Lambda with Amazon S3

Amazon S3 can publish events (for example, when an object is created in a bucket) to AWS Lambda and invoke your Lambda function by passing the event data as a parameter. This integration enables you to write Lambda functions that process Amazon S3 events. In Amazon S3, you add bucket notification configuration that identifies the type of event that you want Amazon S3 to publish and the Lambda function that you want to invoke.

Note the following about how the Amazon S3 and AWS Lambda integration works:

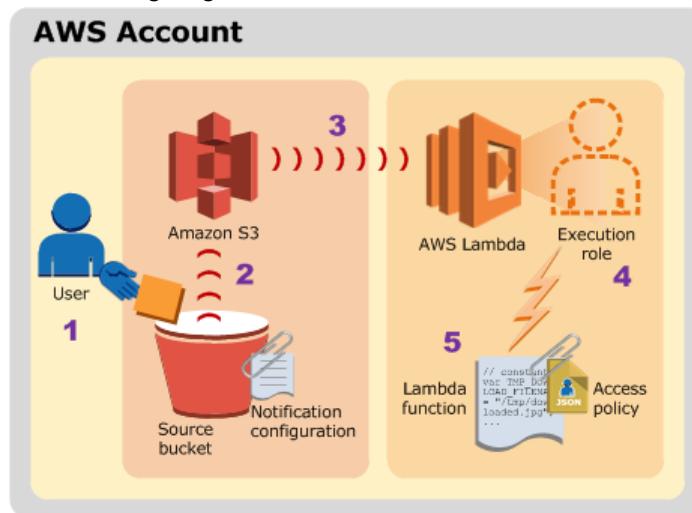
- **Non-stream based (async) model** – This is a model (see [Event Source Mapping \(p. 149\)](#)), where Amazon S3 monitors a bucket and invokes the Lambda function by passing the event data as a parameter. In a push model, you maintain event source mapping within Amazon S3 using the bucket notification configuration. In the configuration, you specify the event types that you want Amazon S3 to monitor and which AWS Lambda function you want Amazon S3 to invoke. For more information, see [Configuring Amazon S3 Event Notifications](#) in the *Amazon Simple Storage Service Developer Guide*.

- **Asynchronous invocation** – AWS Lambda invokes a Lambda function using the Event invocation type (asynchronous invocation). For more information about invocation types, see [Invocation Types \(p. 148\)](#).
- **Event structure** – The event your Lambda function receives is for a single object and it provides information, such as the bucket name and object key name.

Note that there are two types of permissions policies that you work with when you set up the end-to-end experience:

- **Permissions for your Lambda function** – Regardless of what invokes a Lambda function, AWS Lambda executes the function by assuming the IAM role (execution role) that you specify at the time you create the Lambda function. Using the permissions policy associated with this role, you grant your Lambda function the permissions that it needs. For example, if your Lambda function needs to read an object, you grant permissions for the relevant Amazon S3 actions in the permissions policy. For more information, see [Manage Permissions: Using an IAM Role \(Execution Role\) \(p. 362\)](#).
- **Permissions for Amazon S3 to invoke your Lambda function** – Amazon S3 cannot invoke your Lambda function without your permission. You grant this permission via the permissions policy associated with the Lambda function.

The following diagram summarizes the flow:



1. User uploads an object to an S3 bucket (object-created event).
2. Amazon S3 detects the object-created event.
3. Amazon S3 invokes a Lambda function that is specified in the bucket notification configuration.
4. AWS Lambda executes the Lambda function by assuming the execution role that you specified at the time you created the Lambda function.
5. The Lambda function executes.

For a tutorial that walks you through an example setup, see [Tutorial: Using AWS Lambda with Amazon S3 \(p. 174\)](#).

## Tutorial: Using AWS Lambda with Amazon S3

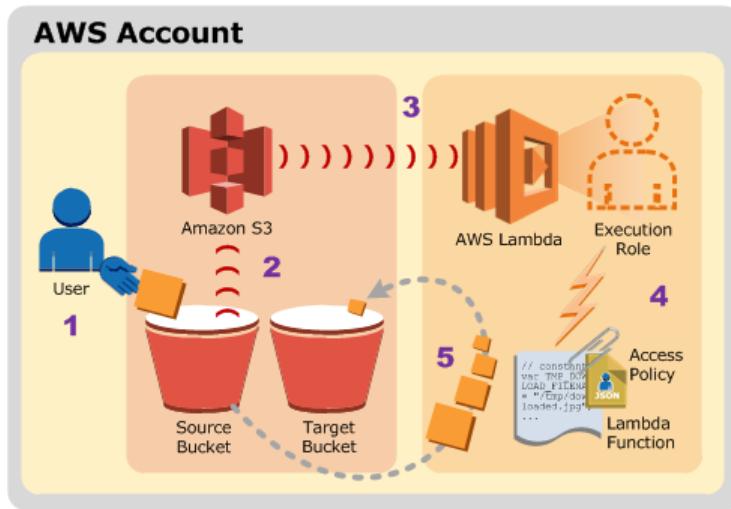
Suppose you want to create a thumbnail for each image (.jpg and .png objects) that is uploaded to a bucket. You can create a Lambda function (`CreateThumbnail`) that Amazon S3 can invoke when objects are created. Then, the Lambda function can read the image object from the `source` bucket and create a thumbnail image target bucket (in this tutorial, it's called the `source`resized bucket).

### Important

The following tutorial assumes you are using two buckets, one for source and for target. If you use the same bucket as the source and the target, each thumbnail uploaded to the source bucket triggers another object-created event, which then invokes the Lambda function again, creating an unwanted recursion. However, you can create a folder within the *source* bucket to create a unique endpoint for your target. If you choose to do that, update the sample below.

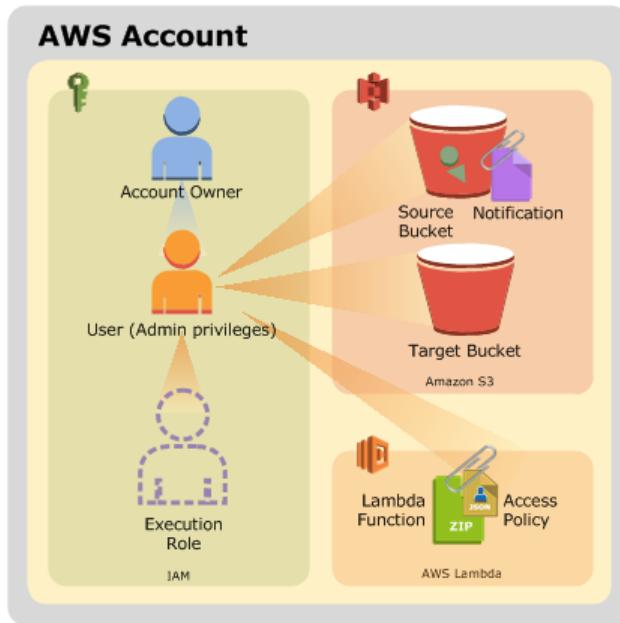
## Implementation Summary

The following diagram illustrates the application flow:



1. A user uploads an object to the source bucket in Amazon S3 (object-created event).
2. Amazon S3 detects the object-created event.
3. Amazon S3 publishes the `s3:ObjectCreated:*` event to AWS Lambda by invoking the Lambda function and passing event data as a function parameter.
4. AWS Lambda executes the Lambda function by assuming the execution role that you specified at the time you created the Lambda function.
5. From the event data it receives, the Lambda function knows the source bucket name and object key name. The Lambda function reads the object and creates a thumbnail using graphics libraries, and saves it to the target bucket.

Note that upon completing this tutorial, you will have the following Amazon S3, Lambda, and IAM resources in your account:



In Lambda:

- A Lambda function.
- An access permissions policy associated with your Lambda function – You grant Amazon S3 permissions to invoke the Lambda function using this permissions policy. You will also restrict the permissions so that Amazon S3 can invoke the Lambda function only for object-created events from a specific bucket that is owned by a specific AWS account.

**Note**

It is possible for an AWS account to delete a bucket and some other AWS account to later create a bucket with the same name. The additional conditions ensure that Amazon S3 can invoke the Lambda function only if Amazon S3 detects object-created events from a specific bucket owned by a specific AWS account.

In IAM:

- Administrator user – Called **adminuser**. Using root credentials of an AWS account is not recommended. Instead, use the **adminuser** credentials to perform the steps in this tutorial.

**Note**

If you have not already created the **adminuser** profile, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#).

- An IAM role (execution role) – You grant permissions that your Lambda function needs through the permissions policy associated with this role.

In Amazon S3:

- Two buckets named **source** and **source resized**. Note that **source** is a placeholder name and you need to replace it with your actual bucket name. For example, if you have a bucket named **example** as your source, you will create **example resized** as the target bucket.
- Notification configuration on the source bucket – You add notification configuration on your source bucket identifying the type of events (object-created events) you want Amazon S3 to publish to AWS Lambda and the Lambda function to invoke. For more information about the Amazon S3 notification

feature, see [Setting Up Notification of Bucket Events](#) in *Amazon Simple Storage Service Developer Guide*.

Now you are ready to start the tutorial. Note that after the initial preparation, the tutorial is divided into two main sections:

- First, you complete the necessary setup steps to create a Lambda function and invoke it manually using Amazon S3 sample event data. This intermediate testing verifies that the function works.
- Second, you add notification configuration to your source bucket so that Amazon S3 can invoke your Lambda function when it detects object-created events.

## Next Step

[Step 1: Prepare \(p. 177\)](#)

### Step 1: Prepare

In this section, you do the following:

- Sign up for an AWS account and set up the AWS CLI.
- Create two buckets (`source` and `source`resized bucket) with a sample .jpg object (`HappyFace.jpg`) in the source bucket. For instructions, see the following procedure.

#### Step 1.1: Sign Up for AWS and Set Up the AWS CLI

Make sure you have completed the following steps:

- Signed up for an AWS account and created an administrator user in the account (called **adminuser**). For instructions, see [Set Up an AWS Account \(p. 4\)](#).
- Installed and set up the AWS CLI. For instructions, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#).

#### Step 1.2: Create Buckets and Upload a Sample Object

Follow the steps to create buckets and upload an object.

##### Important

Both the source bucket and your Lambda function must be in the same AWS region. In addition, the example code used for the Lambda function also assumes that both of the buckets are in the same region. In this tutorial, we use the `us-west-2` region.

1. Using the IAM User Sign-In URL, sign in to the Amazon S3 console as **adminuser**.
2. Create two buckets. The target bucket name must be `source` followed by `resized`, where `source` is the name of the bucket you want to use for the source. For example, `mybucket` and `mybucketresized`.

For instructions, see [Create a Bucket](#) in the *Amazon Simple Storage Service Getting Started Guide*.

3. In the source bucket, upload a .jpg object, `HappyFace.jpg`.

When you invoke the Lambda function manually before you connect to Amazon S3, you pass sample event data to the function that specifies the source bucket and `HappyFace.jpg` as the newly created object so you need to create this sample object first.

## Next Step

[Step 2: Create a Lambda Function and Invoke It Manually \(Using Sample Event Data\) \(p. 178\)](#)

# Step 2: Create a Lambda Function and Invoke It Manually (Using Sample Event Data)

In this section, you do the following:

- Create a Lambda function deployment package using the sample code provided.

**Note**

To see more examples of using other AWS services within your function, including calling other Lambda functions, see [AWS SDK for JavaScript](#)

- Create an IAM role (execution role). At the time you upload the deployment package, you need to specify an IAM role (execution role) that Lambda can assume to execute the function on your behalf.
- Create the Lambda function by uploading the deployment package, and then test it by invoking it manually using sample Amazon S3 event data.

### Topics

- [Step 2.1: Create a Deployment Package \(p. 178\)](#)
- [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 185\)](#)
- [Step 2.3: Create the Lambda Function and Test It Manually \(p. 186\)](#)

## Step 2.1: Create a Deployment Package

From the **Filter View** list, choose the language you want to use for your Lambda function. The appropriate section appears with code and specific instructions for creating a deployment package.

### Node.js

The deployment package is a .zip file containing your Lambda function code and dependencies.

1. Create a folder (`examplefolder`), and then create a subfolder (`node_modules`).
2. Install the Node.js platform. For more information, see the [Node.js](#) website.
3. Install dependencies. The code examples use the following libraries:
  - AWS SDK for JavaScript in Node.js
  - gm, GraphicsMagick for node.js
  - Async utility module

The AWS Lambda runtime already has the AWS SDK for JavaScript in Node.js, so you only need to install the other libraries. Open a command prompt, navigate to the `examplefolder`, and install the libraries using the `npm` command, which is part of Node.js.

```
npm install async gm
```

4. Open a text editor, and then copy the following code.

```
// dependencies
var async = require('async');
```

```

var AWS = require('aws-sdk');
var gm = require('gm')
    .subClass({ imageMagick: true }); // Enable ImageMagick integration.
var util = require('util');

// constants
var MAX_WIDTH = 100;
var MAX_HEIGHT = 100;

// get reference to S3 client
var s3 = new AWS.S3();

exports.handler = function(event, context, callback) {
    // Read options from the event.
    console.log("Reading options from event:\n", util.inspect(event, {depth: 5}));
    var srcBucket = event.Records[0].s3.bucket.name;
    // Object key may have spaces or unicode non-ASCII characters.
    var srcKey =
        decodeURIComponent(event.Records[0].s3.object.key.replace(/\+/g, " "));
    var dstBucket = srcBucket + "resized";
    var dstKey = "resized-" + srcKey;

    // Sanity check: validate that source and destination are different buckets.
    if (srcBucket == dstBucket) {
        callback("Source and destination buckets are the same.");
        return;
    }

    // Infer the image type.
    var typeMatch = srcKey.match(/^.([^.]*$/);
    if (!typeMatch) {
        callback("Could not determine the image type.");
        return;
    }
    var imageType = typeMatch[1];
    if (imageType != "jpg" && imageType != "png") {
        callback('Unsupported image type: ${imageType}');
        return;
    }

    // Download the image from S3, transform, and upload to a different S3 bucket.
    async.waterfall([
        function download(next) {
            // Download the image from S3 into a buffer.
            s3.getObject({
                Bucket: srcBucket,
                Key: srcKey
            },
            next);
        },
        function transform(response, next) {
            gm(response.Body).size(function(err, size) {
                // Infer the scaling factor to avoid stretching the image unnaturally.
                var scalingFactor = Math.min(
                    MAX_WIDTH / size.width,
                    MAX_HEIGHT / size.height
                );
                var width = scalingFactor * size.width;
                var height = scalingFactor * size.height;

                // Transform the image buffer in memory.
                this.resize(width, height)
                    .toBuffer(imageType, function(err, buffer) {
                        if (err) {
                            next(err);
                        } else {

```

```
        next(null, response.ContentType, buffer);
    }
});
},
function upload(contentType, data, next) {
    // Stream the transformed image to a different S3 bucket.
    s3.putObject({
        Bucket: dstBucket,
        Key: dstKey,
        Body: data,
        ContentType: contentType
    },
    next);
},
function (err) {
    if (err) {
        console.error(
            'Unable to resize ' + srcBucket + '/' + srcKey +
            ' and upload to ' + dstBucket + '/' + dstKey +
            ' due to an error: ' + err
        );
    } else {
        console.log(
            'Successfully resized ' + srcBucket + '/' + srcKey +
            ' and uploaded to ' + dstBucket + '/' + dstKey
        );
    }
    callback(null, "message");
}
);
};
};
```

**Note**

The code sample is compliant with the Node.js runtimes v6.10 or v8.10. For more information, see [Programming Model\(Node.js\) \(p. 19\)](#)

5. Review the preceding code and note the following:

- The function knows the source bucket name and the key name of the object from the event data it receives as parameters. If the object is a .jpg, the code creates a thumbnail and saves it to the target bucket.
- The code assumes that the destination bucket exists and its name is a concatenation of the source bucket name followed by the string `resized`. For example, if the source bucket identified in the event data is `examplebucket`, the code assumes you have an `examplebucketresized` destination bucket.
- For the thumbnail it creates, the code derives its key name as the concatenation of the string `resized-` followed by the source object key name. For example, if the source object key is `sample.jpg`, the code creates a thumbnail object that has the key `resized-sample.jpg`.

6. Save the file as `CreateThumbnail.js` in `examplefolder`. After you complete this step, you will have the following folder structure:

```
CreateThumbnail.js
/node_modules/gm
/node_modules/async
```

7. Zip the `CreateThumbnail.js` file and the `node_modules` folder as `CreateThumbnail.zip`.

This is your Lambda function deployment package.

## Next Step

### Step 2.2: Create the Execution Role (IAM Role) (p. 185)

#### Java

The following is example Java code that reads incoming Amazon S3 events and creates a thumbnail. Note that it implements the `RequestHandler` interface provided in the `aws-lambda-java-core` library. Therefore, at the time you create a Lambda function you specify the class as the handler (that is, `example.S3EventProcessorCreateThumbnail`). For more information about using interfaces to provide a handler, see [Leveraging Predefined Interfaces for Creating Handler \(Java\) \(p. 36\)](#).

The `S3Event` type that the handler uses as the input type is one of the predefined classes in the `aws-lambda-java-events` library that provides methods for you to easily read information from the incoming Amazon S3 event. The handler returns a string as output.

```
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.net.URLDecoder;
import java.util.regex.Matcher;
import java.util.regex.Pattern;

import javax.imageio.ImageIO;

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.AmazonS3Client;
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;

public class S3EventProcessorCreateThumbnail 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().getKey()
                .replace('+', ' ');
            srcKey = URLDecoder.decode(srcKey, "UTF-8");

            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 = new AmazonS3Client();
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
// If you want higher quality algorithms, check this link:
// https://today.java.net/pub/a/today/2007/04/03/perils-of-image-
getscaledinstance.html
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);
s3Client.putObject(dstBucket, dstKey, is, meta);
System.out.println("Successfully resized " + srcBucket + "/"
    + srcKey + " and uploaded to " + dstBucket + "/" + dstKey);
return "Ok";
} catch (IOException e) {
    throw new RuntimeException(e);
}
}
```

Amazon S3 invokes your Lambda function using the Event invocation type, where AWS Lambda executes the code asynchronously. What you return does not matter. However, in this case we are implementing an interface that requires us to specify a return type, so in this example the handler uses String as the return type.

Using the preceding code (in a file named `S3EventProcessorCreateThumbnail.java`), create a deployment package. Make sure that you add the following dependencies:

- `aws-lambda-java-core`
- `aws-lambda-java-events`

These can be found at [aws-lambda-java-libs](#).

For more information, see [Programming Model for Authoring Lambda Functions in Java \(p. 30\)](#).

Your deployment package can be a .zip file or a standalone .jar. You can use any build and packaging tool you are familiar with to create a deployment package. For examples of how to use the Maven build tool to create a standalone .jar, see [Creating a .jar Deployment Package Using Maven without any IDE \(Java\) \(p. 90\)](#) and [Creating a .jar Deployment Package Using Maven and Eclipse IDE \(Java\) \(p. 92\)](#). For an example of how to use the Gradle build tool to create a .zip file, see [Creating a .zip Deployment Package \(Java\) \(p. 94\)](#).

After you verify that your deployment package is created, go to the next step to create an IAM role (execution role). You specify this role at the time you create your Lambda function.

## Next Step

[Step 2.2: Create the Execution Role \(IAM Role\) \(p. 185\)](#)

## Python

In this section, you create an example Python function and install dependencies. The code sample is compliant with Python runtime versions 3.6 or 2.7. The steps assume the 3.6 runtime but you can use either one.

1. Open a text editor, and copy the following code. The code uploads the resized image to a different bucket with the same image name, as shown following:

```
source-bucket/image.png -> source-bucketresized/image.png
```

### Note

The `from __future__ import print_function` statement enables you to write code that is compatible with Python 2 or 3. If you are using runtime version 3.6, it is not necessary to include it.

```
from __future__ import print_function
import boto3
```

```
import os
import sys
import uuid
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 handler(event, context):
    for record in event['Records']:
        bucket = record['s3']['bucket']['name']
        key = record['s3']['object']['key']
        download_path = '/tmp/{}{}'.format(uuid.uuid4(), key)
        upload_path = '/tmp/resized-{}'.format(key)

        s3_client.download_file(bucket, key, download_path)
        resize_image(download_path, upload_path)
        s3_client.upload_file(upload_path, '{}resized'.format(bucket), key)
```

2. Save the file as `CreateThumbnail.py`.
3. If your source code is on a local host, copy it over.

```
scp -i key.pem /path/to/my_code.py ec2-user@public-ip-address:~/CreateThumbnail.py
```

4. Connect to a 64-bit Amazon Linux instance via SSH.

```
ssh -i key.pem ec2-user@public-ip-address
```

5. Install Python 3.6 and virtualenv using the following steps:

1. sudo yum install -y gcc zlib zlib-devel openssl openssl-devel
2. wget <https://www.python.org/ftp/python/3.6.1/Python-3.6.1.tgz>
3. tar -xzf Python-3.6.1.tgz
4. cd Python-3.6.1 && ./configure && make
5. sudo make install
6. sudo /usr/local/bin/pip3 install virtualenv

6. Choose the virtual environment that was installed via pip3

```
/usr/local/bin/virtualenv ~/shrink_venv
source ~/shrink_venv/bin/activate
```

7. Install libraries in the virtual environment

```
pip install Pillow
pip install boto3
```

**Note**

AWS Lambda includes the AWS SDK for Python (Boto 3), so you don't need to include it in your deployment package, but you can optionally include it for local testing.

8. Add the contents of lib and lib64 site-packages to your .zip file. Note that the following steps assume you used Python runtime version 3.6. If you used version 2.7 you will need to update accordingly.

```
cd $VIRTUAL_ENV/lib/python3.6/site-packages
```

```
zip -r9 ~/CreateThumbnail.zip *
```

**Note**

To include all hidden files, use the following option: `zip -r9 ~/CreateThumbnail.zip`

9. Add your python code to the .zip file

```
cd ~
```

```
zip -g CreateThumbnail.zip CreateThumbnail.py
```

## Next Step

[Step 2.2: Create the Execution Role \(IAM Role\) \(p. 185\)](#)

### Step 2.2: Create the Execution Role (IAM Role)

In this section, you create an IAM role using the following predefined role type and access permissions policy:

- AWS service role of the type **AWS Lambda** – This role grants AWS Lambda permissions to assume the role.
- **AWSLambdaExecute** access permissions policy that you attach to the role.
- Add a custom policy which allocates permissions for you to add objects to your Amazon S3 bucket.  
For more information, see [Creating a Role to Delegate Permissions to an AWS Service](#) in the *IAM User Guide* to create an IAM role (execution role).

For more information about IAM roles, see [IAM Roles](#) in the *IAM User Guide*. Use the following procedure to create the IAM role.

#### To create an IAM role (execution role)

1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
2. Choose **Create role**
3. In **Select type of trusted entity**, choose **AWS service**, and then choose **Lambda**. This will allow Lambda functions to call AWS services under your account.
4. Choose **Next: Permissions**
5. In **Filter: Policy type** enter **AWSLambdaExecute** and choose **Next: Review**.
6. In **Role name\***, enter a role name that is unique within your AWS account (for example, **lambda-s3-execution-role**) and then choose **Create role**.
7. Open the service role that you just created.
8. Under the **Permissions** tab, choose **Add inline policy**.
9. In **service**, choose **Choose a service**.
10. In **Select a service below**, choose **S3**.
11. In **Actions**, choose **Select actions**.
12. Expand **Write** under **Access level groups** and then choose **PutObject**.
13. Choose **Resources** and then choose the **Any** checkbox.
14. Choose **Review policy**.
15. Enter a **Name\*** and then choose **Create policy**. Note the policy specifications:

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

```
"Statement": [
    {
        "Sid": "VisualEditor0",
        "Effect": "Allow",
        "Action": "s3:PutObject",
        "Resource": "arn:aws:s3:::*/*"
    }
]
```

16. Under the **Summary** of your role, record the **Role ARN**. You will need it in the next step when you create your Lambda function.

## Next Step

[Step 2.3: Create the Lambda Function and Test It Manually \(p. 186\)](#)

### Step 2.3: Create the Lambda Function and Test It Manually

In this section, you do the following:

- Create a Lambda function by uploading the deployment package.
- Test the Lambda function by invoking it manually and passing sample Amazon S3 event data as a parameter.

#### Step 2.3.1: Create the Lambda Function (Upload the Deployment Package)

In this step, you upload the deployment package using the AWS CLI.

1. At the command prompt, run the following Lambda AWS CLI `create-function` command using the `adminuser` as the `--profile`. For more information on setting this up, see [Configuring the AWS CLI](#). You need to update the command by providing the .zip file path and the execution role ARN. For the runtime parameter, choose between `nodejs8.10`, `nodejs6.10` or `nodejs4.3`, `python3.6`, `python2.7` or `java8`, depending on the code sample you used when you created your deployment package.

```
$ aws lambda create-function \
--region region \
--function-name CreateThumbnail \
--zip-file file://file-path/CreateThumbnail.zip \
--role role-arn \
--handler CreateThumbnail.handler \
--runtime runtime \
--profile adminuser \
--timeout 10 \
--memory-size 1024
```

Optionally, you can upload the .zip file to an Amazon S3 bucket in the same AWS region, and then specify the bucket and object name in the preceding command. You need to replace the `--zip-file` parameter by the `--code` parameter, as shown following:

```
--code S3Bucket=bucket-name,S3Key=zip-file-object-key
```

2. Write down the function ARN. You will need this in the next section when you add notification configuration to your Amazon S3 bucket.
3. (Optional) The preceding command specifies a 10-second timeout value as the function configuration. Depending on the size of objects you upload, you might need to increase the timeout value using the following AWS CLI command.

```
$ aws lambda update-function-configuration \
--function-name CreateThumbnail \
--region region \
--timeout timeout-in-seconds \
--profile adminuser
```

**Note**

You can create the Lambda function using the AWS Lambda console, in which case note the value of the `create-function` AWS CLI command parameters. You provide the same values in the console UI.

### Step 2.3.2: Test the Lambda Function (Invoke Manually)

In this step, you invoke the Lambda function manually using sample Amazon S3 event data. You can test the function using the AWS Management Console or the AWS CLI.

#### To test the Lambda function (console)

1. Follow the steps in the Getting Started to create and invoke the Lambda function at [Invoke the Lambda Function Manually and Verify Results, Logs, and Metrics \(p. 11\)](#). For the sample event for testing, choose **S3 Put in Sample event template**.
2. Verify that the thumbnail was created in the target bucket and monitor the activity of your Lambda function in the AWS Lambda console as follows:
  - The AWS Lambda console shows a graphical representation of some of the CloudWatch metrics in the **Cloudwatch Metrics at a glance** section for your function.
  - For each graph, you can also click the **logs** link to view the CloudWatch Logs directly.

#### To test the Lambda function (AWS CLI)

1. Save the following Amazon S3 sample event data in a file and save it as `inputFile.txt`. You need to update the JSON by providing your ***sourcebucket*** name and a .jpg object key.

```
{
    "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": "AIDAJDPLRKLG7UEXAMPLE"
                    }
                }
            }
        }
    ]
}
```

```
        "principalId": "A3NL1KOZZKExample"
    },
    "arn": "arn:aws:s3:::sourcebucket"
},
"object":{
    "key": "HappyFace.jpg",
    "size": 1024,
    "eTag": "d41d8cd98f00b204e9800998ecf8427e",
    "versionId": "096fKKXTRTtl3on89fVO.nfljtsv6qko"
}
}
]
```

- Run the following Lambda CLI `invoke` command to invoke the function. Note that the command requests asynchronous execution. You can optionally invoke it synchronously by specifying `RequestResponse` as the `invocation-type` parameter value.

```
$ aws lambda invoke \
--invocation-type Event \
--function-name CreateThumbnail \
--region region \
--payload file://file-path/inputfile.txt \
--profile adminuser \
outputfile.txt
```

**Note**

You are able to invoke this function because you are using your own credentials to invoke your own function. In the next section, you configure Amazon S3 to invoke this function on your behalf, which requires you to add permissions to the access policy associated with your Lambda function to grant Amazon S3 permissions to invoke your function.

- Verify that the thumbnail was created in the target bucket and monitor the activity of your Lambda function in the AWS Lambda console as follows:
  - The AWS Lambda console shows a graphical representation of some of the CloudWatch metrics in the **Cloudwatch Metrics at a glance** section for your function.
  - For each graph, you can also click the **logs** link to view the CloudWatch Logs directly.

## Next Step

[Step 3: Add an Event Source \(Configure Amazon S3 to Publish Events\) \(p. 188\)](#)

## Step 3: Add an Event Source (Configure Amazon S3 to Publish Events)

In this step, you add the remaining configuration so that Amazon S3 can publish object-created events to AWS Lambda and invoke your Lambda function. You do the following in this step:

- Add permissions to the Lambda function access policy to allow Amazon S3 to invoke the function.
- Add notification configuration to your source bucket. In the notification configuration, you provide the following:
  - Event type for which you want Amazon S3 to publish events. For this tutorial, you specify the `s3:ObjectCreated:*` event type so that Amazon S3 publishes events when objects are created.
  - Lambda function to invoke.

## Step 3.1: Add Permissions to the Lambda Function's Access Permissions Policy

1. Run the following Lambda CLI add-permission command to grant Amazon S3 service principal (`s3.amazonaws.com`) permissions to perform the `lambda:InvokeFunction` action. Note that permission is granted to Amazon S3 to invoke the function only if the following conditions are met:
  - An object-created event is detected on a specific bucket.
  - The bucket is owned by a specific AWS account. If a bucket owner deletes a bucket, some other AWS account can create a bucket with the same name. This condition ensures that only a specific AWS account can invoke your Lambda function.

```
$ aws lambda add-permission \
--function-name CreateThumbnail \
--region region \
--statement-id some-unique-id \
--action "lambda:InvokeFunction" \
--principal s3.amazonaws.com \
--source-arn arn:aws:s3:::sourcebucket \
--source-account bucket-owner-account-id \
--profile adminuser
```

2. Verify the function's access policy by running the AWS CLI get-policy command.

```
$ aws lambda get-policy \
--function-name function-name \
--profile adminuser
```

## Step 3.2: Configure Notification on the Bucket

Add notification configuration on the source bucket to request Amazon S3 to publish object-created events to Lambda. In the configuration, you specify the following:

- Event type – For this tutorial, select the `ObjectCreated (All)` Amazon S3 event type.
- Lambda function – This is your Lambda function that you want Amazon S3 to invoke.

For instructions on adding notification configuration to a bucket, see [Enabling Event Notifications](#) in the *Amazon Simple Storage Service Console User Guide*.

## Step 3.3: Test the Setup

You're all done! Now **adminuser** can test the setup as follows:

1. Upload .jpg or .png objects to the source bucket using the Amazon S3 console.
2. Verify that the thumbnail was created in the target bucket using the `CreateThumbnail` function.
3. The **adminuser** can also verify the CloudWatch Logs. You can monitor the activity of your Lambda function in the AWS Lambda console. For example, choose the `logs` link in the console to view logs, including logs your function wrote to CloudWatch Logs.

## Step 4: Deploy With AWS SAM and AWS CloudFormation

In the previous section, you used AWS Lambda APIs to create and update a Lambda function by providing a deployment package as a ZIP file. However, this mechanism may not be convenient for automating deployment steps for functions, or coordinating deployments and updates to other elements of a serverless application, like event sources and downstream resources.

You can use AWS CloudFormation to easily specify, deploy, and configure serverless applications. AWS CloudFormation is a service that helps you model and set up your Amazon Web Services resources so that you can spend less time managing those resources and more time focusing on your applications that run in AWS. You create a template that describes all the AWS resources that you want (like Lambda functions and DynamoDB tables), and AWS CloudFormation takes care of provisioning and configuring those resources for you.

In addition, you can use the AWS Serverless Application Model to express resources that comprise the serverless application. These resource types, such as Lambda functions and APIs, are fully supported by AWS CloudFormation and make it easier for you to define and deploy your serverless application.

For more information, see [Deploying Lambda-based Applications \(p. 277\)](#).

## Specification for Amazon S3 Thumbnail Application

The following contains the SAM template for this application. 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.

```
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
```

## Deploying the Serverless Application

For information on how to package and deploy your serverless application using the package and deploy commands, see [Packaging and Deployment \(p. 304\)](#).

# Using AWS Lambda with Kinesis

You can create a Kinesis stream to continuously capture and store terabytes of data per hour from hundreds of thousands of sources such as website click streams, financial transactions, social media feeds, IT logs, and location-tracking events. For more information, see [Kinesis](#).

You can subscribe Lambda functions to automatically read batches of records off your Kinesis stream and process them if records are detected on the stream. AWS Lambda then polls the stream periodically (once per second) for new records.

Note the following about how the Kinesis and AWS Lambda integration works:

- **Stream-based model** – This is a model (see [Event Source Mapping \(p. 149\)](#)), where AWS Lambda polls the stream and, when it detects new records, invokes your Lambda function by passing the new records as a parameter.

In a stream-based model, you maintain event source mapping in AWS Lambda. The event source mapping describes which stream maps to which Lambda function. AWS Lambda provides an API ([CreateEventSourceMapping \(p. 407\)](#)) that you can use to create the mapping. You can also use the AWS Lambda console to create event source mappings.

- **Synchronous invocation** – AWS Lambda invokes a Lambda function using the RequestResponse invocation type (synchronous invocation) by polling the Kinesis Stream. For more information about invocation types, see [Invocation Types \(p. 148\)](#).
- **Event structure** – The event your Lambda function receives is a collection of records AWS Lambda reads from your stream. When you configure event source mapping, the batch size you specify is the maximum number of records that you want your Lambda function to receive per invocation.

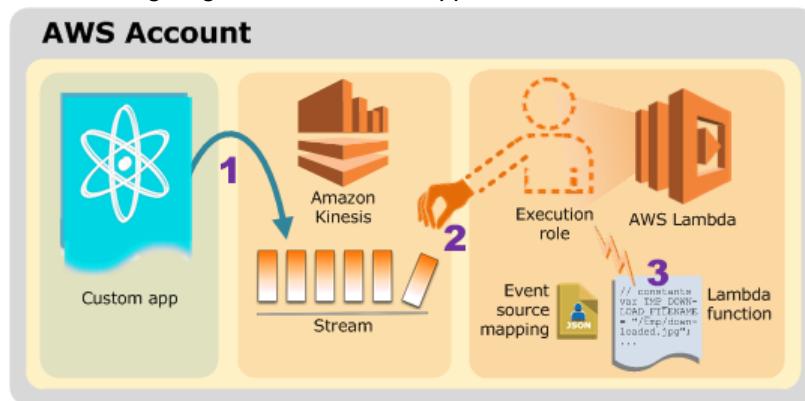
While AWS Lambda will only poll for records once per second, it can be invoked multiple times per second provided that:

- There were more records retrieved during the poll than the batch size will allow for a single invocation.
- The processing time for the function allowed it to complete before 1 second had elapsed.

This means that the limiting factor on how many records your function can process is defined by how quickly it can process records, not how often Lambda polls for new records.

Regardless of what invokes a Lambda function, AWS Lambda always executes a Lambda function on your behalf. If your Lambda function needs to access any AWS resources, you need to grant the relevant permissions to access those resources. You also need to grant AWS Lambda permissions to poll your Kinesis stream. You grant all of these permissions to an IAM role (execution role) that AWS Lambda can assume to poll the stream and execute the Lambda function on your behalf. You create this role first and then enable it at the time you create the Lambda function. For more information, see [Manage Permissions: Using an IAM Role \(Execution Role\) \(p. 362\)](#).

The following diagram illustrates the application flow:



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 executes the Lambda function by assuming the execution role you specified at the time you created the Lambda function.

For a tutorial that walks you through an example setup, see [Tutorial: Using AWS Lambda with Kinesis \(p. 192\)](#).

# Tutorial: Using AWS Lambda with Kinesis

In this tutorial, you create a Lambda function to consume events from an Kinesis stream.

The tutorial is divided into two main sections:

- First, you perform the necessary setup to create a Lambda function and then you test it by invoking it manually using sample event data (you don't need an Kinesis stream).
- Second, you create a Kinesis stream (event source). You add an event source mapping in AWS Lambda to associate the stream with your Lambda function. AWS Lambda starts polling the stream, you add test records to the stream using the Kinesis API, and then you verify that AWS Lambda executed your Lambda function.

## Important

Both the Lambda function and the Kinesis stream must be in the same AWS region. This tutorial assumes that you create these resources in the `us-west-2` region.

In this tutorial, you use the AWS Command Line Interface to perform AWS Lambda operations such as creating a Lambda function, creating a stream, and adding records to the stream. You use the AWS Lambda console to manually invoke the function before you create a Kinesis stream. You verify return values and logs in the console UI.

## Next Step

[Step 1: Prepare \(p. 192\)](#)

## Step 1: Prepare

Make sure you have completed the following steps:

- Signed up for an AWS account and created an administrator user in the account (called **adminuser**). For instructions, see [Set Up an AWS Account \(p. 4\)](#).
- Installed and set up the AWS CLI. For instructions, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#).

## Next Step

[Step 2: Create a Lambda Function and Invoke It Manually \(Using Sample Event Data\) \(p. 192\)](#)

## Step 2: Create a Lambda Function and Invoke It Manually (Using Sample Event Data)

In this section, you do the following:

- Create a Lambda function deployment package using the sample code provided. The sample Lambda function code that you'll use to process Kinesis events is provided in various languages. Select one of the languages and follow the corresponding instructions to create a deployment package.

### Note

To see more examples of using other AWS services within your function, including calling other Lambda functions, see [AWS SDK for JavaScript](#)

- Create an IAM role (execution role). At the time you upload the deployment package, you need to specify an IAM role (execution role) that Lambda can assume to execute the function on your behalf.
- Create the Lambda function by uploading the deployment package, and then test it by invoking it manually using sample Kinesis event data.

## Topics

- [Step 2.1: Create a Deployment Package \(p. 193\)](#)
- [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 196\)](#)
- [Step 2.3: Create the Lambda Function and Test It Manually \(p. 197\)](#)

## Step 2.1: Create a Deployment Package

From the **Filter View** list, choose the language you want to use for your Lambda function. The appropriate section appears with code and specific instructions for creating a deployment package.

### Node.js

The following is example Node.js code that receives Kinesis event records as input and processes them. For illustration, the code writes some of the incoming event data to CloudWatch Logs.

Follow the instructions to create an AWS Lambda function deployment package.

1. Open a text editor, and then copy the following code.

```
console.log('Loading function');

exports.handler = function(event, context, callback) {
    //console.log(JSON.stringify(event, null, 2));
    event.Records.forEach(function(record) {
        // Kinesis data is base64 encoded so decode here
        var payload = new Buffer(record.kinesis.data, 'base64').toString('ascii');
        console.log('Decoded payload:', payload);
    });
    callback(null, "message");
};
```

#### Note

The code sample is compliant with the Node.js runtimes v8.10 or v6.10. For more information, see [Programming Model\(Node.js\) \(p. 19\)](#)

2. Save the file as `ProcessKinesisRecords.js`.
3. Zip the `ProcessKinesisRecords.js` file as `ProcessKinesisRecords.zip`.

## Next Step

### [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 196\)](#)

### Java

The following is example Java code that receives Kinesis event record data as a 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.

```
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 ProcessKinesisEvents 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.

Using the preceding code (in a file named `ProcessKinesisEvents.java`), create a deployment package. Make sure that you add the following dependencies:

- `aws-lambda-java-core`
- `aws-lambda-java-events`

For more information, see [Programming Model for Authoring Lambda Functions in Java \(p. 30\)](#).

Your deployment package can be a .zip file or a standalone .jar. You can use any build and packaging tool you are familiar with to create a deployment package. For examples of how to use the Maven build tool to create a standalone .jar, see [Creating a .jar Deployment Package Using Maven without any IDE \(Java\) \(p. 90\)](#) and [Creating a .jar Deployment Package Using Maven and Eclipse IDE \(Java\) \(p. 92\)](#). For an example of how to use the Gradle build tool to create a .zip file, see [Creating a .zip Deployment Package \(Java\) \(p. 94\)](#).

After you verify that your deployment package is created, go to the next step to create an IAM role (execution role). You specify this role at the time you create your Lambda function.

## Next Step

### [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 196\)](#)

## C#

The following is example C# code that receives Kinesis event record data as a 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.

```
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();  
    }  
}  
}  
}
```

To create a deployment package, follow the steps outlined in [.NET Core CLI \(p. 80\)](#). In doing so, note the following after you've created your .NET project:

- Rename the default *Program.cs* file with a file name of your choice, such as *ProcessingKinesisEvents.cs*.
- Replace the default contents of the renamed *Program.cs* file with the code example above.

After you verify that your deployment package is created, go to the next step to create an IAM role (execution role). You specify this role at the time you create your Lambda function.

## Next Step

### [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 196\)](#)

## Python

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.

Follow the instructions to create a AWS Lambda function deployment package.

1. Open a text editor, and then copy the following code.

### Note

The `from __future__ import print_function` statement enables you to write code that is compatible with Python 2 or 3. If you are using runtime version 3.6, is not necessary to include it.

```
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))
```

2. Save the file as *ProcessKinesisRecords.py*.

3. Zip the `ProcessKinesisRecords.py` file as `ProcessKinesisRecords.zip`.

## Next Step

### [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 196\)](#)

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.

Follow the instructions to create a AWS Lambda function deployment package.

1. Open a text editor, and then copy the following code.

```
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)
    }
}
```

2. Save the file as `ProcessKinesisRecords.go`.
3. Zip the `ProcessKinesisRecords.go` file as `ProcessKinesisRecords.zip`.

## Next Step

### [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 196\)](#)

## Step 2.2: Create the Execution Role (IAM Role)

In this section, you create an IAM role using the following predefined role type and access policy:

- AWS service role of the type **AWS Lambda** – This role grants AWS Lambda permissions to assume the role.
- **AWSLambdaKinesisExecutionRole** – This is the access permissions policy that you attach to the role.

For more information about IAM roles, see [IAM Roles](#) in the *IAM User Guide*. Use the following procedure to create the IAM role.

### To create an IAM role (execution role)

1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
2. Follow the steps in [Creating a Role to Delegate Permissions to an AWS Service](#) in the *IAM User Guide* to create an IAM role (execution role). As you follow the steps to create a role, note the following:
  - In **Role Name**, use a name that is unique within your AWS account (for example, **lambda-kinesis-execution-role**).

- In **Select Role Type**, choose **AWS Service Roles**, and then choose **AWS Lambda**. This grants the AWS Lambda service permissions to assume the role.
  - In **Attach Policy**, choose **AWSLambdaKinesisExecutionRole**. The permissions in this policy are sufficient for the Lambda function in this tutorial.
3. Write down the role ARN. You will need it in the next step when you create your Lambda function.

## Next Step

[Step 2.3: Create the Lambda Function and Test It Manually \(p. 197\)](#)

### Step 2.3: Create the Lambda Function and Test It Manually

In this section, you do the following:

- Create a Lambda function by uploading the deployment package.
- Test the Lambda function by invoking it manually. Instead of creating an event source, you use sample Kinesis event data.

In the next section, you create an Kinesis stream and test the end-to-end experience.

#### Step 2.3.1: Create a Lambda Function (Upload the Deployment Package)

In this step, you upload the deployment package using the AWS CLI.

At the command prompt, run the following Lambda CLI `create-function` command using the **adminuser** profile. For more information on setting this up, see [Configuring the AWS CLI](#).

You need to update the command by providing the .zip file path and the execution role ARN. The `--runtime` parameter value can be `python3.6`, `python2.7`, `nodejs8.10`, `nodejs6.10`, `nodejs4.3`, or `java8`, depending on the language you used to author your code.

```
$ aws lambda create-function \
--region region \
--function-name ProcessKinesisRecords \
--zip-file fileb://file-path/ProcessKinesisRecords.zip \
--role execution-role-arn \
--handler handler \
--runtime runtime-value \
--profile adminuser
```

The `--handler` parameter value for Java should be `example.ProcessKinesisRecords::recordHandler`. For Node.js, it should be `ProcessKinesisRecords.handler` and for Python it should be `ProcessKinesisRecords.lambda_handler`.

Optionally, you can upload the .zip file to an Amazon S3 bucket in the same AWS region, and then specify the bucket and object name in the preceding command. You need to replace the `--zip-file` parameter by the `--code` parameter, as shown following:

```
--code S3Bucket=bucket-name,S3Key=zip-file-object-key
```

#### Note

You can create the Lambda function using the AWS Lambda console, in which case note the value of the `create-function` AWS CLI command parameters. You provide the same values in the console UI.

### Step 2.3.2: Test the Lambda Function (Invoke Manually)

Invoke the function manually using sample Kinesis event data. We recommend that you invoke the function using the console because the console UI provides a user-friendly interface for reviewing the execution results, including the execution summary, logs written by your code, and the results returned by the function (because the console always performs synchronous execution—invokes the Lambda function using the RequestResponse invocation type).

#### To test the Lambda function (console)

1. Follow the steps in the Getting Started to create and invoke the Lambda function at [Invoke the Lambda Function Manually and Verify Results, Logs, and Metrics \(p. 11\)](#). For the sample event for testing, choose **Kinesis** in **Sample event template**.
2. Verify the results in the console.

#### To test the Lambda function (AWS CLI)

1. Copy the following JSON into a file and save it as `input.txt`.

```
{  
    "Records": [  
        {  
            "kinesis": {  
                "partitionKey": "partitionKey-3",  
                "kinesisSchemaVersion": "1.0",  
                "data": "SGVsbG8sIHRoaXMgAXMgYSB0ZXN0IDEyMy4=",  
                "sequenceNumber":  
                    "49545115243490985018280067714973144582180062593244200961"  
            },  
            "eventSource": "aws:kinesis",  
            "eventID":  
                "shardId-000000000000:49545115243490985018280067714973144582180062593244200961",  
                "invokeIdentityArn": "arn:aws:iam::account-id:role/testLEBRole",  
                "eventVersion": "1.0",  
                "eventName": "aws:kinesis:record",  
                "eventSourceARN": "arn:aws:kinesis:us-west-2:35667example:stream/  
examplestream",  
                "awsRegion": "us-west-2"  
            }  
        ]  
    ]  
}
```

2. Execute the following invoke command:

```
$ aws lambda invoke \  
--invocation-type Event \  
--function-name ProcessKinesisRecords \  
--region region \  
--payload file:///file-path/input.txt \  
--profile adminuser  
outputfile.txt
```

#### Note

In this tutorial example, the message is saved in the `outputfile.txt` file. If you request synchronous execution (RequestResponse as the invocation type), the function returns the string message in the response body.

For Node.js, it could be one of the following (whatever one you specify in the code):

```
context.succeed("message")  
context.fail("message")  
context.done(null, "message")
```

For Python or Java, it is the message in the return statement:  
`return "message"`

## Next Step

[Step 3: Add an Event Source \(Create a Kinesis Stream and Associate It with Your Lambda Function\) \(p. 199\)](#)

# Step 3: Add an Event Source (Create a Kinesis Stream and Associate It with Your Lambda Function)

In this section, you create a Kinesis stream, and then you add an event source in AWS Lambda to associate the Kinesis stream with your Lambda function.

After you create an event source, AWS Lambda starts polling the stream. You then test the setup by adding events to the stream and verify that AWS Lambda executed your Lambda function on your behalf:

## Step 3.1: Create a Kinesis Stream

Use the following Kinesis `create-stream` CLI command to create a stream.

```
$ aws kinesis create-stream \  
--stream-name examplestream \  
--shard-count 1 \  
--region region \  
--profile adminuser
```

Run the following Kinesis `describe-stream` AWS CLI command to get the stream ARN.

```
$ aws kinesis describe-stream \  
--stream-name examplestream \  
--region region \  
--profile adminuser
```

You need the stream ARN in the next step to associate the stream with your Lambda function. The stream is of the form:

```
arn:aws:kinesis:aws-region:account-id:stream/stream-name
```

## Step 3.2: Add an Event Source in AWS Lambda

Run the following AWS CLI `add-event-source` command. After the command executes, note down the UUID. You'll need this UUID to refer to the event source in any commands (for example, when deleting the event source).

```
$ aws lambda create-event-source-mapping \  
--region region \  
--function-name ProcessKinesisRecords \  
--event-source kinesis-stream-arn \  
--batch-size 100 \  
--starting-position TRIM_HORIZON \  
--profile adminuser
```

You can get a list of event source mappings by running the following command.

```
$ aws lambda list-event-source-mappings \
--region region \
--function-name ProcessKinesisRecords \
--event-source kinesis-stream-arn \
--profile adminuser \
--debug
```

In the response, you can verify the status value is enabled.

**Note**

If you disable the event source mapping, AWS Lambda stops polling the Kinesis stream. If you re-enable event source mapping, it will resume polling from the sequence number where it stopped, so each record is processed either before you disabled the mapping or after you enabled it. If the sequence number falls behind TRIM\_HORIZON, when you re-enable it polling will start from TRIM\_HORIZON. However, if you create a new event source mapping, polling will always start from TRIM\_HORIZON, LATEST or AT\_TIMESTAMP, depending on the starting position you specify. This applies even if you delete an event source mapping and create a new one with the same configuration as the deleted one.

### Step 3.3: Test the Setup

You're all done! Now *adminuser* can test the setup as follows:

1. Using the following AWS CLI command, add event records to your Kinesis stream. The --data value is a base64-encoded value of the "Hello, this is a test." string. You can run the same command more than once to add multiple records to the stream.

```
$ aws kinesis put-record \
--stream-name examplestream \
--data "This is a test. final" \
--partition-key shardId-000000000000 \
--region region \
--profile adminuser
```

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 from the stream.

AWS Lambda assumes the execution role to poll the stream. You have granted the role permissions for the necessary Kinesis actions so that AWS Lambda can poll the stream and read events from the stream.

3. Your function executes and adds logs to the log group that corresponds to the Lambda function in Amazon CloudWatch.

The **adminuser** can also verify the logs reported in the Amazon CloudWatch console. Make sure you are checking for logs in the same AWS region where you created the Lambda function.

## Step 4: Deploy With AWS SAM and AWS CloudFormation

In the previous section, you used AWS Lambda APIs to create and update a Lambda function by providing a deployment package as a ZIP file. However, this mechanism may not be convenient for automating deployment steps for functions, or coordinating deployments and updates to other elements of a serverless application, like event sources and downstream resources.

You can use AWS CloudFormation to easily specify, deploy, and configure serverless applications. AWS CloudFormation is a service that helps you model and set up your Amazon Web Services resources so that you can spend less time managing those resources and more time focusing on your applications that run in AWS. You create a template that describes all the AWS resources that you want (like Lambda

functions and DynamoDB tables), and AWS CloudFormation takes care of provisioning and configuring those resources for you.

In addition, you can use the AWS Serverless Application Model to express resources that comprise the serverless application. These resource types, such as Lambda functions and APIs, are fully supported by AWS CloudFormation and make it easier for you to define and deploy your serverless application.

For more information, see [Deploying Lambda-based Applications \(p. 277\)](#).

## Specification for Kinesis Application

The following contains the SAM template for this application. 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.

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Resources:
  ProcessKinesisRecords:
    Type: AWS::Serverless::Function
    Properties:
      Handler: handler
      Runtime: runtime
      Policies: AWSLambdaKinesisExecutionRole
      Events:
        Stream:
          Type: Kinesis
          Properties:
            Stream: !GetAtt ExampleStream.Arn
            BatchSize: 100
            StartingPosition: TRIM_HORIZON

  ExampleStream:
    Type: AWS::Kinesis::Stream
    Properties:
      ShardCount: 1
```

## Deploying the Serverless Application

For information on how to package and deploy your serverless application using the package and deploy commands, see [Packaging and Deployment \(p. 304\)](#).

# Using AWS Lambda with Amazon DynamoDB

You can use Lambda functions as triggers for your Amazon DynamoDB table. Triggers are custom actions you take in response to updates made to the DynamoDB table. To create a trigger, first you enable Amazon DynamoDB Streams for your table. Then, you write a Lambda function to process the updates published to the stream.

Note the following about how the Amazon DynamoDB and AWS Lambda integration works:

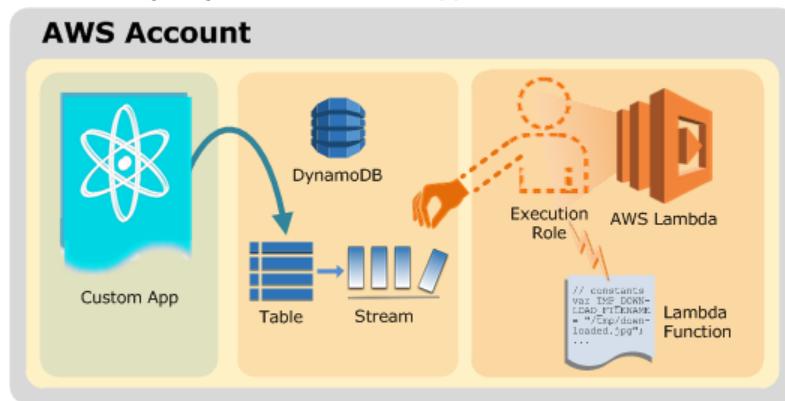
- **Stream-based model** – This is a model (see [Event Source Mapping \(p. 149\)](#)), where AWS Lambda polls the stream at a rate of 4 times per second and, when it detects new records, invokes your Lambda function by passing the update event as parameter.

In a stream-based model, you maintain event source mapping in AWS Lambda. The event source mapping describes which stream maps to which Lambda function. AWS Lambda provides an API ([CreateEventSourceMapping \(p. 407\)](#)) for you to create the mapping. You can also use the AWS Lambda console to create event source mappings.

- **Synchronous invocation** – AWS Lambda invokes a Lambda function using the RequestResponse invocation type (synchronous invocation). For more information about invocation types, see [Invocation Types \(p. 148\)](#).
  - **Event structure** – The event your Lambda function receives is the table update information AWS Lambda reads from your stream. When you configure event source mapping, the batch size you specify is the maximum number of records that you want your Lambda function to receive per invocation.

Regardless of what invokes a Lambda function, AWS Lambda always executes a Lambda function on your behalf. If your Lambda function needs to access any AWS resources, you need to grant the relevant permissions to access those resources. You also need to grant AWS Lambda permissions to poll your DynamoDB stream. You grant all of these permissions to an IAM role (execution role) that AWS Lambda can assume to poll the stream and execute the Lambda function on your behalf. You create this role first and then enable it at the time you create the Lambda function. For more information, see [Manage Permissions: Using an IAM Role \(Execution Role\) \(p. 362\)](#).

The following diagram illustrates the application flow:



1. Custom app updates the DynamoDB table.
  2. Amazon DynamoDB publishes item updates to the stream.
  3. AWS Lambda polls the stream and invokes your Lambda function when it detects new records in the stream.
  4. AWS Lambda executes the Lambda function by assuming the execution role you specified at the time you created the Lambda function.

For a tutorial that walks you through an example setup, see [Tutorial: Using AWS Lambda with Amazon DynamoDB \(p. 202\)](#).

# Tutorial: Using AWS Lambda with Amazon DynamoDB

In this tutorial, you create a Lambda function to consume events from a DynamoDB stream.

The tutorial is divided into two main sections:

- First, you perform the necessary setup to create a Lambda function and then you test it by invoking it manually using sample event data.
  - Second, you create an DynamoDB stream-enabled table and add an event source mapping in AWS Lambda to associate the stream with your Lambda function. AWS Lambda starts polling the stream. Then, you test the end-to-end setup. As you create, update, and delete items from the table, Amazon

DynamoDB writes records to the stream. AWS Lambda detects the new records as it polls the stream and executes your Lambda function on your behalf.

**Important**

Both the Lambda function and the DynamoDB stream must be in the same AWS region. This tutorial assumes that you create these resources in the `us-east-1` region.

In this tutorial, you use the AWS Command Line Interface to perform AWS Lambda operations such as creating a Lambda function, creating a stream, and adding records to the stream. You use the AWS Lambda console to manually invoke the function before you create a DynamoDB stream. You verify return values and logs in the console UI.

## Next Step

[Step 1: Prepare \(p. 203\)](#)

## Step 1: Prepare

Make sure you have completed the following steps:

- Signed up for an AWS account and created an administrator user in the account (called **adminuser**). For instructions, see [Set Up an AWS Account \(p. 4\)](#)
- Installed and set up the AWS CLI. For instructions, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#)

## Next Step

[Step 2: Create a Lambda Function and Invoke It Manually \(Using Sample Event Data\) \(p. 203\)](#)

## Step 2: Create a Lambda Function and Invoke It Manually (Using Sample Event Data)

In this section, you do the following:

- Create a Lambda function deployment package using the sample code provided. The sample Lambda function code that you'll use to process DynamoDB events is provided in various languages. Select one of the languages and follow the corresponding instructions to create a deployment package.

**Note**

To see more examples of using other AWS services within your function, including calling other Lambda functions, see [AWS SDK for JavaScript](#)

- Create an IAM role (execution role). At the time you upload the deployment package, you need to specify an IAM role (execution role) that Lambda can assume to execute the function on your behalf. For example, AWS Lambda needs permissions for DynamoDB actions so it can poll the stream and read records from the stream. In the *pull* model you must also grant AWS Lambda permissions to invoke your Lambda function. The example Lambda function writes some of the event data to CloudWatch, so it needs permissions for necessary CloudWatch actions.
- Create the Lambda function by uploading the deployment package, and then test it by invoking it manually using sample DynamoDB event data. You provide both the deployment package and the IAM role at the time of creating a Lambda function. You can also specify other configuration information, such as the function name, memory size, runtime environment to use, and the handler. For more information about these parameters, see [CreateFunction \(p. 412\)](#). After creating the Lambda function, you invoke it using sample Amazon DynamoDB event data.

## Topics

- [Step 2.1: Create a Lambda Function Deployment Package \(p. 204\)](#)
- [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 207\)](#)
- [Step 2.3: Create the Lambda Function and Test It Manually \(p. 208\)](#)

## Step 2.1: Create a Lambda Function Deployment Package

From the **Filter View** list, choose the language you want to use for your Lambda function. The appropriate section appears with code and specific instructions for creating a deployment package.

### Node.js

1. Open a text editor, and then copy the following code.

```
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");
};
```

#### Note

The code sample is compliant with the Node.js runtimes v6.10 or 8.10. For more information, see [Programming Model\(Node.js\) \(p. 19\)](#)

2. Save the file as `ProcessDynamoDBStream.js`.
3. Zip the `ProcessDynamoDBStream.js` file as `ProcessDynamoDBStream.zip`.

### Next Step

#### [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 207\)](#)

### Java

In the following code, `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.

```
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.

Using the preceding code (in a file named `DDBEventProcessor.java`), create a deployment package. Make sure that you add the following dependencies:

- `aws-lambda-java-core`
- `aws-lambda-java-events`

For more information, see [Programming Model for Authoring Lambda Functions in Java \(p. 30\)](#).

Your deployment package can be a .zip file or a standalone .jar. You can use any build and packaging tool you are familiar with to create a deployment package. For examples of how to use the Maven build tool to create a standalone .jar, see [Creating a .jar Deployment Package Using Maven without any IDE \(Java\) \(p. 90\)](#) and [Creating a .jar Deployment Package Using Maven and Eclipse IDE \(Java\) \(p. 92\)](#). For an example of how to use the Gradle build tool to create a .zip file, see [Creating a .zip Deployment Package \(Java\) \(p. 94\)](#).

After you verify that your deployment package is created, go to the next step to create an IAM role (execution role). You specify this role at the time you create your Lambda function.

## Next Step

[Step 2.2: Create the Execution Role \(IAM Role\) \(p. 207\)](#)

## C#

In the following code, `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.

```
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());
    }
}
}
```

To create a deployment package, follow the steps outlined in [.NET Core CLI \(p. 80\)](#). In doing so, note the following after you've created your .NET project:

- Rename the default *Program.cs* file with a file name of your choice, such as *ProcessingDynamoDBStreams.cs*.
- Replace the default contents of the renamed *Program.cs* file with the code example above.

After you verify that your deployment package is created, go to the next step to create an IAM role (execution role). You specify this role at the time you create your Lambda function.

## Next Step

### [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 207\)](#)

## Python

1. Open a text editor, and then copy the following code.

### Note

The `from __future__ import print_function` statement enables you to write code that is compatible with Python 2 or 3. If you are using runtime version 3.6, it is not necessary to include it.

```
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'])))
```

2. Save the file as `ProcessDynamoDBStream.py`.
3. Zip the `ProcessDynamoDBStream.py` file as `ProcessDynamoDBStream.zip`.

## Next Step

### [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 207\)](#)

## Go

1. Open a text editor, and then copy the following code.

```
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.DynamoDB.NewImage {
            if value.DataType() == events.DataTypeString {
                fmt.Printf("Attribute name: %s, value: %s\n", name, value.String())
            }
        }
    }
}
```

2. Save the file as `ProcessDynamoDBStream.go`.
3. Zip the `ProcessDynamoDBStream.go` file as `ProcessDynamoDBStream.zip`.

## Next Step

[Step 2.2: Create the Execution Role \(IAM Role\) \(p. 207\)](#)

### Step 2.2: Create the Execution Role (IAM Role)

In this section, you create an IAM role using the following predefined role type and access policy:

- AWS service role of the type **Lambda** – This role grants AWS Lambda permissions to call other AWS services.
- **AWSLambdaDynamoDBExecutionRole** – This contains the DynamoDB permissions policy that you attach to augment Lambda's basic execution policy and allows the two services to interoperate under your Lambda function's account.

For more information about IAM roles, see [IAM Roles](#) in the *IAM User Guide* as well as the steps in [Creating a Role to Delegate Permissions to an AWS Service](#) in the *IAM User Guide* to create an IAM role (execution role).

**To create an IAM role (execution role) for this exercise, do the following:**

1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
2. Choose **Roles**
3. Choose **Create role**
4. In **Select type of trusted entity**, choose **AWS service**, and then choose **Lambda**. This will allow Lambda functions to call AWS services under your account.
5. Choose **Next: Permissions**
6. In **Filter: Policy type** enter **AWSLambdaDynamoDBExecutionRole** and choose **Next: Review**.
7. In **Role name\***, enter a role name that is unique within your AWS account (for example, **lambda-dynamodb-execution-role**) and then choose **Create role**.
8. Under the **Summary** of your role, record the **Role ARN** (Amazon Resource Name). You will supply that value in the next step when you create your Lambda function.

## Next Step

[Step 2.3: Create the Lambda Function and Test It Manually \(p. 208\)](#)

### Step 2.3: Create the Lambda Function and Test It Manually

In this section, you do the following:

- Create a Lambda function by uploading the deployment package.
- Test the Lambda function by invoking it manually. Instead of creating an event source, you use sample DynamoDB event data.

In the next section, you create an DynamoDB stream and test the end-to-end experience.

#### Step 2.3.1: Create a Lambda Function (Upload the Deployment Package)

In this step, you upload the deployment package using the AWS CLI.

At the command prompt, run the following Lambda CLI `create-function` command using the **adminuser** profile. If you have already created this profile, see [Set Up an AWS Account \(p. 4\)](#)

You need to update the command by providing the .zip file path and the execution role ARN. The `--runtime` parameter value can be `python3.6`, `python2.7`, `nodejs8.10` or `nodejs6.10>`, or `java8`, depending on the language you used to author your code.

```
$ aws lambda create-function \
--region us-east-1 \
--function-name ProcessDynamoDBStream \
--zip-file fileb://file-path/ProcessDynamoDBStream.zip \
--role role-arn \
--handler ProcessDynamoDBStream.lambda_handler \
--runtime runtime-value \
--profile adminuser
```

#### Note

If you choose Java 8 as the runtime, the handler value must be `packageName::methodName`.

For more information, see [CreateFunction \(p. 412\)](#). AWS Lambda creates the function and returns function configuration information.

Optionally, you can upload the .zip file to an Amazon S3 bucket in the same AWS region, and then specify the bucket and object name in the preceding command. You need to replace the `--zip-file` parameter by the `--code` parameter, as shown following:

```
--code S3Bucket=bucket-name,S3Key=zip-file-object-key
```

#### Step 2.3.2: Test the Lambda Function (Invoke Manually)

In this step, you invoke your Lambda function manually using the `invoke` AWS Lambda CLI command and the following sample DynamoDB event.

1. Copy the following JSON into a file and save it as `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"
}
]
```

2. Execute the following `invoke` command.

```
$ aws lambda invoke \
--invocation-type RequestResponse \
--function-name ProcessDynamoDBStream \
--region us-east-1 \
--payload file://file-path/input.txt \
--profile adminuser \
outputfile.txt
```

Note that the `invoke` command specifies the `RequestResponse` as the invocation type, which requests synchronous execution. For more information, see [Invoke \(p. 450\)](#). The function returns the string message (message in the `context.succeed()` in the code) in the response body.

3. Verify the output in the `outputfile.txt` file.

You can monitor the activity of your Lambda function in the AWS Lambda console.

- The AWS Lambda console shows a graphical representation of some of the CloudWatch metrics in the **Cloudwatch Metrics at a glance** section for your function. Sign in to the AWS Management Console at <https://console.aws.amazon.com/>.
- For each graph you can also click the **logs** link to view the CloudWatch logs directly.

## Next Step

[Step 3: Add an Event Source \(Create a DynamoDB Stream and Associate It with Your Lambda Function\) \(p. 210\)](#)

## Step 3: Add an Event Source (Create a DynamoDB Stream and Associate It with Your Lambda Function)

In this section, you do the following:

- Create an Amazon DynamoDB table with a stream enabled.
- 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.
- 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 executes your Lambda function on your behalf by passing events to the function.

**Note**

The following example assumes you have a user (`adminuser`) with administrator privileges. When you follow the procedure, create a user with name `adminuser`.

**To create an IAM user for yourself and add the user to an Administrators group**

1. Use your AWS account email address and password to sign in as the *AWS account root user* to the IAM console at <https://console.aws.amazon.com/iam/>.

**Note**

We strongly recommend that you adhere to the best practice of using the **Administrator** IAM user below and securely lock away the root user credentials. Sign in as the root user only to perform a few [account and service management tasks](#).

2. In the navigation pane of the console, choose **Users**, and then choose **Add user**.
3. For **User name**, type **Administrator**.
4. Select the check box next to **AWS Management Console access**, select **Custom password**, and then type the new user's password in the text box. You can optionally select **Require password reset** to force the user to create a new password the next time the user signs in.
5. Choose **Next: Permissions**.
6. On the **Set permissions for user** page, choose **Add user to group**.
7. Choose **Create group**.
8. In the **Create group** dialog box, type **Administrators**.
9. For **Filter**, choose **Job function**.
10. In the policy list, select the check box for **AdministratorAccess**. Then choose **Create group**.
11. Back in the list of groups, select the check box for your new group. Choose **Refresh** if necessary to see the group in the list.
12. Choose **Next: Review** to see the list of group memberships to be added to the new user. When you are ready to proceed, choose **Create user**.

You can use this same process to create more groups and users, and to give your users access to your AWS account resources. To learn about using policies to restrict users' permissions to specific AWS resources, go to [Access Management](#) and [Example Policies](#).

### Step 3.1: Create a DynamoDB Table with a Stream Enabled

Follow the procedure to create a table with a stream:

1. Sign in to the AWS Management Console and open the DynamoDB console at <https://console.aws.amazon.com/dynamodb/>.
2. In the DynamoDB console, create a table with streams enabled. For more information on enabling streams, see [Capturing Table Activity with DynamoDB Streams](#).

**Important**

You must create a DynamoDB table in the same region where you created the Lambda function. This tutorial assumes the US East (N. Virginia) region. In addition, both the table and the Lambda functions must belong to the same AWS account.

3. Write down the stream ARN. You need this in the next step when you associate the stream with your Lambda function.

## Step 3.2: Add an Event Source in AWS Lambda

Run the following AWS CLI `create-event-source-mapping` command. After the command executes, 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 \
--region us-east-1 \
--function-name ProcessDynamoDBStream \
--event-source DynamoDB-stream-arn \
--batch-size 100 \
--starting-position TRIM_HORIZON \
--profile adminuser
```

### Note

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 \
--region us-east-1 \
--function-name ProcessDynamoDBStream \
--event-source DynamoDB-stream-arn \
--profile adminuser
```

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.

## Step 3.3: Test the Setup

You're all done! Now **adminuser** can test the setup as follows:

1. In the DynamoDB console, add, update, 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 executes and creates logs in Amazon CloudWatch. The **adminuser** can also verify the logs reported in the Amazon CloudWatch console.

## Step 4: Deploy With AWS SAM and AWS CloudFormation

In the previous section, you used AWS Lambda APIs to create and update a Lambda function by providing a deployment package as a ZIP file. However, this mechanism may not be convenient for automating deployment steps for functions, or coordinating deployments and updates to other elements of a serverless application, like event sources and downstream resources.

You can use AWS CloudFormation to easily specify, deploy, and configure serverless applications. AWS CloudFormation is a service that helps you model and set up your Amazon Web Services resources so that you can spend less time managing those resources and more time focusing on your applications.

that run in AWS. You create a template that describes all the AWS resources that you want (like Lambda functions and DynamoDB tables), and AWS CloudFormation takes care of provisioning and configuring those resources for you.

In addition, you can use the AWS Serverless Application Model to express resources that comprise the serverless application. These resource types, such as Lambda functions and APIs, are fully supported by AWS CloudFormation and make it easier for you to define and deploy your serverless application.

For more information, see [Deploying Lambda-based Applications \(p. 277\)](#).

## Specification for DynamoDB Application

The following contains the SAM template for this application. 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.

```
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
```

## Deploying the Serverless Application

For information on how to package and deploy your serverless application using the package and deploy commands, see [Packaging and Deployment \(p. 304\)](#).

# Using AWS Lambda with AWS CloudTrail

You can enable CloudTrail in your AWS account to get logs of API calls and related events history in your account. CloudTrail records all of the API access events as objects in your Amazon S3 bucket that you specify at the time you enable CloudTrail.

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.

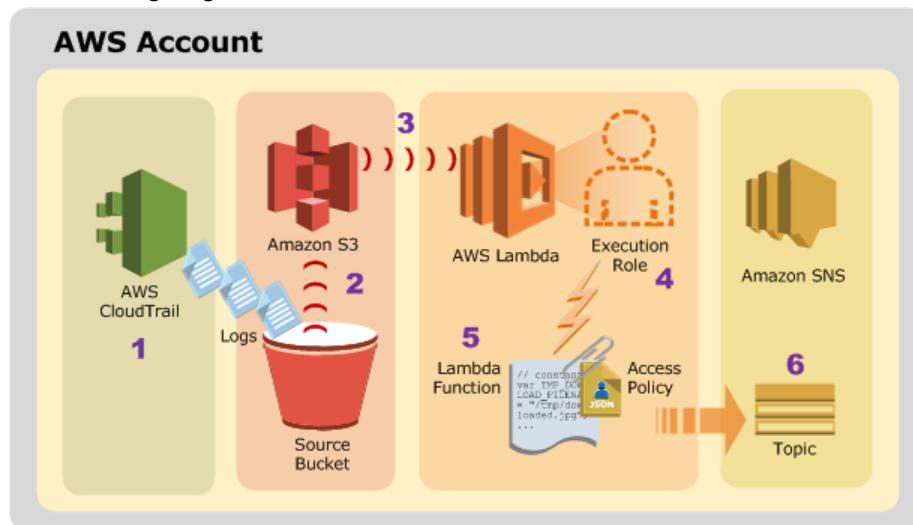
In this scenario, you enable CloudTrail so it can write access logs to your S3 bucket. As for AWS Lambda, Amazon S3 is the event source so Amazon S3 publishes events to AWS Lambda and invokes your Lambda function.

**Note**

Amazon S3 can only support one event destination.

For detailed information about how to configure Amazon S3 as the event source, see [Using AWS Lambda with Amazon S3 \(p. 173\)](#).

The following diagram summarizes the flow:



1. AWS CloudTrail saves logs to an S3 bucket (object-created event).
2. Amazon S3 detects the object-created event.
3. Amazon S3 publishes the `s3:ObjectCreated:*` event to AWS Lambda by invoking the Lambda function, as specified in the bucket notification configuration. Because the Lambda function's access permissions policy includes permissions for Amazon S3 to invoke the function, Amazon S3 can invoke the function.
4. AWS Lambda executes the Lambda function by assuming the execution role that you specified at the time you created the Lambda function.
5. The Lambda function reads the Amazon S3 event it receives as a parameter, determines where the CloudTrail object is, reads the CloudTrail object, and then it processes the log records in the CloudTrail object.
6. If the log includes a record with specific `eventType` and `eventSource` values, it publishes the event to your Amazon SNS topic. In [Tutorial: Using AWS Lambda with AWS CloudTrail \(p. 215\)](#), you subscribe to the SNS topic using the email protocol, so you get email notifications.

For a tutorial that walks you through an example scenario, see [Tutorial: Using AWS Lambda with AWS CloudTrail \(p. 215\)](#).

## Tutorial: Using AWS Lambda with AWS CloudTrail

Suppose you have turned on AWS CloudTrail for your AWS account to maintain records (logs) of AWS API calls made on your account and you want to be notified anytime an API call is made to create an SNS topic. As API calls are made in your account, CloudTrail writes logs to an Amazon S3 bucket that you configured. In this scenario, you want Amazon S3 to publish the object-created events to AWS Lambda and invoke your Lambda function as CloudTrail creates log objects.

When Amazon S3 invokes your Lambda function, it passes an S3 event identifying, among other things, the bucket name and key name of the object that CloudTrail created. Your Lambda function can read the log object, and it knows the API calls that were reported in the log.

Each object CloudTrail creates in your S3 bucket is a JSON object, with one or more event records. Each record, among other things, provides `eventSource` and `eventName`.

```
{  
    "Records": [  
        {  
            "eventVersion": "1.02",  
            "userIdentity": {  
                ...  
            },  
            "eventTime": "2014-12-16T19:17:43Z",  
            "eventSource": "sns.amazonaws.com",  
            "eventName": "CreateTopic",  
            "awsRegion": "us-west-2",  
            "sourceIPAddress": "72.21.198.64",  
            ...  
        },  
        {  
            ...  
        },  
        ...  
    ]  
}
```

For illustration, the Lambda function notifies you by email if an API call to create an Amazon SNS topic is reported in the log. That is, when your Lambda function parses the log, it looks for records with the following:

- `eventSource = "sns.amazonaws.com"`
- `eventName = "CreateTopic"`

If found, it publishes the event to your Amazon SNS topic (you configure this topic to notify you by email).

## Implementation Summary

Upon completing this tutorial, you will have Amazon S3, AWS Lambda, Amazon SNS, and AWS Identity and Access Management (IAM) resources in your account:

### Note

This tutorial assumes that you create these resources in the `us-west-2` region.

In Lambda:

- A Lambda function.
- An access policy associated with your Lambda function – You grant Amazon S3 permissions to invoke the Lambda function using this permissions policy. You will also restrict the permissions so that

Amazon S3 can invoke the Lambda function only for object-created events from a specific bucket that is owned by a specific AWS account.

**Note**

It is possible for an AWS account to delete a bucket and some other AWS account to later create a bucket with same name. The additional conditions ensure that Amazon S3 can invoke the Lambda function only if Amazon S3 detects object-created events from a specific bucket owned by a specific AWS account.

In IAM:

- An IAM role (execution role) – You grant permissions that your Lambda function needs through the permissions policy associated with this role.

In Amazon S3:

- A bucket – In this tutorial, the bucket name is `examplebucket`. When you turn the trail on in the CloudTrail console, you specify this bucket for CloudTrail to save the logs.
- Notification configuration on the `examplebucket` – In the configuration, you direct Amazon S3 to publish object-created events to Lambda, by invoking your Lambda function. For more information about the Amazon S3 notification feature, see [Setting Up Notification of Bucket Events](#) in *Amazon Simple Storage Service Developer Guide*.
- Sample CloudTrail log object (`ExampleCloudTrailLog.json`) in `examplebucket` bucket – In the first half of this exercise, you create and test your Lambda function by manually invoking it using a sample S3 event. This sample event identifies `examplebucket` as the bucket name and this sample object key name. Your Lambda function then reads the object and sends you email notifications using an SNS topic.

In Amazon SNS

- An SNS topic – You subscribe to this topic by specifying email as the protocol.

Now you are ready to start the tutorial.

## Next Step

[Step 1: Prepare \(p. 216\)](#)

### Step 1: Prepare

In this section you do the following:

- Sign up for an AWS account and set up the AWS CLI.
- Turn on CloudTrail in your account.
- Create an SNS topic and subscribe to it.

Follow the steps in the following sections to walk through the setup process.

**Note**

In this tutorial, we assume that you are setting the resources in the `us-west-2` region.

#### [Step 1.1: Sign Up for AWS and Set Up the AWS CLI](#)

Make sure you have completed the following steps:

- Signed up for an AWS account and created an administrator user in the account (called **adminuser**). For instructions, see [Set Up an AWS Account \(p. 4\)](#).
- Installed and set up the AWS CLI. For instructions, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#).

## Step 1.2: Turn on CloudTrail

In the AWS CloudTrail console, turn on the trail in your account by specifying `examplebucket` in the `us-west-2` region for CloudTrail to save logs. When configuring the trail, do not enable SNS notification.

For instructions, see [Creating and Updating Your Trail](#) in the *AWS CloudTrail User Guide*.

### Note

Although you turn CloudTrail on now, you do not perform any additional configuration for your Lambda function to process the real CloudTrail logs in the first half of this exercise. Instead, you will use sample CloudTrail log objects (that you will upload) and sample S3 events to manually invoke and test your Lambda function. In the second half of this tutorial, you perform additional configuration steps that enable your Lambda function to process the CloudTrail logs.

## Step 1.3: Create an SNS Topic and Subscribe to the Topic

Follow the procedure to create an SNS topic in the `us-west-2` region and subscribe to it by providing an email address as the endpoint.

### To create and subscribe to a topic

1. Create an SNS topic.

For instructions, see [Create a Topic](#) in the *Amazon Simple Notification Service Developer Guide*.

2. Subscribe to the topic by providing an email address as the endpoint.

For instructions, see [Subscribe to a Topic](#) in the *Amazon Simple Notification Service Developer Guide*.

3. Note down the topic ARN. You will need the value in the following sections.

## Next Step

[Step 2: Create a Lambda Function and Invoke It Manually \(Using Sample Event Data\) \(p. 217\)](#)

## Step 2: Create a Lambda Function and Invoke It Manually (Using Sample Event Data)

In this section, you do the following:

- Create a Lambda function deployment package using the sample code provided. The sample Lambda function code that you'll use to process Amazon S3 events is provided in various languages. Select one of the languages and follow the corresponding instructions to create a deployment package.

### Note

Your Lambda function uses an S3 event that provides the bucket name and key name of the object CloudTrail created. Your Lambda function then reads that object to process CloudTrail records.

- Create an IAM role (execution role). At the time you upload the deployment package, you need to specify an IAM role (execution role) that Lambda can assume to execute the function on your behalf.

- Create the Lambda function by uploading the deployment package, and then test it by invoking it manually using sample CloudTrail event data.

### Topics

- [Step 2.1: Create a Deployment Package \(p. 218\)](#)
- [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 219\)](#)
- [Step 2.3: Create the Lambda Function and Test It Manually \(p. 221\)](#)

## Step 2.1: Create a Deployment Package

The deployment package is a .zip file containing your Lambda function code. For this tutorial, you will need to install the `async` library. To do this, open a command window and navigate to the directory where you intend to store the code file you will copy and save below. Use `npm` to install the `async` library as shown below :

```
npm install async
```

### Node.js

1. Open a text editor, and then copy the following code.

```
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) {
                console.error('Error parsing CloudTrail JSON:', err);
                return next(err);
            }
            var snsMessage = {
                TopicArn: SNS_TOPIC_ARN,
                Subject: 'CloudTrail Log',
                Message: json
            };
            sns.publish(snsMessage, next);
        }
    ],
    function done(err) {
        if (err) {
            return callback(err);
        }
        else {
            return callback(null, 'Success');
        }
    }
});
```

```
        } 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");
});
};

};
```

**Note**

The code sample is compliant with the Node.js runtimes v8.10 or v6.10. For more information, see [Programming Model\(Node.js\) \(p. 19\)](#)

2. Save the file as `CloudTrailEventProcessing.js`.
3. Zip the `CloudTrailEventProcessing.js` file as `CloudTrailEventProcessing.zip`.

**Note**

We're using Node.js in this tutorial example, but you can author your Lambda functions in Java or Python too.

## Next Step

[Step 2.2: Create the Execution Role \(IAM Role\) \(p. 219\)](#)

### Step 2.2: Create the Execution Role (IAM Role)

Now you create an IAM role (execution role) that you specify when creating your Lambda function. This role has a permissions policy that grant the necessary permissions that your Lambda function needs, such as permissions to write CloudWatch logs, permissions to read CloudTrail log objects from an S3 bucket, and permissions to publish events to your SNS topic when your Lambda function finds specific API calls in the CloudTrail records.

For more information about the execution role, see [Manage Permissions: Using an IAM Role \(Execution Role\) \(p. 362\)](#).

### To create an IAM role (execution role)

1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
2. Create a managed policy and attach it to the IAM role. In this step, you modify an existing AWS Managed Policy, save it using a different name, and then attach the permissions policy to an IAM role that you create.
  - a. In the navigation pane of the IAM console, choose **Policies**, and then choose **Create Policy**.
  - b. Next to **Copy an AWS Managed Policy**, choose **Select**.
  - c. Next to **AWSLambdaExecute**, choose **Select**.
  - d. Copy the following policy into the **Policy Document**, replacing the existing policy, and then update the policy with the ARN of the Amazon SNS topic that you created.

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Effect": "Allow",  
            "Action": [  
                "logs:*"  
            ],  
            "Resource": "arn:aws:logs:*:*:  
        },  
        {  
            "Effect": "Allow",  
            "Action": [  
                "s3:GetObject"  
            ],  
            "Resource": "arn:aws:s3:::examplebucket/*"  
        },  
        {  
            "Effect": "Allow",  
            "Action": [  
                "sns:Publish"  
            ],  
            "Resource": "your sns topic ARN"  
        }  
    ]  
}
```

3. Note the permissions policy name because you will use it in the next step.
4. Follow the steps in [Creating a Role to Delegate Permissions to an AWS Service](#) in the *IAM User Guide* to create an IAM role and then attach the permissions policy you just created to the role. As you follow the steps to create a role, note the following:
  - In **Role Name**, use a name that is unique within your AWS account (for example, **lambda-cloudtrail-execution-role**).
  - In **Select Role Type**, choose **AWS Service Roles**, and then choose **AWS Lambda**.
  - In **Attach Policy**, choose the policy you created in the previous step.

### Next Step

[Step 2.3: Create the Lambda Function and Test It Manually \(p. 221\)](#)

## Step 2.3: Create the Lambda Function and Test It Manually

In this section, you do the following:

- Create a Lambda function by uploading the deployment package.
- Test the Lambda function by invoking it manually.

In this step, you use a sample S3 event that identifies your bucket name and the sample object (that is, an example CloudTrail log). In the next section you configure your S3 bucket notification to publish object-created events and test the end-to-end experience.

### Step 2.3.1: Create the Lambda Function (Upload the Deployment Package)

In this step, you upload the deployment package using the AWS CLI and provide configuration information when you create the Lambda function using the `adminuser` profile.

For more information on setting up the `admin` profile and using the AWS CLI, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#).

**Note**

You need to update the command by providing the .zip file path (`//file-path/CloudTrailEventProcessing.zip`) and the execution role ARN (`execution-role-arn`).

If you used the sample code provided earlier in this tutorial, set the `--runtime` parameter value to `nodejs8.10` or `nodejs6.10`. The sample following uses `nodejs6.10`.

You can author your Lambda functions in Java or Python too. If you use another language, change the `--runtime` parameter value to `java8, python3.6` or `python2.7` as needed.

```
$ aws lambda create-function \
--region region \
--function-name CloudTrailEventProcessing \
--zip-file fileb://file-path/CloudTrailEventProcessing.zip \
--role execution-role-arn \
--handler CloudTrailEventProcessing.handler \
--runtime nodejs6.10 \
--profile adminuser \
--timeout 10 \
--memory-size 1024
```

Optionally, you can upload the .zip file to an Amazon S3 bucket in the same AWS region, and then specify the bucket and object name in the preceding command. You need to replace the `--zip-file` parameter by the `--code` parameter as shown:

```
--code S3Bucket=bucket-name,S3Key=zip-file-object-key
```

**Note**

You can create the Lambda function using the AWS Lambda console, in which case note the value of the `create-function` AWS CLI command parameters. You provide the same values in the console.

### Step 2.3.2: Test the Lambda Function (Invoke Manually)

In this section, you invoke the Lambda function manually using sample Amazon S3 event data. When the Lambda function executes, it reads the S3 object (a sample CloudTrail log) from the bucket identified in the S3 event data, and then it publishes an event to your SNS topic if the sample CloudTrail log reports use a specific API. For this tutorial, the API is the SNS API used to create a topic. That is, the CloudTrail log reports a record identifying `sns.amazonaws.com` as the `eventSource`, and `CreateTopic` as the `eventName`.

1. Save the following sample CloudTrail log to a file (`ExampleCloudTrailLog.json`).

**Note**

Note that one of events in this log has `sns.amazonaws.com` as the `eventSource` and `CreateTopic` as the `eventName`. Your Lambda function reads the logs and if it finds an event of this type, it publishes the event to the Amazon SNS topic that you created and then you receive one email when you invoke the Lambda function manually.

```
{  
  "Records": [  
    {  
      "eventVersion": "1.02",  
      "userIdentity": {  
        "type": "Root",  
        "principalId": "account-id",  
        "arn": "arn:aws:iam::account-id:root",  
        "accountId": "account-id",  
        "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-west-2",  
      "sourceIPAddress": "205.251.233.176",  
      "userAgent": "console.amazonaws.com",  
      "requestParameters": {  
        "name": "dropmeplease"  
      },  
      "responseElements": {  
        "topicArn": "arn:aws:sns:us-west-2:account-id:exampletopic"  
      },  
      "requestID": "3fdb7834-9079-557e-8ef2-350abc03536b",  
      "eventID": "17b46459-dada-4278-b8e2-5a4ca9ff1a9c",  
      "eventType": "AwsApiCall",  
      "recipientAccountId": "account-id"  
    },  
    {  
      "eventVersion": "1.02",  
      "userIdentity": {  
        "type": "Root",  
        "principalId": "account-id",  
        "arn": "arn:aws:iam::account-id:root",  
        "accountId": "account-id",  
        "accessKeyId": "access-key-id",  
        "sessionContext": {  
          "attributes": {  
            "mfaAuthenticated": "false",  
            "creationDate": "2015-01-24T22:41:54Z"  
          }  
        }  
      },  
      "eventTime": "2015-01-24T23:27:02Z",  
      "eventSource": "sns.amazonaws.com",  
      "eventName": "GetTopicAttributes",  
      "awsRegion": "us-west-2",  
      "sourceIPAddress": "205.251.233.176",  
      "userAgent": "console.amazonaws.com",  
      "requestParameters": {  
        "topicArn": "arn:aws:sns:us-west-2:account-id:exampletopic"  
      },  
    }  
  ]  
}
```

```
        "responseElements":null,
        "requestID":"4a0388f7-a0af-5df9-9587-c5c98c29cbec",
        "eventID":"ec5bb073-8fa1-4d45-b03c-f07b9fc9ea18",
        "eventType":"AwsApiCall",
        "recipientAccountId":"account-id"
    }
]
```

2. Run the `gzip` command to create a `.gz` file from the preceding source file.

```
$ gzip ExampleCloudTrailLog.json
```

This creates `ExampleCloudTrailLog.json.gz` file.

3. Upload the `ExampleCloudTrailLog.json.gz` file to the `examplebucket` that you specified in the CloudTrail configuration.

This object is specified in the sample Amazon S3 event data that we use to manually invoke the Lambda function.

4. Save the following JSON (an example S3 event) in a file, `input.txt`. Note the bucket name and the object key name values.

You provide this sample event when you invoke your Lambda function. For more information about the S3 event structure, see [Event Message Structure](#) in the *Amazon Simple Storage Service Developer Guide*.

```
{
    "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": "your bucket name",
                    "ownerIdentity": {
                        "principalId": "A3NL1KOZZKExample"
                    },
                    "arn": "arn:aws:s3:::mybucket"
                },
                "object": {
                    "key": "ExampleCloudTrailLog.json.gz",
                    "size": 1024,
                    "eTag": "d41d8cd98f00b204e9800998ecf8427e",
                    "versionId": "096fKKXTRTtl3on89fVO.nfljtsv6qko"
                }
            }
        }
}
```

```
        }
    ]
}
```

5. In the AWS Management Console, invoke the function manually using sample Amazon S3 event data. In the console, use the following sample Amazon S3 event data.

**Note**

We recommend that you invoke the function using the console because the console UI provides a user-friendly interface for reviewing the execution results, including the execution summary, logs written by your code, and the results returned by the function (because the console always performs synchronous execution—invokes the Lambda function using the `RequestResponse` invocation type).

```
{
  "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": "your bucket name",
          "ownerIdentity": {
            "principalId": "A3NL1KOZZKExample"
          },
          "arn": "arn:aws:s3:::mybucket"
        },
        "object": {
          "key": "ExampleCloudTrailLog.json.gz",
          "size": 1024,
          "eTag": "d41d8cd98f00b204e9800998ecf8427e",
          "versionId": "096fKKXTRTl3on89fVO.nfljtsv6qko"
        }
      }
    }
  ]
}
```

6. Execute the following AWS CLI command to invoke the function manually using the `adminuser` profile.

**Note**

If you have not already created this profile, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#).

```
$ aws lambda invoke-async \
--function-name CloudTrailEventProcessing \
```

```
--region region \
--invoke-args /filepath/input.txt \
--debug \
--profile adminuser
```

Because your example log object has an event record showing the SNS API to call to create a topic, the Lambda function posts that event to your SNS topic, and you should get an email notification.

You can monitor the activity of your Lambda function by using CloudWatch metrics and logs. For more information about CloudWatch monitoring, see [Using Amazon CloudWatch \(p. 314\)](#).

7. (Optional) Manually invoke the Lambda function using AWS CLI as follows:

- a. Save the JSON from Step 2 earlier in this procedure to a file called `input.txt`.
- b. Execute the following invoke command:

```
$ aws lambda invoke \
--invocation-type Event \
--function-name CloudTrailEventProcessing \
--region region \
--payload file:///file-path/input.txt \
--profile adminuser
outputfile.txt
```

#### Note

In this tutorial example, the message is saved in the `outputfile.txt` file. If you request synchronous execution (`RequestResponse` as the invocation type), the function returns the string message in the response body.

For Node.js, it could be one of the following (whatever one you specify in the code):

```
context.succeed("message")
context.fail("message")
context.done(null, "message")
```

For Python or Java, it is the message in the return statement:

```
return "message"
```

#### Next Step

[Step 3: Add Event Source \(Configure Amazon S3 to Publish Events\) \(p. 225\)](#)

## Step 3: Add Event Source (Configure Amazon S3 to Publish Events)

In this section, you add the remaining configuration so Amazon S3 can publish object-created events to AWS Lambda and invoke your Lambda function. You will do the following:

- Add permissions to the Lambda function's access policy to allow Amazon S3 to invoke the function.
- Add notification configuration to your source bucket. In the notification configuration, you provide the following:
  - Event type for which you want Amazon S3 to publish events. For this tutorial, you specify the `s3:ObjectCreated:*` event type.
  - Lambda function to invoke.

## Step 3.1: Add Permissions to the Lambda Function's Access Permissions Policy

1. Run the following Lambda CLI add-permission command to grant Amazon S3 service principal (`s3.amazonaws.com`) permissions to perform the `lambda:InvokeFunction` action. Note that permission is granted to Amazon S3 to invoke the function only if the following conditions are met:
  - An object-created event is detected on a specific bucket.
  - The bucket is owned by a specific AWS account. If a bucket owner deletes a bucket, some other AWS account can create a bucket with the same name. This condition ensures that only a specific AWS account can invoke your Lambda function.

**Note**

If you have not already created the `adminuser` profile, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#).

```
$ aws lambda add-permission \
--function-name CloudTrailEventProcessing \
--region region \
--statement-id Id-1 \
--action "lambda:InvokeFunction" \
--principal s3.amazonaws.com \
--source-arn arn:aws:s3:::examplebucket \
--source-account examplebucket-owner-account-id \
--profile adminuser
```

2. Verify the function's access policy by running the AWS CLI get-policy command.

```
$ aws lambda get-policy \
--function-name function-name \
--profile adminuser
```

## Step 3.2: Configure Notification on the Bucket

Add notification configuration on the `examplebucket` to request Amazon S3 to publish object-created events to Lambda. In the configuration, you specify the following:

- Event type – For this tutorial, these can be any event types that create objects.
- Lambda function ARN – This is your Lambda function that you want Amazon S3 to invoke. The ARN is of the following form:

```
arn:aws:lambda:aws-region:account-id:function:function-name
```

For example, the function `CloudTrailEventProcessing` created in us-west-2 region has the following ARN:

```
arn:aws:lambda:us-west-2:account-id:function:CloudTrailEventProcessing
```

For instructions on adding notification configuration to a bucket, see [Enabling Event Notifications](#) in the [Amazon Simple Storage Service Console User Guide](#).

## Step 3.3: Test the Setup

You're all done! Now you can test the setup as follows:

1. Perform some action in your AWS account. For example, add another topic in the Amazon SNS console.
2. You receive an email notification about this event.
3. AWS CloudTrail creates a log object in your bucket.
4. If you open the log object (.gz file), the log shows the `CreateTopic` SNS event.
5. For each object AWS CloudTrail creates, Amazon S3 invokes your Lambda function by passing in the log object as event data.
6. Lambda executes your function. The function parses the log, finds a `CreateTopic` SNS event, and then you receive an email notification.

You can monitor the activity of your Lambda function by using CloudWatch metrics and logs. For more information about CloudWatch monitoring, see [Using Amazon CloudWatch \(p. 314\)](#).

The screenshot shows the AWS CloudWatch Metrics and Logs interface. On the left, there's a sidebar with links like Dashboard, Alarms, Logs (which is selected and highlighted in orange), Metrics, Selected Metrics, DynamoDB, EBS, EC2, and ELB. The main area has a title bar "Log Groups > Streams for /aws/lambda/CloudTrailEvent..." with "Create Log Stream" and "Delete Log Stream" buttons. Below that is a table titled "Log Streams" with columns "Log Streams" and "Last Ingestion Time". The table lists several log stream names and their last ingestion times:

Log Streams	Last Ingestion Time
00478cb7889e4986bdeaccc248ae5b17	2014-12-18 06:49 UTC-8
03faa169843045c4b0228b2cca9688ab	2014-12-17 21:04 UTC-8
0a769e0aeb314968a5a97f3bea96c932	2014-12-18 12:34 UTC-8
163d530f1d7e431abd2eb0cf26276dd3	2014-12-18 17:39 UTC-8
17f694642e704654bf054dca9334383	2014-12-17 19:34 UTC-8
1b667a95ea84b7da4357009ab544040	2014-12-18 01:34 UTC-8
1b84b98a43ea42f78d59c735a8277905	2014-12-18 18:34 UTC-8

## Step 4: Deploy With AWS SAM and AWS CloudFormation

In the previous section, you used AWS Lambda APIs to create and update a Lambda function by providing a deployment package as a ZIP file. However, this mechanism may not be convenient for automating deployment steps for functions, or coordinating deployments and updates to other elements of a serverless application, like event sources and downstream resources.

You can use AWS CloudFormation to easily specify, deploy, and configure serverless applications. AWS CloudFormation is a service that helps you model and set up your Amazon Web Services resources so that you can spend less time managing those resources and more time focusing on your applications that run in AWS. You create a template that describes all the AWS resources that you want (like Lambda functions and DynamoDB tables), and AWS CloudFormation takes care of provisioning and configuring those resources for you.

In addition, you can use the AWS Serverless Application Model to express resources that comprise the serverless application. These resource types, such as Lambda functions and APIs, are fully supported by AWS CloudFormation and make it easier for you to define and deploy your serverless application.

For more information, see [Deploying Lambda-based Applications \(p. 277\)](#).

### Specification for Amazon API Gateway Application

The following contains the SAM template for this application. Copy the text below to a .yaml file and save it next to the ZIP package you created in the previous section. Note that the `Handler` and `Runtime` parameter values should match the ones you used when you created the function in the previous section.

```
AWSTemplateFormatVersion: '2010-09-09'  
Transform: AWS::Serverless-2016-10-31
```

```
Parameters:
  NotificationEmail:
    Type: String
Resources:
  CloudTrailEventProcessing:
    Type: AWS::Serverless::Function
    Properties:
      Handler: handler
      Runtime: runtime
      Timeout: 10
      MemorySize: 1024
    Policies:
      Statement:
        - Effect: Allow
          Action: s3:GetObject
          Resource: !Sub 'arn:aws:s3:::${Bucket}/*'
        - Effect: Allow
          Action: sns:Publish
          Resource: !Ref Topic
    Events:
      PhotoUpload:
        Type: S3
        Properties:
          Bucket: !Ref Bucket
          Events: s3:ObjectCreated:*
    Environment:
      Variables:
        SNS_TOPIC_ARN: !Ref Topic

  Bucket:
    Type: AWS::S3::Bucket

  Trail:
    Type: AWS::CloudTrail::Trail
    Properties:
      IsLogging: true
      S3BucketName: !Ref Bucket

  Topic:
    Type: AWS::SNS::Topic
    Properties:
      Subscription:
        - Protocol: email
          Endpoint: !Ref NotificationEmail
```

## Deploying the Serverless Application

For information on how to package and deploy your serverless application using the package and deploy commands, see [Packaging and Deployment \(p. 304\)](#).

# Using AWS Lambda with Amazon SNS from Different Accounts

In order to perform cross account Amazon SNS deliveries to Lambda, you need to authorize your Lambda function to be invoked from Amazon SNS. In turn, Amazon SNS needs to allow the Lambda account 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 console, you use the AWS CLI to set up the entire process.

For a tutorial that walks you through an example setup, see [Tutorial: Using AWS Lambda with Amazon SNS \(p. 229\)](#).

## Tutorial: Using AWS Lambda with Amazon SNS

In this tutorial, you create a Lambda function in one AWS account to subscribe to an Amazon SNS topic in a separate AWS account.

The tutorial is divided into three main sections:

- First, you perform the necessary setup to create a Lambda function.
- Second, you create an Amazon SNS topic in a separate AWS account.
- Third, you grant permissions from each account in order for the Lambda function to subscribe to the Amazon SNS topic. Then, you test the end-to-end setup.

### Important

This tutorial assumes that you create these resources in the `us-east-1` region.

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.

## Next Step

[Step 1: Prepare \(p. 229\)](#)

### Step 1: Prepare

- Sign up for an AWS account and create an administrator user in the account (called `adminuser`).
- Install and set up the AWS CLI.

For instructions, see [Set Up an AWS Account \(p. 4\)](#).

## Next Step

[Step 2: Create a Lambda Function \(p. 229\)](#)

### Step 2: Create a Lambda Function

In this section, you do the following:

- Create a Lambda function deployment package using the sample code provided. The sample Lambda function code that you'll use to subscribe to an Amazon SNS topic is provided in various languages. Select one of the languages and follow the corresponding instructions to create a deployment package.
- Create an IAM role (execution role). At the time you upload the deployment package, you need to specify an IAM role (execution role) that Lambda can assume to execute the function on your behalf.

### Topics

- [Step 2.1: Create a Lambda Function Deployment Package \(p. 230\)](#)
- [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 232\)](#)

## Step 2.1: Create a Lambda Function Deployment Package

From the **Filter View** list, choose the language you want to use for your Lambda function. The appropriate section appears with code and specific instructions for creating a deployment package.

### Node.js

1. Open a text editor, and then copy the following code.

```
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");
};
```

#### Note

The code sample is compliant with the Node.js runtimes v6.10 or v8.10. For more information, see [Programming Model\(Node.js\) \(p. 19\)](#)

2. Save the file as `index.js`.
3. Zip the `index.js` file as `LambdaWithSNS.zip`.

### Next Step

#### [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 232\)](#)

### Java

- Open a text editor, and then copy the following code.

```
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;
    }
}
```

Using the preceding code (in a file named `LambdaWithSNS.java`), create a deployment package. Make sure that you add the following dependencies:

- aws-lambda-java-core
- aws-lambda-java-events

For more information, see [Programming Model for Authoring Lambda Functions in Java \(p. 30\)](#).

Your deployment package can be a .zip file or a standalone .jar. You can use any build and packaging tool you are familiar with to create a deployment package. For examples of how to use the Maven build tool to create a standalone .jar, see [Creating a .jar Deployment Package Using Maven without any IDE \(Java\) \(p. 90\)](#) and [Creating a .jar Deployment Package Using Maven and Eclipse IDE \(Java\) \(p. 92\)](#). For an example of how to use the Gradle build tool to create a .zip file, see [Creating a .zip Deployment Package \(Java\) \(p. 94\)](#).

After you verify that your deployment package is created, go to the next step to create an IAM role (execution role). You specify this role at the time you create your Lambda function.

## Next Step

[Step 2.2: Create the Execution Role \(IAM Role\) \(p. 232\)](#)

### Go

1. Open a text editor, and then copy the following code.

```
import (
    "strings"
    "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)
    }
}
```

2. Save the file as `lambda_handler.go`.
3. Zip the `lambda_handler.go` file as `LambdaWithSNS.zip`.

## Next Step

[Step 2.2: Create the Execution Role \(IAM Role\) \(p. 232\)](#)

### Python

1. Open a text editor, and then copy the following code.

#### Note

The `from __future__` statement enables you to write code that is compatible with Python 2 or 3. If you are using runtime version 3.6, it is not necessary to include it.

```
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
```

2. Save the file as `lambda_handler.py`.
3. Zip the `lambda_handler.py` file as `LambdaWithSNS.zip`.

## Next Step

### Step 2.2: Create the Execution Role (IAM Role) (p. 232)

#### Step 2.2: Create the Execution Role (IAM Role)

In this section, you create an IAM role using the following predefined role type and access policy:

- AWS service role of the type **AWS Lambda** – This role grants AWS Lambda permissions to assume the role.
- **AWSLambdaBasicExecutionRole** – This is the access permissions policy that you attach to the role.

For more information about IAM roles, see [IAM Roles](#) in the *IAM User Guide*. Use the following procedure to create the IAM role.

#### To create an IAM role (execution role)

1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
2. Follow the steps in [Creating a Role to Delegate Permissions to an AWS Service](#) in the *IAM User Guide* to create an IAM role (execution role). As you follow the steps to create a role, note the following:
  - In **Role Name**, use a name that is unique within your AWS account (for example, `lambda-sns-execution-role`).
  - In **Select Role Type**, choose **AWS Service Roles**, and then choose **AWS Lambda**. This grants the AWS Lambda service permissions to assume the role.
  - In **Attach Policy**, choose **AWSLambdaBasicExecutionRole**. The permissions in this policy are sufficient for the Lambda function in this tutorial.
3. Write down the role ARN. You will need it in the next step when you create your Lambda function.

## Step 3: Set Up Cross-Account Permissions

In this section, you use CLI commands to set permissions across the Lambda function account and the Amazon SNS topic account and then test the subscription.

1. From account A, create the Amazon SNS topic:

```
aws sns create-topic \
  --name lambda-x-account
```

Note the topic arn that is returned by the command. You will need it when you add permissions to the Lambda function to subscribe to the topic.

2. From account B, create the Lambda function. For the runtime parameter, select either `nodejs8.10` or `nodejs6.10, python3.6, python2.7` or `java8`, depending on the code sample you selected when you created your deployment package.

```
aws lambda create-function \
  --function-name SNS-X-Account \
  --runtime runtime language \
```

```
--role role arn \
--handler handler-name \
--description "SNS X Account Test Function" \
--timeout 60 \
--memory-size 128 \
--zip-file fileb://path/LambdaWithSNS.zip
```

Note the function arn that is returned by the command. You will need it when you add permissions to allow Amazon SNS to invoke your function.

3. From account A add permission to account B to subscribe to the topic:

```
aws sns add-permission \
--region us-east-1 \
--topic-arn Amazon SNS topic arn \
--label lambda-access \
--aws-account-id B \
--action-name Subscribe ListSubscriptionsByTopic Receive
```

4. From account B add the Lambda permission to allow invocation from Amazon SNS:

```
aws lambda add-permission \
--function-name SNS-X-Account \
--statement-id sns-x-account \
--action "lambda:InvokeFunction" \
--principal sns.amazonaws.com \
--source-arn Amazon SNS topic arn
```

In response, Lambda returns the following JSON code. The Statement value is a JSON string version of the statement added to the Lambda function policy:

```
{
  "Statement": "{\"Condition\":{\"ArnLike\":{\"AWS:SourceArn\":\"arn:aws:lambda:us-east-1:B:function:SNS-X-Account\"}},\"Action\":[\"lambda:InvokeFunction\"],\"Resource\":\"arn:aws:lambda:us-east-1:A:function:SNS-X-Account\",\"Effect\":\"Allow\",\"Principal\":{\"Service\":\"sns.amazonaws.com\"},\"Sid\":\"sns-x-account1\"}"
}
```

#### Note

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. This has no security impact as the source account is included in the source ARN.

5. From account B subscribe the Lambda function to the topic:

```
aws sns subscribe \
--topic-arn Amazon SNS topic arn \
--protocol lambda \
--notification-endpoint arn:aws:lambda:us-east-1:B:function:SNS-X-Account
```

You should see JSON output similar to the following:

```
{
  "SubscriptionArn": "arn:aws:sns:us-east-1:A:lambda-x-account:5d906xxxx-7c8x-45dx-a9dx-0484e31c98xx"
}
```

6. From account A you can now test the subscription. Type "Hello World" into a text file and save it as message.txt. Then run the following command:

```
aws sns publish \
--topic-arn arn:aws:sns:us-east-1:A:lambda-x-account \
--message file://message.txt \
--subject Test
```

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.

**Note**

Alternatively, you could supply a JSON string directly to the `message` parameter, but using a text file allows for line breaks in the message.

For more information on Amazon SNS, see [What is Amazon Simple Notification Service?](#)

## Using AWS Lambda with Amazon API Gateway (On-Demand Over HTTPS)

You can invoke AWS Lambda functions over HTTPS. You can do this by defining a custom REST API and endpoint using [Amazon API Gateway](#), and then mapping individual methods, such as `GET` and `PUT`, to specific Lambda functions. Alternatively, you could add a special method named `ANY` to map all supported methods (`GET`, `POST`, `PATCH`, `DELETE`) to your Lambda function. When you send an HTTPS request to the API endpoint, the Amazon API Gateway service invokes the corresponding Lambda function. For more information about the `ANY` method, see [Create a Simple Microservice using Lambda and API Gateway \(p. 248\)](#).

Amazon API Gateway also adds a layer between your application users and your app logic that enables the following:

- Ability to throttle individual users or requests.
- Protect against Distributed Denial of Service attacks.
- Provide a caching layer to cache response from your Lambda function.

Note the following about how the Amazon API Gateway and AWS Lambda integration works:

- **Push-event model** – This is a model (see [Event Source Mapping \(p. 149\)](#)), where Amazon API Gateway invokes the Lambda function by passing data in the request body as parameter to the Lambda function.
- **Synchronous invocation** – The Amazon API Gateway can invoke the Lambda function and get a response back in real time by specifying `RequestResponse` as the invocation type. For information about invocation types, see [Invocation Types \(p. 148\)](#).
- **Event structure** – The event your Lambda function receives is the body from the HTTPS request that Amazon API Gateway receives and your Lambda function is the custom code written to process the specific event type.

Note that there are two types of permissions policies that you work with when you set up the end-to-end experience:

- **Permissions for your Lambda function** – Regardless of what invokes a Lambda function, AWS Lambda executes the function by assuming the IAM role (execution role) that you specify at the time you create the Lambda function. Using the permissions policy associated with this role, you grant your

Lambda function the permissions that it needs. For example, if your Lambda function needs to read an object, you grant permissions for the relevant Amazon S3 actions in the permissions policy. For more information, see [Manage Permissions: Using an IAM Role \(Execution Role\) \(p. 362\)](#).

- **Permission for Amazon API Gateway to invoke your Lambda function** – Amazon API Gateway cannot invoke your Lambda function without your permission. You grant this permission via the permission policy associated with the Lambda function.

For a tutorial that walks you through an example setup, see [Using AWS Lambda with Amazon API Gateway \(On-Demand Over HTTPS\) \(p. 235\)](#).

## Using AWS Lambda with Amazon API Gateway (On-Demand Over HTTPS)

In this example you create a simple API (`DynamoDBOperations`) using Amazon API Gateway. An Amazon API Gateway is a collection of resources and methods. For this tutorial, you create one resource (`DynamoDBManager`) and define one method (`POST`) on it. The method is backed by a Lambda function (`LambdaFunctionOverHttps`). That is, when you invoke the method through an HTTPS endpoint, Amazon API Gateway invokes the Lambda function.

The `POST` method on the `DynamoDBManager` resource supports the following 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.

The request payload you send in the `POST` request identifies the DynamoDB operation and provides necessary data. For example:

- The following is a sample request payload for a DynamoDB create item operation:

```
{  
    "operation": "create",  
    "tableName": "LambdaTable",  
    "payload": {  
        "Item": {  
            "Id": "1",  
            "name": "Bob"  
        }  
    }  
}
```

- The following is a sample request payload for a DynamoDB read item operation:

```
{  
    "operation": "read",  
    "tableName": "LambdaTable",  
    "payload": {  
        "Key": {  
            "Id": "1"  
        }  
    }  
}
```

- The following is a sample request payload for an echo operation. You send an HTTPS POST request to the endpoint, using the following data in the request body.

```
{  
  "operation": "echo",  
  "payload": {  
    "somekey1": "somevalue1",  
    "somekey2": "somevalue2"  
  }  
}
```

You can also create and manage API endpoints from the AWS Lambda console. For example, search for the **microservice** in the blueprints. This tutorial does not use the console, instead it uses AWS CLI to provide you with more details of how the API works.

**Note**

API Gateway offers advanced capabilities, such as:

- **Pass through the entire request** – A Lambda function can receive the entire HTTP request (instead of just the request body) and set the HTTP response (instead of just the response body) using the `AWS_PROXY` integration type.
- **Catch-all methods** – Map all methods of an API resource to a single Lambda function with a single mapping, using the `ANY` catch-all method.
- **Catch-all resources** – Map all sub-paths of a resource to a Lambda function without any additional configuration using the new path parameter (`{proxy+}`).

To learn more about these API Gateway features, see [Configure Proxy Integration for a Proxy Resource](#).

## Next Step

[Step 1: Prepare \(p. 236\)](#)

## Step 1: Prepare

Make sure you have completed the following steps:

- Signed up for an AWS account and created an administrator user in the account (called **adminuser**). For instructions, see [Set Up an AWS Account \(p. 4\)](#).
- Installed and set up the AWS CLI. For instructions, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#).

## Next Step

[Step 2: Create a Lambda Function and Test It Manually \(p. 236\)](#)

## Step 2: Create a Lambda Function and Test It Manually

In this section, you do the following:

- Create a Lambda function deployment package using the sample code provided.
- Create an IAM role (execution role). At the time you upload the deployment package, you need to specify an IAM role (execution role) that Lambda can assume to execute the function on your behalf.
- Create the Lambda function and then test it manually.

## Topics

- [Step 2.1: Create a Deployment Package \(p. 237\)](#)
- [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 239\)](#)
- [Step 2.3: Create the Lambda Function and Test It Manually \(p. 240\)](#)

## Step 2.1: Create a Deployment Package

From the **Filter View** list, choose the language you want to use for your Lambda function. The appropriate section appears with code and specific instructions for creating a deployment package.

### Node.js

Follow the instructions to create an AWS Lambda function deployment package.

1. Open a text editor, and then copy the following code.

```
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}');
    }
}
```

```
};
```

**Note**

The code sample is compliant with the Node.js runtimes v6.10 or v4.3. For more information, see [Programming Model\(Node.js\) \(p. 19\)](#)

2. Save the file as `LambdaFunctionOverHttps.js`.
3. Zip the `LambdaFunctionOverHttps.js` file as `LambdaFunctionOverHttps.zip`.

## Next Step

### [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 239\)](#)

#### Python

Follow the instructions to create an AWS Lambda function deployment package.

1. Open a text editor, and then copy the following code.

**Note**

The `from __future__ import print_function` statement enables you to write code that is compatible with Python 2 or 3. If you are using runtime version 3.6, it is not necessary to include it.

```
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))
```

2. Save the file as `LambdaFunctionOverHttps.py`.
3. Zip the `LambdaFunctionOverHttps.py` file as `LambdaFunctionOverHttps.zip`.

## Next Step

### [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 239\)](#)

#### Go

Follow the instructions to create an AWS Lambda function deployment package.

1. Open a text editor, and then copy the following code.

```
import (
    "strings"
    "github.com/aws/aws-lambda-go/events"
)

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
}
```

2. Save the file as `LambdaFunctionOverHttps.go`.
3. Zip the `LambdaFunctionOverHttps.go` file as `LambdaFunctionOverHttps.zip`.

## Next Step

### [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 239\)](#)

## Step 2.2: Create the Execution Role (IAM Role)

In this section, you create an IAM role using the following predefined role type:

- AWS service role of the type **AWS Lambda** – This role grants AWS Lambda permissions to assume the role.

For more information about IAM roles, see [IAM Roles](#) in the *IAM User Guide*. Use the following procedure to create the IAM role.

### To create an IAM role (execution role)

1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
2. Follow the steps in [Creating a Role to Delegate Permissions to an AWS Service](#) in the *IAM User Guide* to create an IAM role (execution role). As you follow the steps to create a role, note the following:
  - In **Role Name**, use a name that is unique within your AWS account (for example, **lambda-gateway-execution-role**).
  - In **Select Role Type**, choose **AWS Service Roles**, and then choose **AWS Lambda**. This grants the AWS Lambda service permissions to assume the role.

- You create an IAM role without attaching a permissions policy in the console. After you create the role, you update the role, and then attach the following permissions policy to the role.

```
{  
    "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"  
        }  
    ]  
}
```

3. Write down the role ARN (Amazon Resource Name). You need it in the next step when you create your Lambda function.

## Next Step

[Step 2.3: Create the Lambda Function and Test It Manually \(p. 240\)](#)

### Step 2.3: Create the Lambda Function and Test It Manually

In this section, you do the following:

- Create a Lambda function by uploading the deployment package.
- Test the Lambda function by invoking it manually and passing sample event data.

#### [Step 2.3.1: Create a Lambda Function \(Upload the Deployment Package\)](#)

In this step, you upload the deployment package using the AWS CLI.

At the command prompt, run the following Lambda CLI `create-function` command using the **admininuser** profile.

You need to update the command by providing the .zip file path and the execution role ARN. The `--runtime` parameter value can be `python3.6`, `python2.7`, `nodejs8.10` or `nodejs6.10`, or `java8`, depending on the language you used to author your code.

```
$ aws lambda create-function \
```

```
--region region \
--function-name LambdaFunctionOverHttps \
--zip-file fileb://file-path/LambdaFunctionOverHttps.zip \
--role execution-role-arn \
--handler LambdaFunctionOverHttps.handler \
--runtime runtime-value \
--profile adminuser
```

Optionally, you can upload the .zip file to an Amazon S3 bucket in the same AWS region, and then specify the bucket and object name in the preceding command. You need to replace the --zip-file parameter by the --code parameter, as shown following:

```
--code S3Bucket=bucket-name,S3Key=zip-file-object-key
```

**Note**

You can create the Lambda function using the AWS Lambda console, in which case note the value of the `create-function` AWS CLI command parameters. You provide the same values in the console UI.

### Step 2.3.2: Test the Lambda Function (Invoke Manually)

Invoke the function manually using the sample event data. We recommend that you invoke the function using the console because the console UI provides a user-friendly interface for reviewing the execution results, including the execution summary, logs written by your code, and the results returned by the function (because the console always performs synchronous execution—invokes the Lambda function using the `RequestResponse` invocation type).

#### To test the Lambda function (AWS Management Console)

- Follow the steps in the Getting Started exercise to create and invoke the Lambda function at [Invoke the Lambda Function Manually and Verify Results, Logs, and Metrics \(p. 11\)](#). For the sample event for testing, choose **Hello World** in **Sample event template**, and then replace the data using the following:

```
{
    "operation": "echo",
    "payload": {
        "somekey1": "somevalue1",
        "somekey2": "somevalue2"
    }
}
```

- To test one of the dynamo operations, such as `read`, change the input data to the following:

```
{
    "operation": "read",
    "tableName": "the name of your stream table",
    "payload": {
        "Key": {
            "the primary key of the table": "the value of the key"
        }
    }
}
```

- Verify the results in the console.

#### To test the Lambda function (AWS CLI)

- Copy the following JSON into a file and save it as `input.txt`.

```
{  
    "operation": "echo",  
    "payload": {  
        "somekey1": "somevalue1",  
        "somekey2": "somevalue2"  
    }  
}
```

2. Execute the following `invoke` command:

```
$ aws lambda invoke \  
--invocation-type Event \  
--function-name LambdaFunctionOverHttps \  
--region region \  
--payload fileb://file-path/input.txt \  
--profile adminuser \  
outputfile.txt
```

**Note**

In this tutorial example, the message is saved in the `outputfile.txt` file if you request synchronous execution (`RequestResponse` as the invocation type). The function returns the string message in the response body. If you use the `Event` invocation type, no message is returned to the output file. In either case, the `outputfile.txt` parameter is required.

## Next Step

[Step 3: Create an API Using Amazon API Gateway and Test It \(p. 242\)](#)

## Step 3: Create an API Using Amazon API Gateway and Test It

In this step, you associate your Lambda function with a method in the API that you created using Amazon API Gateway and test the end-to-end experience. That is, when an HTTPS request is sent to an API method, Amazon API Gateway invokes your Lambda function.

First, you create an API (`DynamoDBOperations`) using Amazon API Gateway with one resource (`DynamoDBManager`) and one method (`POST`). You associate the `POST` method with your Lambda function. Then, you test the end-to-end experience.

### Step 3.1: Create the API

Run the following `create-rest-api` command to create the `DynamoDBOperations` API for this tutorial.

```
$ aws apigateway create-rest-api \  
--name DynamoDBOperations \  
--region region \  
--profile profile
```

The following is an example response:

```
{  
    "name": "DynamoDBOperations",  
    "id": "api-id",  
    "createdDate": 1447724091
```

```
}
```

Note the API ID.

You also need the ID of the API root resource. To get the ID, run the `get-resources` command.

```
$ aws apigateway get-resources \
--rest-api-id api-id
```

The following is example response (at this time you only have the root resource, but you add more resources in the next step):

```
{
  "items": [
    {
      "path": "/",
      "id": "root-id"
    }
  ]
}
```

### Step 3.2: Create a Resource (DynamoDBManager) in the API

Run the following `create-resource` command to create a resource (DynamoDBManager) in the API that you created in the preceding section.

```
$ aws apigateway create-resource \
--rest-api-id api-id \
--parent-id root-id \
--path-part DynamoDBManager
```

The following is an example response:

```
{
  "path": "/DynamoDBManager",
  "pathPart": "DynamoDBManager",
  "id": "resource-id",
  "parentId": "root-id"
}
```

Note the ID in the response. This is the ID of the resource (DynamoDBManager) that you created.

### Step 3.3: Create Method (POST) on the Resource

Run the following `put-method` command to create a method (POST) on the resource (DynamoDBManager) in your API (DynamoDBOperations).

```
$ aws apigateway put-method \
--rest-api-id api-id \
--resource-id resource-id \
--http-method POST \
--authorization-type NONE
```

We specify NONE for the --authorization-type parameter, which means that unauthenticated requests for this method are supported. This is fine for testing but in production you should use either the key-based or role-base authentication.

The following is an example response:

```
{  
    "apiKeyRequired": false,  
    "httpMethod": "POST",  
    "authorizationType": "NONE"  
}
```

### Step 3.4: Set the Lambda Function as the Destination for the POST Method

Run the following command to set the Lambda function as the integration point for the `POST` method (this is the method Amazon API Gateway invokes when you make an HTTPS request for the `POST` method endpoint).

```
$ aws apigateway put-integration \  
--rest-api-id api-id \  
--resource-id resource-id \  
--http-method POST \  
--type AWS \  
--integration-http-method POST \  
--uri arn:aws:apigateway:aws-region:lambda:path/2015-03-31/functions/arn:aws:lambda:aws-region:aws-acct-id:function:LambdaFunctionOverHttps/invocations
```

#### Note

- `--rest-api-id` is the ID of the API (`DynamoDBOperations`) that you created in Amazon API Gateway.
- `--resource-id` is the resource ID of the resource (`DynamoDBManager`) you created in the API
- `--http-method` is the API Gateway method and `--integration-http-method` is the method that API Gateway uses to communicate with AWS Lambda.
- `--uri` is unique identifier for the endpoint to which Amazon API Gateway can send request.

The following is an example response:

```
{  
    "httpMethod": "POST",  
    "type": "AWS",  
    "uri": "arn:aws:apigateway:region:lambda:path/2015-03-31/functions/  
arn:aws:lambda:region:aws-acct-id:function:LambdaFunctionOverHttps/invocations",  
    "cacheNamespace": "resource-id"  
}
```

Set `content-type` of the `POST` method response and integration response to JSON as follows:

- Run the following command to set the `POST` method response to JSON. This is the response type that your API method returns.

```
$ aws apigateway put-method-response \  
--rest-api-id api-id \  
--resource-id resource-id \  
--http-method POST \  
--status-code 200 \  
--response-models "{\"application/json\": \"Empty\"}"
```

- Run the following command to set the `POST` method integration response to JSON. This is the response type that Lambda function returns.

```
$ aws apigateway put-integration-response \
--rest-api-id api-id \
--resource-id resource-id \
--http-method POST \
--status-code 200 \
--response-templates "{\"application/json\": \"\"}"
```

## Step 3.5: Deploy the API

In this step, you deploy the API that you created to a stage called `prod`.

```
$ aws apigateway create-deployment \
--rest-api-id api-id \
--stage-name prod
```

The following is an example response:

```
{  
    "id": "deployment-id",  
    "createdDate": 1447726017  
}
```

## Step 3.6: Grant Permissions that Allows Amazon API Gateway to Invoke the Lambda Function

Now that you have an API created using Amazon API Gateway and you've deployed it, you can test. First, you need to add permissions so that Amazon API Gateway can invoke your Lambda function when you send HTTPS request to the `POST` method.

To do this, you need to add a permissions to the permissions policy associated with your Lambda function. Run the following `add-permission` AWS Lambda command to grant the Amazon API Gateway service principal (`apigateway.amazonaws.com`) permissions to invoke your Lambda function (`LambdaFunctionOverHttps`).

```
$ aws lambda add-permission \
--function-name LambdaFunctionOverHttps \
--statement-id apigateway-test-2 \
--action lambda:InvokeFunction \
--principal apigateway.amazonaws.com \
--source-arn "arn:aws:execute-api:region:aws-acct-id:api-id/*/POST/DynamoDBManager"
```

You must grant this permission to enable testing (if you go to the Amazon API Gateway and choose **Test** to test the API method, you need this permission). Note the `--source-arn` specifies a wildcard character (\*) as the stage value (indicates testing only). This allows you to test without deploying the API.

Now, run the same command again, but this time you grant to your deployed API permissions to invoke the Lambda function.

```
$ aws lambda add-permission \
--function-name LambdaFunctionOverHttps \
--statement-id apigateway-prod-2 \
--action lambda:InvokeFunction \
--principal apigateway.amazonaws.com \
--source-arn "arn:aws:execute-api:region:aws-acct-id:api-id/prod/POST/DynamoDBManager"
```

You grant this permission so that your deployed API has permissions to invoke the Lambda function. Note that the --source-arn specifies a `prod` which is the stage name we used when deploying the API.

### Step 3.7: Test Sending a HTTPS Request

In this step, you are ready to send a HTTPS request to the `POST` method endpoint. You can use either Curl or a method (`test-invoke-method`) provided by Amazon API Gateway.

If you want to test operations that your Lambda function supports on a DynamoDB table, first you need to create a table in Amazon DynamoDB `LambdaTable` (`Id`), where `Id` is the hash key of string type.

If you are testing the `echo` and `ping` operations that your Lambda function supports, you don't need to create the DynamoDB table.

You can use Amazon API Gateway CLI commands to send an HTTPS `POST` request to the resource (`DynamoDBManager`) endpoint. Because you deployed your Amazon API Gateway, you can use Curl to invoke the methods for the same operation.

The Lambda function supports using the `create` operation to create an item in your DynamoDB table. To request this operation, use the following JSON:

```
{  
    "operation": "create",  
    "tableName": "LambdaTable",  
    "payload": {  
        "Item": {  
            "Id": "foo",  
            "number": 5  
        }  
    }  
}
```

Run the `test-invoke-method` Amazon API Gateway command to send an HTTPS `POST` method request to the resource (`DynamoDBManager`) endpoint with the preceding JSON in the request body.

```
$ aws apigateway test-invoke-method \  
--rest-api-id api-id \  
--resource-id resource-id \  
--http-method POST \  
--path-with-query-string "" \  
--body "{\"operation\":\"create\",\"tableName\":\"LambdaTable\",\"payload\":{\"Item\":{\"Id\":\"1\",\"name\":\"Bob\"}}}"
```

Or, you can use the following Curl command:

```
curl -X POST -d "{\"operation\":\"create\",\"tableName\":\"LambdaTable\",\"payload\":{\"Item\":{\"Id\":\"1\",\"name\":\"Bob\"}}}" https://api-id.execute-api.aws-region.amazonaws.com/prod/DynamoDBManager
```

To send request for the `echo` operation that your Lambda function supports, you can use the following request payload:

```
{  
    "operation": "echo",  
    "payload": {  
        "somekey1": "somevalue1",  
        "somekey2": "somevalue2"
```

```
}
```

Run the `test-invoke-method` Amazon API Gateway CLI command to send an HTTPS POST method request to the resource (`DynamoDBManager`) endpoint using the preceding JSON in the request body.

```
$ aws apigateway test-invoke-method \
--rest-api-id api-id \
--resource-id resource-id \
--http-method POST \
--path-with-query-string "" \
--body "{\"operation\":\"echo\", \"payload\":{\"somekey1\":\"somevalue1\", \"somekey2\":\
\"somevalue2\"}}"
```

Or, you can use the following Curl command:

```
curl -X POST -d "{\"operation\":\"echo\", \"payload\":{\"somekey1\":\"somevalue1\", \
\"somekey2\":\"somevalue2\"}}" https://api-id.execute-api.region.amazonaws.com/prod/ \
DynamoDBManager
```

## Step 4: Deploy With AWS SAM and AWS CloudFormation

In the previous section, you used AWS Lambda APIs to create and update a Lambda function by providing a deployment package as a ZIP file. However, this mechanism may not be convenient for automating deployment steps for functions, or coordinating deployments and updates to other elements of a serverless application, like event sources and downstream resources.

You can use AWS CloudFormation to easily specify, deploy, and configure serverless applications. AWS CloudFormation is a service that helps you model and set up your Amazon Web Services resources so that you can spend less time managing those resources and more time focusing on your applications that run in AWS. You create a template that describes all the AWS resources that you want (like Lambda functions and DynamoDB tables), and AWS CloudFormation takes care of provisioning and configuring those resources for you.

In addition, you can use the AWS Serverless Application Model to express resources that comprise the serverless application. These resource types, such as Lambda functions and APIs, are fully supported by AWS CloudFormation and make it easier for you to define and deploy your serverless application.

For more information, see [Deploying Lambda-based Applications \(p. 277\)](#).

### Specification for Amazon API Gateway Application

The following contains the SAM template for this application. 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.

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Resources:
  LambdaFunctionOverHttps:
    Type: AWS::Serverless::Function
    Properties:
      Handler: handler
      Runtime: runtime
      Policies: AmazonDynamoDBFullAccess
      Events:
        HttpPost:
```

```
Type: Api
Properties:
  Path: '/DynamoDBOperations/DynamoDBManager'
  Method: post
```

## Deploying the Serverless Application

For information on how to package and deploy your serverless application using the package and deploy commands, see [Packaging and Deployment \(p. 304\)](#).

## Create a Simple Microservice using Lambda and API Gateway

In this exercise you will use the Lambda console to create a Lambda function (`MyLambdaMicroservice`), 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

## Next Step

[Step 3.1: Create an API Using Amazon API Gateway \(p. 248\)](#)

### Step 3.1: 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:

1. Sign in to the AWS Management Console and open the AWS Lambda console.
2. Choose **Create Lambda function**.
3. On the **Select blueprint** page, choose the **microservice-http-endpoint** blueprint. You can use the **Filter** to find it.
4. The **Configure triggers** page will be populated with an API Gateway trigger. The default API name that will be created is `LambdaMicroservice` (You can change this name via the **API Name** field if you wish).

#### Note

When you complete the wizard and create your function, Lambda automatically creates a proxy resource named `MyLambdaMicroservice` (your function name) 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.

After reviewing your trigger, choose **Next**.

5. On the **Configure function** page, do the following:

- a. Review the preconfigured Lambda function configuration information, including:
  - **Runtime** is Node.js 6.10
  - Code authored in JavaScript is provided. The code performs DynamoDB operations based on the method called and payload provided.
  - **Handler** shows index.handler. The format is: filename.handler-function
- b. Enter the function name **MyLambdaMicroservice** in **Name**.
- c. In **Role**, enter a role name for the new role that will be created.

**Note**

The **microservice-http-endpoint** blueprint pre-populates the Simple Microservice permission policy template in the **Policy templates** field, to be added to your new role upon creation. This automatically adds the requisite permissions attached to that policy to your new role. For more information, see [Policy Templates \(p. 366\)](#).

6. Choose **Create function**.

## Next Step

[Step 3.2: Test Sending an HTTPS Request \(p. 249\)](#)

## Step 3.2: Test Sending an HTTPS 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 HTTPS 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 [Step 3.1: Create a DynamoDB Table with a Stream Enabled \(p. 211\)](#)

1. With your **MyLambdaMicroService** function still open in the console, choose the **Actions** tab and then choose **Configure test event**.
2. Replace the existing text with the following:

```
{  
  "httpMethod": "GET",  
  "queryStringParameters": {  
    "TableName": "MyTable"  
  }  
}
```

3. After entering the text above choose **Save and test**.

## Using AWS Lambda as Mobile Application Backend (Custom Event Source: Android)

You can use AWS Lambda to host backend logic for mobile applications. That is, some of your mobile app code can be run as Lambda functions. This allows you to put minimal logic in the mobile application itself making it easy to scale and update (for example, you only apply code updates to the Lambda function, instead of having to deploy code updates in your app clients).

After you create the Lambda function, you can invoke it from your mobile app using AWS Mobile SDKs, such as the AWS SDK for Android. For more information, see [Tools for Amazon Web Services](#).

### Note

You can also invoke your Lambda function over HTTP using Amazon API Gateway (instead of using any of the AWS SDKs). Amazon API Gateway adds an additional layer between your mobile users and your app logic that enable the following:

- Ability to throttle individual users or requests.
- Protect against Distributed Denial of Service attacks.
- Provide a caching layer to cache response from your Lambda function.

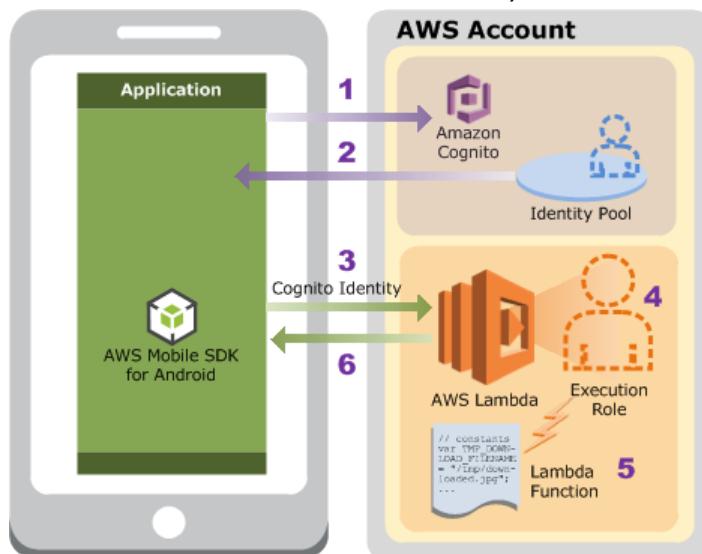
Note the following about how the mobile application and AWS Lambda integration works:

- **Push-event model** – This is a model (see [Event Source Mapping \(p. 149\)](#)), where the app invokes the Lambda function by passing the event data as parameter.
- **Synchronous or asynchronous invocation** – The app can invoke the Lambda function and get a response back in real time by specifying RequestResponse as the invocation type (or use the Event invocation type for asynchronous invocation). For information about invocation types, see [Manage Permissions: Using a Lambda Function Policy \(p. 363\)](#).
- **Event structure** – The event your Lambda function receives is defined by your application, and your Lambda function is the custom code written to process the specific event type.

Note that there are two types of permissions policies that you work with in setting the end-to-end experience:

- **Permissions for your Lambda function** – Regardless of what invokes a Lambda function, AWS Lambda executes the function by assuming the IAM role (execution role) that you specify at the time you create the Lambda function. Using the permissions policy associated with this role, you grant your Lambda function the permissions that it needs. For example, if your Lambda function needs to read an object, you grant permissions for the relevant Amazon S3 actions in the permissions policy. For more information, see [Manage Permissions: Using an IAM Role \(Execution Role\) \(p. 362\)](#).
- **Permissions for the mobile app to invoke your Lambda function** – The application must have valid security credentials and permissions to invoke a Lambda function. For mobile applications, you can use the Amazon Cognito service to manage user identities, authentication, and permissions.

The following diagram illustrates the application flow (the illustration assumes a mobile app using AWS Mobile SDK for Android to make the API calls):



1. The mobile application sends a request to Amazon Cognito with an identity pool ID in the request (you create the identity pool as part the setup).
2. Amazon Cognito returns temporary security credentials back to the application.

Amazon Cognito assumes the role associated with the identity pool to generate temporary credentials. What the application can do using the credentials is limited to the permissions defined in the permissions policy associated with the role Amazon Cognito used in obtaining the temporary credential.

**Note**

The AWS SDK can cache the temporary credentials so that the application does not send a request to Amazon Cognito each time it needs to invoke a Lambda function.

3. The mobile application invokes the Lambda function using temporary credentials (Cognito Identity).
4. AWS Lambda assumes the execution role to execute your Lambda function on your behalf.
5. The Lambda function executes.
6. AWS Lambda returns results to the mobile application, assuming the app invoked the Lambda function using the RequestResponse invocation type (synchronous invocation).

For a tutorial that walks you through an example setup, see [Tutorial: Using AWS Lambda as Mobile Application Backend \(p. 251\)](#).

## Tutorial: Using AWS Lambda as Mobile Application Backend

In this tutorial, you create a simple Android mobile application. The primary purpose of this tutorial is to show you how to hook up various components to enable an Android mobile application to invoke a Lambda function and process response. The app itself is simple, we will assume following:

- The sample mobile application will generate event data consisting of a name (first name and last name) in this format:

```
{ firstName: 'value1', lastName: 'value2' }
```

- You use Lambda function to process the event. That is, the app (using the AWS Mobile SDK for Android) invokes a Lambda function (`ExampleAndroidEventProcessor`) by passing the event data to it. The Lambda function in this tutorial does the following:
  - Logs incoming event data to Amazon CloudWatch Logs.
  - Upon successful execution, returns a simple string in the response body. Your mobile app displays the message using the Android `Toast` class.

**Note**

The way that the mobile application invokes a Lambda function as shown in this tutorial is an example of the AWS Lambda request-response model in which an application invokes a Lambda function and then receives a response in real time. For more information, see [Programming Model \(p. 18\)](#).

## Implementation Summary

The tutorial is divided into two main sections:

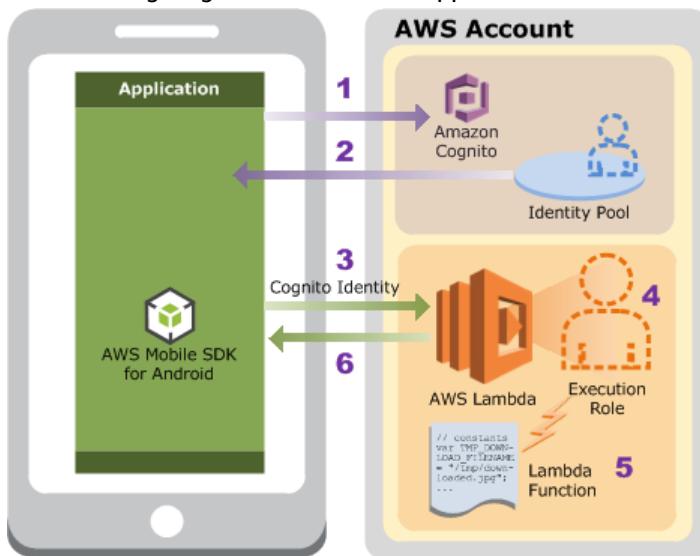
- First, you perform the necessary setup to create a Lambda function and test it by invoking it manually using sample event data (you don't need mobile app to test your Lambda function).

- Second, you create an Amazon Cognito identity pool to manage authentication and permissions, and create the example Android application. Then, you run the application and it invokes the Lambda function. You can then verify the end-to-end experience. In this tutorial example:
  - You use the Amazon Cognito service to manage user identities, authentication, and permissions. The mobile application must have valid security credentials and permissions to invoke a Lambda function. As part of the application setup, you create an Amazon Cognito identity pool to store user identities and define permissions. For more information, see [Amazon Cognito](#)
  - This mobile application does not require its users to log in. A mobile application can require its users to log in using public identity providers such as Amazon and Facebook. The scope of this tutorial is limited and assumes that the mobile application users are unauthenticated. Therefore, when you configure Amazon Cognito identity pool you will do the following:
    - Enable access for unauthenticated identities.

Amazon Cognito provides a unique identifier and temporary AWS credentials for these users to invoke the Lambda function.

- In the access permissions policy associated with the IAM role for unauthenticated users, add permissions to invoke the Lambda function. An identity pool has two associated IAM roles, one for authenticated and one for unauthenticated application users. In this example, Amazon Cognito assumes the role for unauthenticated users to obtain temporary credentials. When the app uses these temporary credentials to invoke your Lambda function, it can do so only if has necessary permissions (that is, credentials may be valid, but you also need permissions). You do this by updating the permissions policy that Amazon Cognito uses to obtain the temporary credentials.

The following diagram illustrates the application flow:



Now you are ready to start the tutorial.

## Next Step

[Step 1: Prepare \(p. 252\)](#)

### Step 1: Prepare

Make sure you have completed the following steps:

- Signed up for an AWS account and created an administrator user in the account (called **adminuser**). For instructions, see [Set Up an AWS Account \(p. 4\)](#)

- Installed and set up the AWS CLI. For instructions, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#)

**Note**

The tutorial creates a Lambda function and an Amazon Cognito identity pool in the `us-east-1` region. If you want to use a different AWS region, you must create these resources in the same region. You also need to update the example mobile application code by providing the specific region that you want to use.

## Next Step

[Step 2: Create the Lambda Function and Invoke It Manually \(Using Sample Event Data\) \(p. 253\)](#)

# Step 2: Create the Lambda Function and Invoke It Manually (Using Sample Event Data)

In this section, you do the following:

- Create a Lambda function deployment package using the sample code provided. The sample Lambda function code to process your mobile application events is provided in various languages. Select one of the languages and follow the corresponding instructions to create a deployment package.

**Note**

To see more examples of using other AWS services within your function, including calling other Lambda functions, see [AWS SDK for JavaScript](#)

- Create an IAM role (execution role). At the time you upload the deployment package, you need to specify an IAM role (execution role). This is the role that AWS Lambda assumes to invoke your Lambda function on your behalf.
- Create the Lambda function by uploading the deployment package, and then test it by invoking it manually using sample event data.

### Topics

- [Step 2.1: Create a Deployment Package \(p. 253\)](#)
- [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 255\)](#)
- [Step 2.3: Create the Lambda Function and Invoke It Manually \(Using Sample Event Data\) \(p. 256\)](#)

## Step 2.1: Create a Deployment Package

From the **Filter View** list, choose the language you want to use for your Lambda function. The appropriate section appears with code and specific instructions for creating a deployment package.

### Node.js

Follow the instructions to create an AWS Lambda function deployment package.

1. Open a text editor, and then copy the following code.

```
exports.handler = function(event, context, callback) {
    console.log("Received event: ", event);
    var data = {
        "greetings": "Hello, " + event.firstName + " " + event.lastName + "."
    };
    callback(null, data);
}
```

**Note**

The code sample is compliant with the Node.js runtimes v6.10 or v8.10. For more information, see [Programming Model\(Node.js\) \(p. 19\)](#)

2. Save the file as `AndroidBackendLambdaFunction.js`.
3. Zip the `AndroidBackendLambdaFunction.js` file as `AndroidBackendLambdaFunction.zip`.

**Next Step**

[Step 2.2: Create the Execution Role \(IAM Role\) \(p. 255\)](#)

**Java**

Use the following Java code to create your Lambda function (`AndroidBackendLambdaFunction`). The code receives Android app event data as the first parameter to the handler. Then, the code processes event data (for illustration this code writes some of the event data to CloudWatch Logs and returns a string in 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.

**Important**

You use the same classes (POJOs) to handle the input and output data when you create the sample mobile application in the next section.

```
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);
}
}
```

Save the preceding code in a file (`HelloPojo.java`). Create a deployment package. You need to include the following dependency:

- `aws-lambda-java-core`

Your deployment package can be a .zip file or a standalone .jar. You can use any build and packaging tool you are familiar with to create a deployment package. For examples of how to use the Maven build tool to create a standalone .jar, see [Creating a .jar Deployment Package Using Maven without any IDE \(Java\) \(p. 90\)](#) and [Creating a .jar Deployment Package Using Maven and Eclipse IDE \(Java\) \(p. 92\)](#). For an example of how to use the Gradle build tool to create a .zip file, see [Creating a .zip Deployment Package \(Java\) \(p. 94\)](#).

After you verify that your deployment package (`lambda-java-example-1.0-SNAPSHOT.jar`) is created, go to the next section to create an IAM role (execution role). You specify the role when you create your Lambda function.

## Next Step

[Step 2.2: Create the Execution Role \(IAM Role\) \(p. 255\)](#)

### Step 2.2: Create the Execution Role (IAM Role)

In this section, you create an IAM role using the following predefined role type and access policy:

- AWS service role of the type **AWS Lambda** – This role grants AWS Lambda permissions to assume the role.
- **AWSLambdaBasicExecute** – This is the access permissions policy that you attach to the role. This Lambda function only writes logs to CloudWatch Logs. So it only needs permission for specific CloudWatch actions. This policy provides these permissions.

For more information about IAM roles, see [IAM Roles](#) in the *IAM User Guide*. Use the following procedure to create the IAM role.

### To create an IAM role (execution role)

1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
2. Follow the steps in [Creating a Role to Delegate Permissions to an AWS Service](#) in the *IAM User Guide* to create an IAM role (execution role). As you follow the steps to create a role, note the following:
  - In **Role Name**, use a name that is unique within your AWS account (for example, **lambda-android-execution-role**).
  - In **Select Role Type**, choose **AWS Service Roles**, and then choose **AWS Lambda**. This grants the AWS Lambda service permissions to assume the role.
  - In **Attach Policy**, choose **AWSLambdaBasicExecute**. The permissions in this policy are sufficient for the Lambda function in this tutorial.
3. Write down the role ARN. You will need it in the next step when you create your Lambda function.

### Next Step

[Step 2.3: Create the Lambda Function and Invoke It Manually \(Using Sample Event Data\) \(p. 256\)](#)

## Step 2.3: Create the Lambda Function and Invoke It Manually (Using Sample Event Data)

In this section, you do the following:

- Create a Lambda function, by uploading the deployment package.
- Test the Lambda function by invoking it manually. Instead of creating an event source, you use sample event data. In the next section, you create an Android mobile app and test the end-to-end experience.

### Step 2.3.1: Create a Lambda Function (Upload the Deployment Package)

In this step, you upload the deployment package using the AWS CLI.

At the command prompt, run the following Lambda CLI `create-function` command using the `adminuser` profile.

You need to update the command by providing the .zip file path and the execution role ARN. The `--runtime` parameter value can be `nodejs8.10`, `nodejs6.10`, or `java8`, depending on the language you chose to author your code.

```
$ aws lambda create-function \
--region us-east-1 \
--function-name AndroidBackendLambdaFunction \
--zip-file fileb://file-path-to-jar-or-zip-deployment-package \
--role execution-role-arn \
--handler handler-name \
--runtime runtime-value \
--profile adminuser
```

Optionally, you can upload the .zip file to an Amazon S3 bucket in the same AWS region, and then specify the bucket and object name in the preceding command. You need to replace the `--zip-file` parameter by the `--code` parameter, as shown following:

```
--code S3Bucket=bucket-name,S3Key=zip-file-object-key
```

### Note

You can create the Lambda function using the AWS Lambda console, in which case note the value of the `create-function` AWS CLI command parameters. You provide the same values in the console UI.

#### Step 2.3.2: Test the Lambda Function (Invoke Manually)

Invoke the function manually using the sample event data. We recommend that you invoke the function using the console because the console UI provides a user-friendly interface for reviewing the execution results, including the execution summary, logs written by your code, and the results returned by the function (because the console always performs synchronous execution—invokes the Lambda function using the `RequestResponse` invocation type).

#### To test the Lambda function (AWS Management Console)

- Follow the steps in the Getting Started exercise to create and invoke the Lambda function at [Invoke the Lambda Function Manually and Verify Results, Logs, and Metrics \(p. 11\)](#). After you choose the Lambda function, choose **Configure test event** from the **Actions** menu to specify the following sample event data:

```
{ "firstName": "first-name", "lastName": "last-name" }
```

- Verify the results in the console.

- Execution result should be Succeeded with the following return value:

```
{  
  "greetings": "Hello first-name, last-name."  
}
```

- Review the **Summary** and the **Log output** sections.

#### To test the Lambda function (AWS CLI)

- Save the following sample event JSON in a file, `input.txt`.

```
{ "firstName": "first-name", "lastName": "last-name" }
```

- Execute the following `invoke` command:

```
$ aws lambda invoke \  
--invocation-type Event \  
--function-name AndroidBackendLambdaFunction \  
--region us-east-1 \  
--payload file://file-path/input.txt \  
--profile adminuser  
outputfile.txt
```

### Note

In this tutorial example, the message is saved in the `outputfile.txt` file. If you request synchronous execution (`RequestResponse` as the invocation type), the function returns the string message in the response body.

For Node.js, it could be one of the following (whatever one you specify in the code):

```
context.succeed("message")  
context.fail("message")  
context.done(null, "message")
```

For Java, it is the message in the return statement:

```
return "message"
```

## Next Step

[Step 3: Create an Amazon Cognito Identity Pool \(p. 258\)](#)

## Step 3: 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 execute 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. Using the IAM User Sign-In URL, sign in to the Amazon Cognito console as `adminuser`.
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 (the application users are unauthenticated). Therefore, make sure to select the **Enable access to unauthenticated identities** option.
  - The unauthenticated application users need permission to invoke the Lambda function. To enable this, you will add the following statement to the permission policy associated with the unauthenticated identities (it allows permission for the `lambda:InvokeFunction` action on the specific Lambda function (you must update the resource ARN by providing your account ID)).

```
{  
    "Effect": "Allow",  
    "Action": [  
        "lambda:InvokeFunction"  
    ],  
    "Resource": [  
        "arn:aws:lambda:us-east-1:account-  
id: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": [  
                "*"  
            ]  
        }  
    ]  
}
```

```
    "Resource": [
        "arn:aws:lambda:us-east-1:account-id:function:AndroidBackendLambdaFunction"
    ]
}
```

**Note**

You can update policy at the time of creating the identity pool. You can also update the policy after you create the identity pool, in which case make sure you write down the IAM role name for the unauthenticated users from the Amazon Cognito console. Then, go to the IAM console and search for the specific role and edit the access permissions policy.

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 down 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.

## Next Step

[Step 4: Create a Mobile Application for Android \(p. 259\)](#)

## Step 4: Create a Mobile Application for Android

Now you can 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.

**Note**

The `@LambdaFunction` annotation in the code maps the specific client method to the same-name Lambda function. For more information about this annotation, see [AWS Lambda](#) in the [AWS Mobile SDK for Android Developer Guide](#).

```
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);

}
```

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);
```

- 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.

## Using AWS Lambda with Scheduled Events

You can create a Lambda function and direct AWS Lambda to execute it on a regular schedule. You can specify a fixed rate (for example, execute a Lambda function every hour or 15 minutes), or you can specify a Cron expression. For more information on expressions schedules, see [Schedule Expressions Using Rate or Cron \(p. 266\)](#).

This functionality is available when you create a Lambda function using the AWS Lambda console or the AWS CLI. To configure it using the AWS CLI, see [Run an AWS Lambda Function on a Schedule Using the AWS CLI](#). The console provides **CloudWatch Events** as an event source. At the time of creating a Lambda function, you choose this event source and specify a time interval.

If you have made any manual changes to the permissions on your function, you may need to reapply the scheduled event access to your function. You can do that by using the following CLI command.

```
aws lambda add-permission \
--statement-id 'statement_id' \
--action 'lambda:InvokeFunction' \
--principal events.amazonaws.com \
--source-arn arn:aws:events:region:account-id:rule/rule_name \
--function-name:function_name \
--region region
```

### Note

Each AWS account can have up to 100 unique event sources of the **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.

The console also provides a blueprint (**lambda-canary**) that uses the **CloudWatch Events - Schedule** source type. Using this blueprint, you can create a sample Lambda function and test this feature. The example code that the blueprint provides checks for the presence of a specific webpage and specific text string on the webpage. If either the webpage or the text string is not found, the Lambda function throws an error.

For a tutorial that walks you through an example setup, see [Tutorial: Using AWS Lambda with Scheduled Events \(p. 262\)](#).

## 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, AWS Lambda logs error metrics to 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.

## Next Step

[Step 1: Create a Lambda Function \(p. 263\)](#)

### Step 1: 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 **blueprints** and then choose the **lambda-canary** blueprint.
4. In Basic information, enter a **Name\*** for your function.
5. In **Role\***, choose **Choose an existing role**.
6. In **Existing role\***, choose **lambda\_basic\_execution**.
7. In **CloudWatch Events**, choose the **Rule** list and then choose **Create a new rule**.
  - In **Rule name**, type a name (for example, **CheckWebsiteScheduledEvent**).
  - In **Rule description**, type a description (for example, **CheckWebsiteScheduledEvent trigger**).
  - Choose **Schedule expression** and then specify **rate(1 minute)**. Note that you can specify the value as a rate or in the cron expression format. All schedules use the UTC time zone, and the minimum precision for schedules is one minute.

#### Note

When setting a rate expression, the first execution is immediate and subsequent executions occur based on the rate schedule. In the preceding example, the subsequent execution rate would be every minute.

For more information on expressions schedules, see [Schedule Expressions Using Rate or Cron \(p. 266\)](#).

- In **Enable trigger**, we recommend that you leave the trigger in a disabled state until you have tested it.
- Note the **Lambda function code** section. This is sample code that you can configure after you create the function. In addition, the console will also allow you to select runtimes that Lambda supports and add your custom code.

#### Important

As mentioned previously, the code provided in the blueprint can be edited once you've created the function. But also note that it uses `SITE` and `EXPECTED` variables as placeholders for environment variables that you can set, as explained below.

- The **Environment variables** section is where you configure settings that you apply to your Lambda function without having to update the function code. In this case, you can supply a URL value for the `site` key and an expected value to be returned from that site in the `expected` key. While we strongly recommend populating these values, should you choose not to use environment variables for this function, you will need to clear the `<enter value here>` fields for both `site` and `expected` fields prior to creating your function. You will also need to update the sample function code to replace the `SITE` and `EXPECTED` variables with literal values of your choice.

- Choose **Create function**.

**Note**

Once you have created your Lambda function, you can also add to or update the environment variables section to suit your function's requirements. For more information, see [Environment Variables \(p. 377\)](#).

## Next Step

[Step 2: Test the Lambda Function \(Using a Sample Test Event\) \(p. 264\)](#)

## Step 2: Test the Lambda Function (Using a Sample Test Event)

1. Choose the function you created in the previous step and then choose **Test**.
2. On the **Input sample event** page, choose **Scheduled Event** in the **Sample event** list.

Note the event time in the sample event. This value will be different when AWS Lambda invokes the function at scheduled intervals. The sample Lambda function code logs this time to CloudWatch Logs.

3. Choose **Save and test** and verify that the **Execution result** section shows success.

## Next Step

[Step 3: Create an Amazon SNS Topic and Subscribe to It \(p. 264\)](#)

## Step 3: Create an Amazon SNS Topic and Subscribe to It

1. Create an SNS topic using the Amazon SNS console. For instructions, see [Create a Topic in the Amazon Simple Notification Service Developer Guide](#).
2. Subscribe to the topic. For this exercise, use email as the communication protocol. For instructions, see [Subscribe to a Topic in the Amazon Simple Notification Service Developer Guide](#).

You use this Amazon SNS topic in the next step when you configure a CloudWatch alarm so that when AWS Lambda emits an error the alarm will publish a notification to this topic.

## Next Step

[Step 4: Configure a CloudWatch Alarm \(p. 264\)](#)

## Step 4: Configure a CloudWatch Alarm

To configure a CloudWatch alarm, follow the instructions at [Create Alarm](#) in the *Amazon CloudWatch User Guide*. As you follow the steps, note the following:

- In **Create Alarm (1. Select Metric** step), choose **Lambda Metrics**, and then choose the **Errors (Metric Name is Errors)** for the Lambda function you created. Also, on the statistics drop-down, change the settings from **Average** to **Sum** statistics.
- In **Create Alarm (2. Define Metric** step), set the alarm threshold to **Whenever: Errors is >= 1** and select your Amazon SNS topic from the **Send notification to:** list.

## Next Step

[Step 5: Test the Lambda Function Again \(p. 265\)](#)

## Step 5: Test the Lambda Function Again

Now test the Lambda function again. This time, update the code by specifying either a non-existing webpage URL or a text string. This causes the function to return an error that AWS Lambda sends to CloudWatch error metrics. CloudWatch posts this message to the Amazon SNS topic and you get an email notification.

## (Optional): Deploy With AWS SAM and AWS CloudFormation

In the previous section, you used AWS Lambda APIs to create and update a Lambda function by providing a deployment package as a ZIP file. However, this mechanism may not be convenient for automating deployment steps for functions, or coordinating deployments and updates to other elements of a serverless application, like event sources and downstream resources.

You can use AWS CloudFormation to easily specify, deploy, and configure serverless applications. AWS CloudFormation is a service that helps you model and set up your Amazon Web Services resources so that you can spend less time managing those resources and more time focusing on your applications that run in AWS. You create a template that describes all the AWS resources that you want (like Lambda functions and DynamoDB tables), and AWS CloudFormation takes care of provisioning and configuring those resources for you.

In addition, you can use the AWS Serverless Application Model to express resources that comprise the serverless application. These resource types, such as Lambda functions and APIs, are fully supported by AWS CloudFormation and make it easier for you to define and deploy your serverless application.

For more information, see [Deploying Lambda-based Applications \(p. 277\)](#).

## Specification for Scheduled Event Application

The following contains the SAM template for this application. Copy the text below to a .yaml file and save it next to the ZIP package you created previously. Make sure the `Runtime:` parameter value matches the one you chose in the previous section.

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Parameters:
  NotificationEmail:
    Type: String
Resources:
  CheckWebsitePeriodically:
    Type: AWS::Serverless::Function
    Properties:
      Handler: LambdaFunctionOverHttps.handler
      Runtime: runtime
      Policies: AmazonDynamoDBFullAccess
    Events:
      CheckWebsiteScheduledEvent:
        Type: Schedule
        Properties:
          Schedule: rate(1 minute)

  AlarmTopic:
    Type: AWS::SNS::Topic
    Properties:
      Subscription:
        - Protocol: email
          Endpoint: !Ref NotificationEmail

  Alarm:
    Type: AWS::CloudWatch::Alarm
```

```
Properties:  
  AlarmActions:  
    - !Ref AlarmTopic  
  ComparisonOperator: GreaterThanOrEqualToThreshold  
  Dimensions:  
    - Name: FunctionName  
      Value: !Ref CheckWebsitePeriodically  
  EvaluationPeriods: 1  
  MetricName: Errors  
  Namespace: AWS/Lambda  
  Period: 60  
  Statistic: Sum  
  Threshold: '1'
```

## Deploying the Serverless Application

For information on how to package and deploy your serverless application using the package and deploy commands, see [Packaging and Deployment \(p. 304\)](#).

## Schedule Expressions Using Rate or Cron

### Rate expression

```
rate(Value Unit)
```

Where:

*Value* can be a positive integer.

*Unit* can be minute(s), hour(s), or day(s).

For example:

Example	Cron expression
Invoke Lambda function every 5 minutes	rate(5 minutes)
Invoke Lambda function every hour	rate(1 hour)
Invoke Lambda function every seven days	rate(7 days)

Note the following:

- Rate frequencies of less than one minute are not supported.
- For a singular value the unit must be singular (for example, `rate(1 day)`), otherwise plural (for example, `rate(5 days)`).

### Cron expression

```
cron(Minutes Hours Day-of-month Month Day-of-week Year)
```

All fields are required and time zone is UTC only. The following table describes these fields.

Field	Values	Wildcards
Minutes	0-59	, - * /
Hours	0-23	, - * /
Day-of-month	1-31	, - * ? / L W
Month	1-12 or JAN-DEC	, - * /
Day-of-week	1-7 or SUN-SAT	, - * ? / L #
Year	1970-2199	, - * /

The following table describes the wildcard characters.

Character	Definition	Example
/	Specifies increments	0/15 in the minutes field directs execution to occur every 15 minutes.
L	Specifies "Last"	If used in Day-of-month field, specifies last day of the month. If used in Day-of-week field, specifies last day of the week (Saturday).
W	Specifies <i>Weekday</i>	When used with a date, such as 5/W, specifies the closest weekday to 5th day of the month. If the 5th falls on a Saturday, execution occurs on Friday. If the 5th falls on a Sunday, execution occurs on Monday.
#	Specifies the <i>nd</i> or <i>nth</i> day of the month	Specifying 3#2 means the second Tuesday of the month (Tuesday is the third day of the 7-day week).
*	Specifies <i>All values</i>	If used in the Day-of-month field, it means all days in the month.
?	No specified value	Used in conjunction with another specified value. For example, if a specific date is specified, but you don't care what day of the week it falls on.
-	Specifies ranges	10-12 would mean 10, 11 and 12
,	Specifies additional values	SUN, MON, TUE means Sunday, Monday and Tuesday
/	Specifies increments	5/10 means 5, 15, 25, 35, etc.

The following table lists common examples of cron expressions.

Example	Cron expression
Invoke a Lambda function at 10:00am (UTC) everyday	<code>cron(0 10 * * ? *)</code>

Example	Cron expression
Invoke a Lambda function 12:15pm (UTC) everyday	<code>cron(15 12 * * ? *)</code>
Invoke a Lambda function at 06:00pm (UTC) every Mon-Fri	<code>cron(0 18 ? * MON-FRI *)</code>
Invoke a Lambda function at 8:00am (UTC) every first day of the month	<code>cron(0 8 1 * ? *)</code>
Invoke a Lambda function every 10 min Mon-Fri	<code>cron(0/10 * ? * MON-FRI *)</code>
Invoke a Lambda function every 5 minutes Mon-Fri between 8:00am and 5:55pm (UTC)	<code>cron(0/5 8-17 ? * MON-FRI *)</code>
Invoke a Lambda function at 9 a.m. (UTC) the first Monday of each month	<code>cron(0 9 ? * 2#1 *)</code>

Note the following:

- Cron expressions that lead to rates faster than one minute are not supported.
- One of the day-of-month or day-of-week values must be a question mark (?).

## Using AWS Lambda with Custom User Applications

One of the use cases for using AWS Lambda is to process events generated by a user application. For demonstration purposes, you don't need to write a user application that invokes your Lambda function. Instead, the tutorial provided in this section provides sample event data that you can use and then you invoke your Lambda function manually.

When a user application invokes a Lambda function, it's an example of the AWS Lambda *request-response* model in which an application invokes a Lambda function and receives a response in real time.

For a tutorial that walks you through an example setup, see [Tutorial: Using AWS Lambda with Custom User Applications \(p. 268\)](#).

## Tutorial: Using AWS Lambda with Custom User Applications

In this tutorial, you use the AWS CLI to create and invoke a Lambda function and explore other AWS Lambda APIs.

You'll do the following:

- Create a Lambda function to process an event it receives as a parameter. You use the following example Node.js code to create your Lambda function.

```
console.log('Loading function');
```

```
exports.handler = function(event, context, callback) {
    console.log('value1 =', event.key1);
    console.log('value2 =', event.key2);
    console.log('value3 =', event.key3);
    callback(null,"Success");
};
```

**Note**

The code sample is compliant with the Node.js runtime v6.10 or v8.10. For more information, see [Programming Model\(Node.js\) \(p. 19\)](#)

The function is simple. It processes incoming event data by logging it (these logs are available in Amazon CloudWatch), and in the request-response model, you can request the log data be returned in the response.

- Simulate a user application that sends an event to your Lambda function by invoking your Lambda function manually using the following sample event data.

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

**Note**

This example is similar to the Getting Started exercise (see [Getting Started \(p. 3\)](#)). The difference is that the Getting Started exercise provides a console-based experience. The console does many things for you, which simplifies the experience. When using the AWS CLI, you get the experience of making the API calls, which can help you develop a better understanding of the AWS Lambda operations. In addition to creating and invoking a Lambda function, you can explore other Lambda APIs.

## Next Step

[Step 1: Prepare \(p. 269\)](#)

### Step 1: Prepare

Make sure you have completed the following steps:

- Signed up for an AWS account and created an administrator user in the account (called **adminuser**). For instructions, see [Set Up an AWS Account \(p. 4\)](#).
- Installed and set up the AWS CLI. For instructions, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#).

## Next Step

[Step 2: Create a Lambda Function and Invoke It Manually \(p. 269\)](#)

### Step 2: Create a Lambda Function and Invoke It Manually

In this section, you do the following:

- Create a deployment package. A deployment package is a .zip file that contains your code and any dependencies. For this tutorial there are no dependencies, you only have a simple example code.

- Create an IAM role (execution role). At the time you upload the deployment package, you need to specify an IAM role (execution role) that Lambda can assume to execute the function on your behalf.

You also grant this role the permissions that your Lambda function needs. The code in this tutorial writes logs to Amazon CloudWatch Logs. So you need to grant permissions for CloudWatch actions. For more information, see [AWS Lambda Watch Logs](#).

- Create a Lambda function (`HelloWorld`) using the `create-function` CLI command. For more information about the underlying API and related parameters, see [CreateFunction \(p. 412\)](#).

#### Topics

- [Step 2.1: Create a Lambda Function Deployment Package \(p. 270\)](#)
- [Step 2.2: Create the Execution Role \(IAM Role\) \(p. 270\)](#)
- [Step 2.3: Create a Lambda Function \(p. 271\)](#)
- [Next Step \(p. 272\)](#)

## Step 2.1: Create a Lambda Function Deployment Package

Follow the instructions to create an AWS Lambda function deployment package.

1. Open a text editor, and then copy the following code.

```
console.log('Loading function');

exports.handler = function(event, context, callback) {
    console.log('value1 =', event.key1);
    console.log('value2 =', event.key2);
    console.log('value3 =', event.key3);
    callback(null, "Success");
};
```

#### Note

The code sample is compliant with the Node.js runtimes 6.10 or 8.10. For more information, see [Programming Model\(Node.js\) \(p. 19\)](#)

2. Save the file as `helloworld.js`.
3. Zip the `helloworld.js` file as `helloworld.zip`.

#### Note

To see more examples of using other AWS services within your function, including calling other Lambda functions, see [AWS SDK for JavaScript](#)

## Step 2.2: Create the Execution Role (IAM Role)

When the Lambda function in this tutorial executes, it needs permissions to write logs to Amazon CloudWatch. You grant these permissions by creating an IAM role (execution role). AWS Lambda assumes this role when executing your Lambda function on your behalf. In this section, you create an IAM role using the following predefined role type and access policy:

- AWS service role of the "AWS Lambda" type. This role grants AWS Lambda permission to assume the role.
- "AWSLambdaBasicExecutionRole" access policy that you attach to the role. This existing policy grants permissions that include permissions for Amazon CloudWatch actions that your Lambda function needs.

For more information about IAM roles, see [IAM Roles](#) in the *IAM User Guide*.

In this section, you create an IAM role using the following predefined role type and access permissions policy:

- AWS service role of the type **AWS Lambda** – This role grants AWS Lambda permissions to assume the role.
- **AWSLambdaBasicExecutionRole** access permissions policy that you attach to the role.

For more information about IAM roles, see [IAM Roles](#) in the *IAM User Guide*. Use the following procedure to create the IAM role.

### To create an IAM role (execution role)

1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
2. Follow the steps in [Creating a Role to Delegate Permissions to an AWS Service](#) in the *IAM User Guide* to create an IAM role (execution role). As you follow the steps to create a role, note the following:
  - In **Role Name**, use a name that is unique within your AWS account (for example, **lambda-custom-app-execution-role**).
  - In **Select Role Type**, choose **AWS Service Roles**, and then choose **AWS Lambda**. This grants the AWS Lambda service permissions to assume the role.
  - In **Attach Policy**, choose **AWSLambdaBasicExecutionRole**.
3. Write down the role ARN. You will need it in the next step when you create your Lambda function.

## Step 2.3: Create a Lambda Function

Execute the following Lambda CLI `create-function` command to create a Lambda function. You provide the deployment package and IAM role ARN as parameters. Note that the `Runtime` parameter uses `nodejs6.10` but you can also specify `nodejs8.10`.

```
$ aws lambda create-function \
--region region \
--function-name helloworld \
--zip-file fileb://file-path/helloworld.zip \
--role role-arn \
--handler helloworld.handler \
--runtime nodejs6.10 \
--profile adminuser
```

Optionally, you can upload the .zip file to an Amazon S3 bucket in the same AWS region, and then specify the bucket and object name in the preceding command. You need to replace the `--zip-file` parameter by the `--code` parameter, as shown following:

```
--code S3Bucket=bucket-name,S3Key=zip-file-object-key
```

For more information, see [CreateFunction \(p. 412\)](#). AWS Lambda creates the function and returns function configuration information as shown in the following example:

```
{  
  "FunctionName": "helloworld",  
  "CodeSize": 351,  
  "MemorySize": 128,  
  "FunctionArn": "function-arn",  
  "Handler": "helloworld.handler",  
  "LastModified": "2017-03-21T22:14:12.120Z",  
  "Runtime": "nodejs6.10",  
  "Timeout": 3,  
  "Version": "1",  
  "Description": ""}
```

```
"Role": "arn:aws:iam::account-id:role/LambdaExecRole",
"Timeout": 3,
"LastModified": "2015-04-07T22:02:58.854+0000",
"Runtime": "nodejs6.10",
"Description": ""
}
```

## Next Step

[Step 3: Invoke the Lambda Function \(AWS CLI\) \(p. 272\)](#)

## Step 3: Invoke the Lambda Function (AWS CLI)

In this section, you invoke your Lambda function manually using the `invoke` AWS CLI command.

```
$ aws lambda invoke \
--invocation-type RequestResponse \
--function-name helloworld \
--region region \
--log-type Tail \
--payload '{"key1":"value1", "key2":"value2", "key3":"value3"}' \
--profile adminuser \
outputfile.txt
```

If you want you can save the payload to a file (for example, `input.txt`) and provide the file name as a parameter.

```
--payload file://input.txt \
```

The preceding `invoke` command specifies `RequestResponse` as the invocation type, which returns a response immediately in response to the function execution. Alternatively, you can specify `Event` as the invocation type to invoke the function asynchronously.

By specifying the `--log-type` parameter, the command also requests the tail end of the log produced by the function. The log data in the response is base64-encoded as shown in the following example response:

```
{
    "LogResult": "base64-encoded-log",
    "StatusCode": 200
}
```

On Linux and Mac, you can use the `base64` command to decode the log.

```
$ echo base64-encoded-log | base64 --decode
```

The following is a decoded version of an example log.

```
START RequestId: 16d25499-d89f-11e4-9e64-5d70fce44801
2015-04-01T18:44:12.323Z 16d25499-d89f-11e4-9e64-5d70fce44801  value1 = value1
2015-04-01T18:44:12.323Z 16d25499-d89f-11e4-9e64-5d70fce44801  value2 = value2
2015-04-01T18:44:12.323Z 16d25499-d89f-11e4-9e64-5d70fce44801  value3 = value3
2015-04-01T18:44:12.323Z 16d25499-d89f-11e4-9e64-5d70fce44801  result: "value1"
END RequestId: 16d25499-d89f-11e4-9e64-5d70fce44801
REPORT RequestId: 16d25499-d89f-11e4-9e64-5d70fce44801
Duration: 13.35 ms      Billed Duration: 100 ms   Memory Size: 128 MB
Max Memory Used: 9 MB
```

For more information, see [Invoke \(p. 450\)](#).

Because you invoked the function using the RequestResponse invocation type, the function executes and returns the object you passed to the context.succeed() in real time when it is called. In this tutorial, you see the following text written to the outputfile.txt you specified in the CLI command:

```
"value1"
```

#### Note

You are able to execute this function because you are using the same AWS account to create and invoke the Lambda function. However, if you want to grant cross-account permissions to another AWS account or grant permissions to another AWS service to execute the function, you must add a permissions to the access permissions policy associated with the function. The Amazon S3 tutorial, which uses Amazon S3 as the event source (see [Tutorial: Using AWS Lambda with Amazon S3 \(p. 174\)](#)), grants such permissions to Amazon S3 to invoke the function.

You can monitor the activity of your Lambda function in the AWS Lambda console.

- Sign in to the AWS Management Console and open the AWS Lambda console at <https://console.aws.amazon.com/lambda/>.

The AWS Lambda console shows a graphical representation of some of the CloudWatch metrics in the **Cloudwatch Metrics at a glance** section for your function.

- For each graph, you can also choose the **logs** link to view the CloudWatch logs directly.

## Next Step

[Step 4: Try More CLI Commands \(AWS CLI\) \(p. 273\)](#)

## Step 4: Try More CLI Commands (AWS CLI)

### Step 4.1: List the Lambda Functions in Your Account

In this section, you try AWS Lambda list function operations. Execute the following AWS CLI list-functions command to retrieve a list of functions that you uploaded.

```
$ aws lambda list-functions \
--max-items 10 \
--profile adminuser
```

To illustrate the use of pagination, the command specifies the optional --max-items parameter to limit the number of functions returned in the response. For more information, see [ListFunctions \(p. 464\)](#). The following is an example response.

```
{
    "Functions": [
        {
            "FunctionName": "helloworld",
            "MemorySize": 128,
            "CodeSize": 412,
            "FunctionArn": "arn:aws:lambda:us-east-1:account-id:function:ProcessKinesisRecords",
            "Handler": "ProcessKinesisRecords.handler",
            "Role": "arn:aws:iam::account-id:role/LambdaExecRole",
            "Timeout": 3,
            "LastModified": "2015-02-22T21:03:01.172+0000",
            "Runtime": "nodejs6.10",
            "Description": ""
```

```
        },
        {
            "FunctionName": "ProcessKinesisRecords",
            "MemorySize": 128,
            "CodeSize": 412,
            "FunctionArn": "arn:aws:lambda:us-east-1:account-id:function:ProcessKinesisRecords",
            "Handler": "ProcessKinesisRecords.handler",
            "Role": "arn:aws:iam::account-id:role/lambda-execute-test-kinesis",
            "Timeout": 3,
            "LastModified": "2015-02-22T21:03:01.172+0000",
            "Runtime": "nodejs6.10",
            "Description": ""
        },
        ...
    ],
    "NextMarker": null
}
```

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

```
$ aws lambda list-functions \
--max-items 10 \
--marker value-of-NextMarker-from-previous-response \
--profile adminuser
```

## Step 4.2: Get Metadata and a URL to Download Previously Uploaded Lambda Function Deployment Packages

The Lambda CLI `get-function` command returns Lambda function metadata and a presigned URL that you can use to download the function's .zip file (deployment package) that you uploaded to create the function. For more information, see [GetFunction \(p. 438\)](#).

```
$ aws lambda get-function \
--function-name helloworld \
--region region \
--profile adminuser
```

The following is an example response.

```
{
    "Code": {
        "RepositoryType": "S3",
        "Location": "pre-signed-url"
    },
    "Configuration": {
        "FunctionName": "helloworld",
        "MemorySize": 128,
        "CodeSize": 287,
        "FunctionArn": "arn:aws:lambda:us-west-2:account-id:function:helloworld",
        "Handler": "helloworld.handler",
        "Role": "arn:aws:iam::account-id:role/LambdaExecRole",
        "Timeout": 3,
        "LastModified": "2015-04-07T22:02:58.854+0000",
        "Runtime": "nodejs6.10",
        "Description": ""
    }
}
```

}

If you want the function configuration information only (not the presigned URL), you can use the Lambda CLI `get-function-configuration` command.

```
$ aws lambda get-function-configuration \
--function-name helloworld \
--region region \
--profile adminuser
```

### Next Step

[Step 5: Delete the Lambda Function and IAM Role \(AWS CLI\) \(p. 275\)](#)

## Step 5: Delete the Lambda Function and IAM Role (AWS CLI)

Execute the following `delete-function` command to delete the `helloworld` function.

```
$ aws lambda delete-function \
--function-name helloworld \
--region region \
--profile adminuser
```

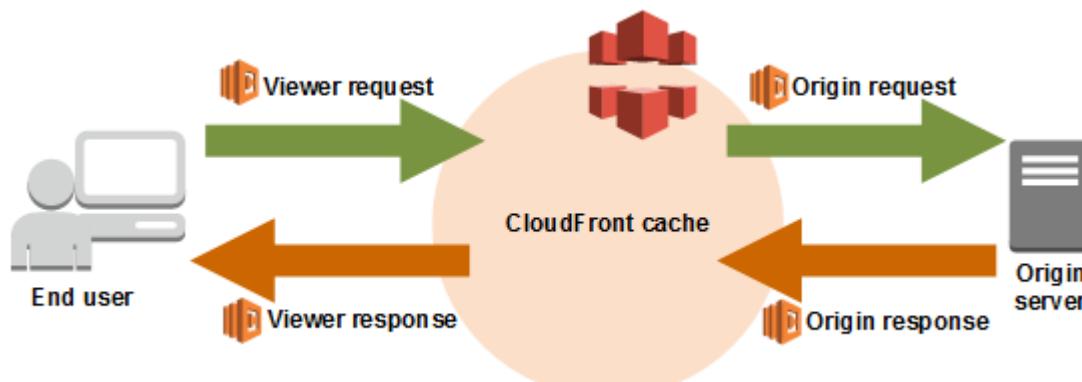
### Delete the IAM Role

After you delete the Lambda function you can also 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@Edge

Lambda@Edge lets you run 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)



You can also generate responses to viewers without ever sending the request to the origin.

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](#).

# Deploying Lambda-based Applications

Lambda-based applications (also referred to as *serverless applications*) are composed of functions triggered by events. A typical serverless application consists of one or more functions triggered by events such as object uploads to Amazon S3, Amazon SNS notifications, and API actions. Those functions can stand alone or leverage other resources such as DynamoDB tables or Amazon S3 buckets. The most basic serverless application is simply a function.

AWS Lambda provides API operations that you can use to create and update Lambda functions by providing a deployment package as a ZIP file. However, this mechanism might not be convenient for automating deployment steps for functions, or coordinating deployments and updates to other elements of a serverless application (like event sources and downstream resources). For example, in order to deploy an Amazon SNS trigger, you need to update the function, the Amazon SNS topic, the mapping between the function and the topic, and any other downstream resources required by your function such as a DynamoDB table.

You can deploy your serverless applications in the following ways:

- **AWS CLI** - Using the `aws cloudformation deploy` command. For more information, see [Deployment \(p. 305\)](#), which is included in a tutorial on creating a severless application. For more information, see [Create Your Own Serverless Application \(p. 303\)](#). Lambda also offers other AWS CLI operations for you to deploy your serverless applications:
  - [CreateFunction \(p. 412\)](#)
  - [UpdateFunctionConfiguration \(p. 502\)](#)
- **AWS CloudFormation** - You can use AWS CloudFormation to specify, deploy, and configure serverless applications. AWS CloudFormation is a service that helps you model and set up your AWS resources so that you can spend less time managing those resources and more time focusing on your applications that run in AWS. You create a template that describes all of the AWS resources that you want (like Lambda functions and DynamoDB tables), and AWS CloudFormation takes care of provisioning and configuring those resources for you. You don't need to individually create and configure AWS resources and figure out what's dependent on what—AWS CloudFormation handles all of that. For more information, see [AWS CloudFormation Concepts](#) in the *AWS CloudFormation User Guide*.
- **AWS SAM** - AWS SAM supports special resource types that simplify how to express functions, APIs, mappings, and DynamoDB tables for serverless applications, as well as some features for these services like environment variables. The AWS CloudFormation description of these resources conforms to the [AWS Serverless Application Model](#). In order to deploy your application, simply specify the resources you need as part of your application, along with their associated permissions policies in an AWS CloudFormation template file (written in either JSON or YAML), package your deployment artifacts, and deploy the template. For more information, see [Using the AWS Serverless Application Model \(AWS SAM\) \(p. 297\)](#)

Before you learn about the AWS Serverless Model (AWS SAM), we suggest you read the following section, which discusses Lambda function versioning, aliases and how to shift traffic to function revisions, which is a pivotal aspect to serverless application development. For more information, see [AWS Lambda Function Versioning and Aliases \(p. 277\)](#).

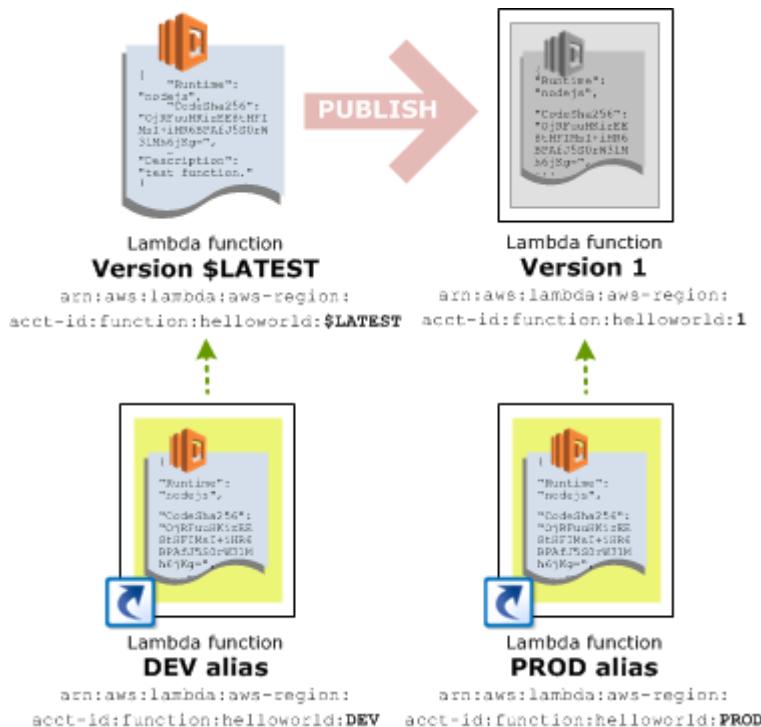
## AWS Lambda Function Versioning and Aliases

By using versioning, you can manage your in-production function code in AWS Lambda better. When you use versioning in AWS Lambda, you can publish one or more versions of your Lambda function. As

a result, you can work with different variations of your Lambda function in your development workflow, such as development, beta, and production.

Each Lambda function version has a unique Amazon Resource Name (ARN). After you publish a version, it is immutable (that is, it can't be changed).

AWS Lambda also supports creating aliases for each of your Lambda function versions. Conceptually, an AWS Lambda alias is a pointer to a specific Lambda function version. It's also a resource similar to a Lambda function, and each alias has a unique ARN. Each alias maintains an ARN for the function version to which it points. An alias can only point to a function version, not to another alias. Unlike versions, which are immutable, aliases are mutable (that is, they can be changed). You can update aliases to point to different versions of functions.



Aliases enable you to abstract the process of promoting new Lambda function versions into production from the mapping of the Lambda function version and its event source.

For example, suppose Amazon S3 is the event source that invokes your Lambda function when new objects are created in a bucket. When Amazon S3 is your event source, you store the event source mapping information in the bucket notification configuration. In that configuration, you can identify the Lambda function ARN that Amazon S3 can invoke. However, in this case each time you publish a new version of your Lambda function you need to update the notification configuration so that Amazon S3 invokes the correct version.

In contrast, instead of specifying the function ARN, suppose that you specify an alias ARN in the notification configuration (for example, PROD alias ARN). As you promote new versions of your Lambda function into production, you only need to update the PROD alias to point to the latest stable version. You don't need to update the notification configuration in Amazon S3.

The same applies when you need to roll back to a previous version of your Lambda function. In this scenario, you just update the PROD alias to point to a different function version. There is no need to update event source mappings.

We recommend that you use versioning and aliases to deploy your Lambda functions when building applications with multiple dependencies and developers involved.

For detailed information, see the following topics.

#### Topics

- [Introduction to AWS Lambda Versioning \(p. 279\)](#)
- [Introduction to AWS Lambda Aliases \(p. 283\)](#)
- [Versioning, Aliases, and Resource Policies \(p. 291\)](#)
- [Managing Versioning Using the AWS Management Console, the AWS CLI, or Lambda API Operations \(p. 293\)](#)
- [Traffic Shifting Using Aliases \(p. 295\)](#)

## Introduction to AWS Lambda Versioning

Following, you can find how to create a Lambda function and publish a version from it. You can also find how to update function code and configuration information when you have one or more published versions. In addition, you can find information on how to delete function versions, either specific versions or an entire Lambda function with all of its versions and associated aliases.

### Creating a Lambda Function (the \$LATEST Version)

When you create a Lambda function, there is only one version—the \$LATEST version.



You can refer to this function using its Amazon Resource Name (ARN). There are two ARNs associated with this initial version:

- **Qualified ARN** – The function ARN with the version suffix.

```
arn:aws:lambda:aws-region:acct-id:function:helloworld:$LATEST
```

- **Unqualified ARN** – The function ARN without the version suffix.

You can use this unqualified ARN in all relevant operations. However, you cannot use it to create an alias. For more information, see [Introduction to AWS Lambda Aliases \(p. 283\)](#).

The unqualified ARN has its own resource policies.

```
arn:aws:lambda:aws-region:acct-id:function:helloworld
```

**Note**

Unless you choose to publish versions, the \$LATEST function version is the only Lambda function version that you have. You can use either the qualified or unqualified ARN in your event source mapping to invoke the \$LATEST version.

The following is an example response for a CreateFunction API call.

```
{  
    "CodeSize": 287,  
    "Description": "test function."  
    "FunctionArn": "arn:aws:lambda:aws-region:acct-id:function:helloworld",  
    "FunctionName": "helloworld",  
    "Handler": "helloworld.handler",  
    "LastModified": "2015-07-16T00:34:31.322+0000",  
    "MemorySize": 128,  
    "Role": "arn:aws:iam::acct-id:role/lambda_basic_execution",  
    "Runtime": "nodejs6.10",  
    "Timeout": 3,  
    "CodeSHA256": "OjRFuuHKizEE8tHFIMsI+iHR6BPAfJ5S0rW31Mh6jKg=",  
    "Version": "$LATEST"  
}
```

For more information, see [CreateFunction \(p. 412\)](#).

In this response, AWS Lambda returns the unqualified ARN of the newly created function and also its version, \$LATEST. The response also shows that the Version is \$LATEST. The CodeSha256 is the checksum of the deployment package that you uploaded.

## Publishing an AWS Lambda Function Version

When you publish a version, AWS Lambda makes a snapshot copy of the Lambda function code (and configuration) in the \$LATEST version. A published version is immutable. That is, you can't change the code or configuration information. The new version has a unique ARN that includes a version number suffix as shown following.



You can publish a version by using any of the following methods:

- **Publish a version explicitly** – You can use the PublishVersion API operation to explicitly publish a version. For more information, see [PublishVersion \(p. 472\)](#). This operation creates a new version using the code and configuration in the \$LATEST version.
- **Publish a version at the time you create or update a Lambda function** – You can also use the CreateFunction or UpdateFunctionCode requests to publish a version by adding the optional publish parameter in the request:
  - Specify the publish parameter in your CreateFunction request to create a new Lambda function (the \$LATEST version). You can then immediately publish the new function by creating

a snapshot and assigning it to be version 1. For more information about `CreateFunction`, see [CreateFunction \(p. 412\)](#).

- Specify the `publish` parameter in your `UpdateFunctionCode` request to update the code in the `$LATEST` version. You can then publish a version from the `$LATEST`. For more information about `UpdateFunctionCode`, see [UpdateFunctionCode \(p. 495\)](#).

If you specify the `publish` parameter at the time you create a Lambda function, the function configuration information that AWS Lambda returns in response shows the version number of the newly published version. In the following example, the version is 1.

```
{  
    "CodeSize": 287,  
    "Description": "test function."  
    "FunctionArn": "arn:aws:lambda:aws-region:acct-id:function:helloworld",  
    "FunctionName": "helloworld",  
    "Handler": "helloworld.handler",  
    "LastModified": "2015-07-16T00:34:31.322+0000",  
    "MemorySize": 128,  
    "Role": "arn:aws:iam::acct-id:role/lambda_basic_execution",  
    "Runtime": "nodejs6.10",  
    "Timeout": 3,  
    "CodeSHA256": "OjRFuuHKizEE8tHFIMsI+iHR6BPAfJ5S0rW31Mh6jKg=",  
    "Version": "1"  
}
```

#### Note

Lambda only publishes a new version if the code hasn't yet been published or if the code has changed when compared against the `$LATEST` version. If there is no change, the `$LATEST` published version is returned.

We recommend that you publish a version at the same time that you create your Lambda function or update your Lambda function code. This recommendation especially applies when multiple developers contribute to the same Lambda function development. You can use the `publish` parameter in your request to do this.

When you have multiple developers working on a project, you can have a scenario where developer A creates a Lambda function (`$LATEST` version). Before developer A publishes this version, developer B might update the code (the deployment package) associated with the `$LATEST` version. In this case, you lose the original code that developer A uploaded. When both developers add the `publish` parameter, it prevents the race condition described.

#### Note

The published versions are immutable. That is, you can't change code or configuration information associated with a version.

Each version of a Lambda function is a unique resource with a Amazon Resource Name (ARN). The following example shows the ARN of version number 1 of the `helloworld` Lambda function.

```
arn:aws:lambda:aws-region:acct-id:function:helloworld:1
```

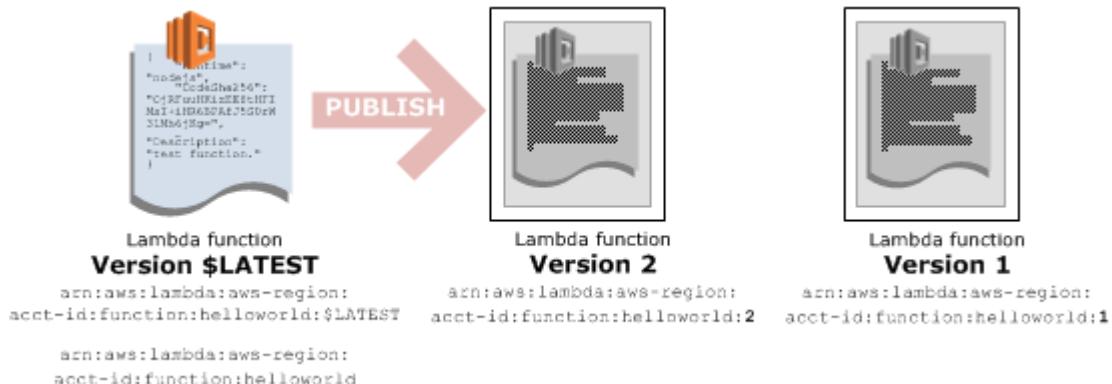
#### Note

This ARN is qualified, where the version number is a suffix. Published versions can have only qualified ARN.

You can publish multiple versions of a Lambda function. Each time you publish a version, AWS Lambda copies `$LATEST` version (code and configuration information) to create a new version. When you publish additional versions, AWS Lambda assigns a monotonically increasing sequence number for versioning, even if the function was deleted and recreated. Version numbers are never reused, even for a function

that has been deleted and recreated. This approach means that the consumer of a function version can depend on the executable of that version to never change (except if it's deleted).

If you want to reuse a qualifier, use aliases with your versions. Aliases can be deleted and re-created with the same name.



## Updating Lambda Function Code and Configuration

AWS Lambda maintains your latest function code in the `$LATEST` version. When you update your function code, AWS Lambda replaces the code in the `$LATEST` version of the Lambda function. For more information, see [UpdateFunctionCode \(p. 495\)](#).

Published versions are immutable. You can't update code or configuration information associated with a published version.

You have the following options of publishing a new version as you update your Lambda function code:

- **Publish a version in the same update code request** – Use the `UpdateFunctionCode` API operation (recommended).
- **First update the code, and then explicitly publish a version** – Use the `PublishVersion` API operation.

You can update code and configuration information (such as description, memory size, and execution timeout) for the `$LATEST` version of the Lambda function. However, published versions are immutable. That is, you can't change code or configuration information.

## Deleting a Lambda Function and a Specific Version

With versioning, you have the following choices:

- **Delete a specific version** – You can delete a Lambda function version by specifying the version you want to delete in your `DeleteFunction` request. If there are aliases that depend on this version, the request fails. AWS Lambda deletes the version only if there are no aliases dependent on this version. For more information about aliases, see [Introduction to AWS Lambda Aliases \(p. 283\)](#).
- **Delete the entire Lambda function (all of its versions and aliases)** – To delete the Lambda function and all of its versions, don't specify any version in your `DeleteFunction` request. Doing this deletes the entire function including all of its versions and aliases.

### Important

You can delete a specific function version, but you cannot delete the `$LATEST`.

## Related Topics

[Introduction to AWS Lambda Aliases \(p. 283\)](#)

[Managing Versioning Using the AWS Management Console, the AWS CLI, or Lambda API Operations \(p. 293\)](#)

## Introduction to AWS Lambda Aliases

You can create one or more aliases for your Lambda function. An *AWS Lambda alias* is like a pointer to a specific Lambda function version. For more information about versioning, see [Introduction to AWS Lambda Versioning \(p. 279\)](#).

By using aliases, you can access the Lambda function an alias is pointing to (for example, to invoke the function) without the caller having to know the specific version the alias is pointing to.

AWS Lambda aliases enable the following use cases:

- **Easier support for promotion of new versions of Lambda functions and rollback when needed –** After initially creating a Lambda function (the `$LATEST` version), you can publish a version 1 of it. By creating an alias named PROD that points to version 1, you can now use the PROD alias to invoke version 1 of the Lambda function.

Now, you can update the code (the `$LATEST` version) with all of your improvements, and then publish another stable and improved version (version 2). You can promote version 2 to production by remapping the PROD alias so that it points to version 2. If you find something wrong, you can easily roll back the production version to version 1 by remapping the PROD alias so that it points to version 1.

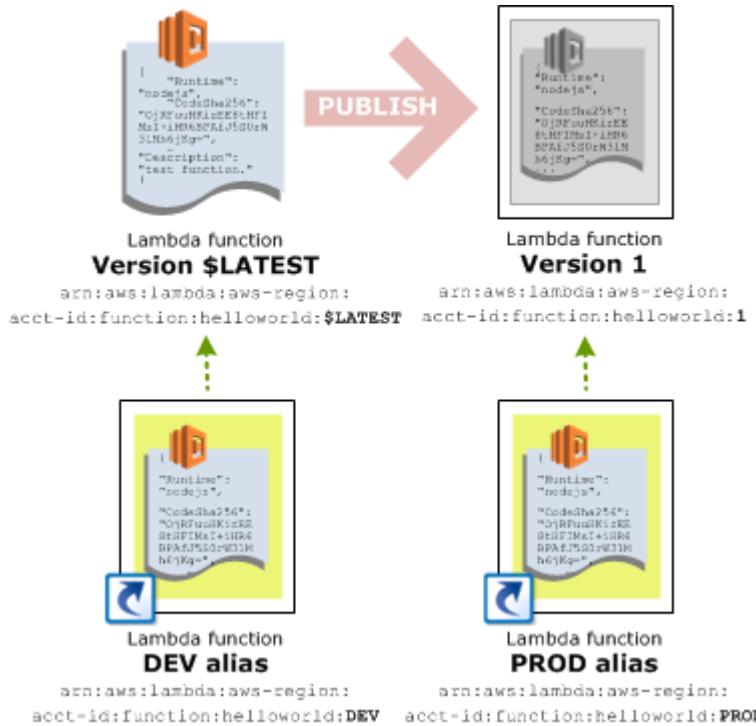
### Note

In this context, the terms *promotion* and *roll back* refer to the remapping of aliases to different function versions.

- **Simplify management of event source mappings –** Instead of using Amazon Resource Names (ARNs) for Lambda function in event source mappings, you can use an alias ARN. This approach means that you don't need to update your event source mappings when you promote a new version or roll back to a previous version.

An AWS Lambda alias is a resource similar to a Lambda function. However, you can't create an alias independently. You create an alias for an existing Lambda function. If a Lambda function is a resource, you can think of an AWS Lambda alias as a subresource that is associated with a Lambda function.

Both the Lambda function and alias are AWS Lambda resources, and like all other AWS resources they both have unique ARNs. The following example shows a Lambda function (the `$LATEST` version), with one published version. Each version has an alias pointing to it.



You can access the function using either the function ARN or the alias ARN.

- Because the function version for an unqualified function always maps to \$LATEST, you can access it using the qualified or unqualified function ARN. The following shows a qualified function ARN with the \$LATEST version suffix.

```
arn:aws:lambda:aws-region:acct-id:function:helloworld:$LATEST
```

- When using any of the alias ARNs, you are using a qualified ARN. Each alias ARN has an alias name suffix.

```
arn:aws:lambda:aws-region:acct-id:function:helloworld:PROD
arn:aws:lambda:aws-region:acct-id:function:helloworld:BETA
arn:aws:lambda:aws-region:acct-id:function:helloworld:DEV
```

AWS Lambda provides the following API operations for you to create and manage aliases:

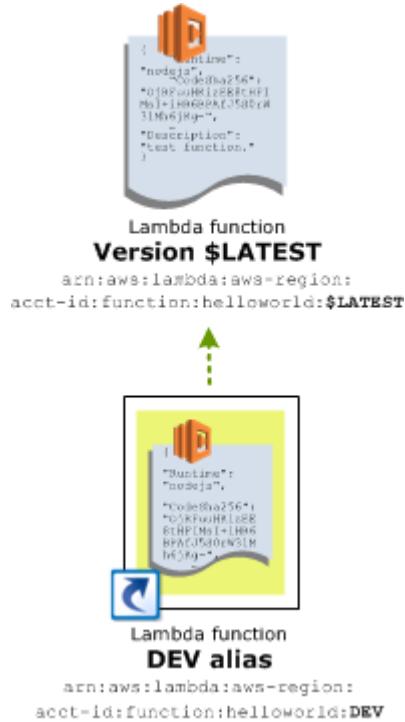
- [CreateAlias \(p. 403\)](#)
- [UpdateAlias \(p. 487\)](#)
- [GetAlias \(p. 432\)](#)
- [ListAliases \(p. 458\)](#)
- [DeleteAlias \(p. 420\)](#)

## Example: Using Aliases to Manage Lambda Function Versions

The following is an example scenario of how to use versioning and aliases to promote new versions of Lambda functions into production.

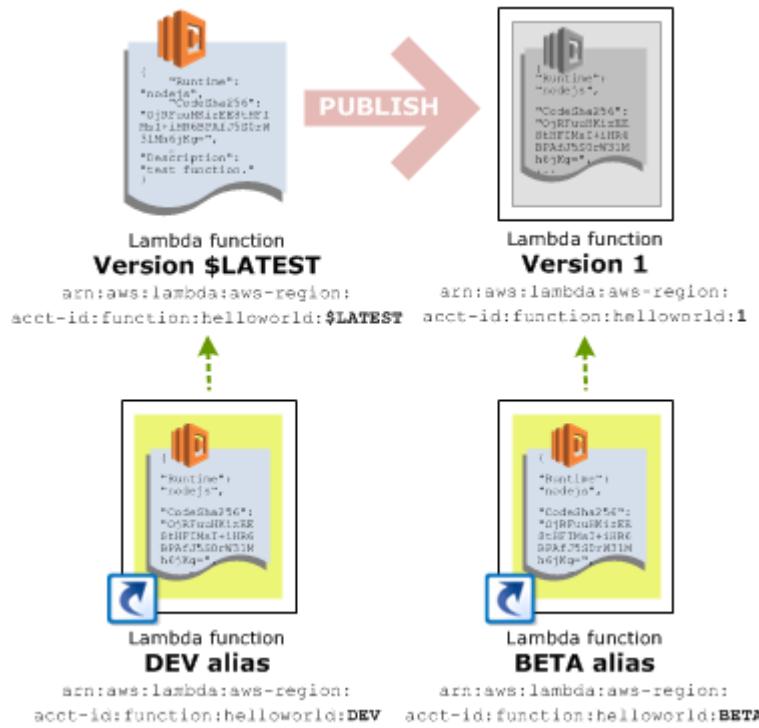
**Initially, you create a Lambda function.**

The function you create is the `$LATEST` version. You also create an alias (DEV, for development) that points to the newly created function. Developers can use this alias to test the function with the event sources in a development environment.



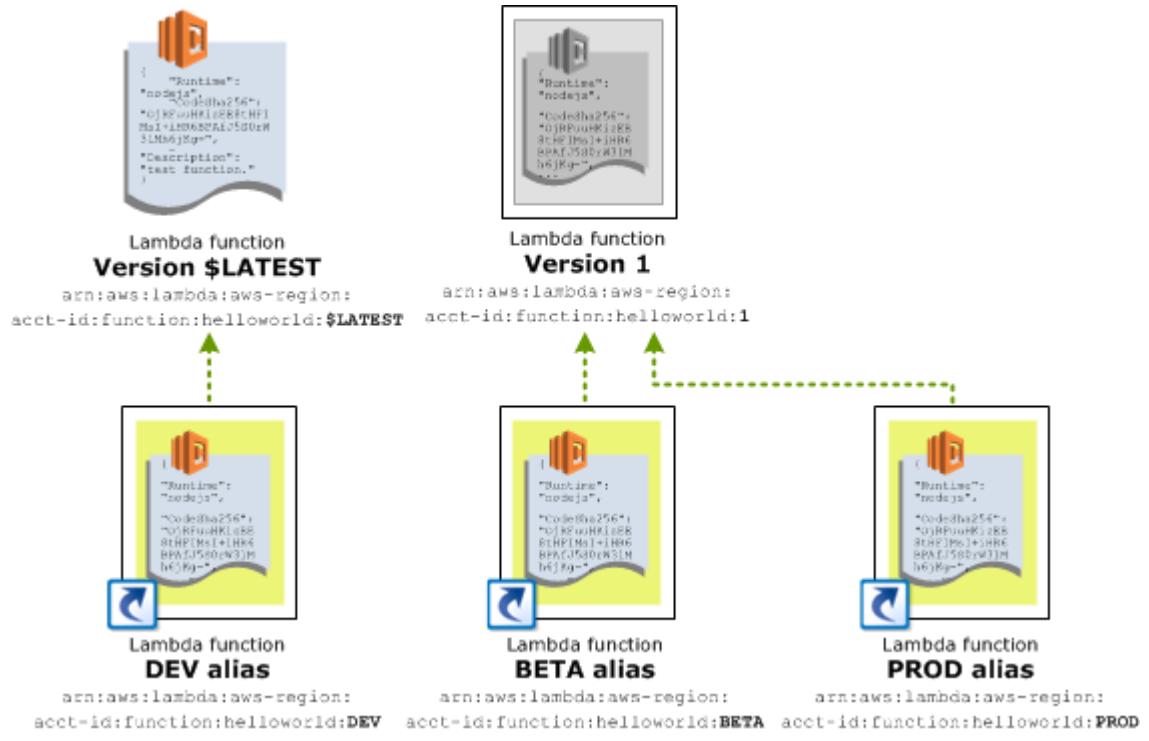
**You then test the function version using event sources in a beta environment in a stable way, while continuing to develop newer versions.**

You publish a version from the `$LATEST` and have another alias (BETA) point to it. This approach allows you to associate your beta event sources to this specific alias. In the event source mappings, use the BETA alias to associate your Lambda function with the event source.



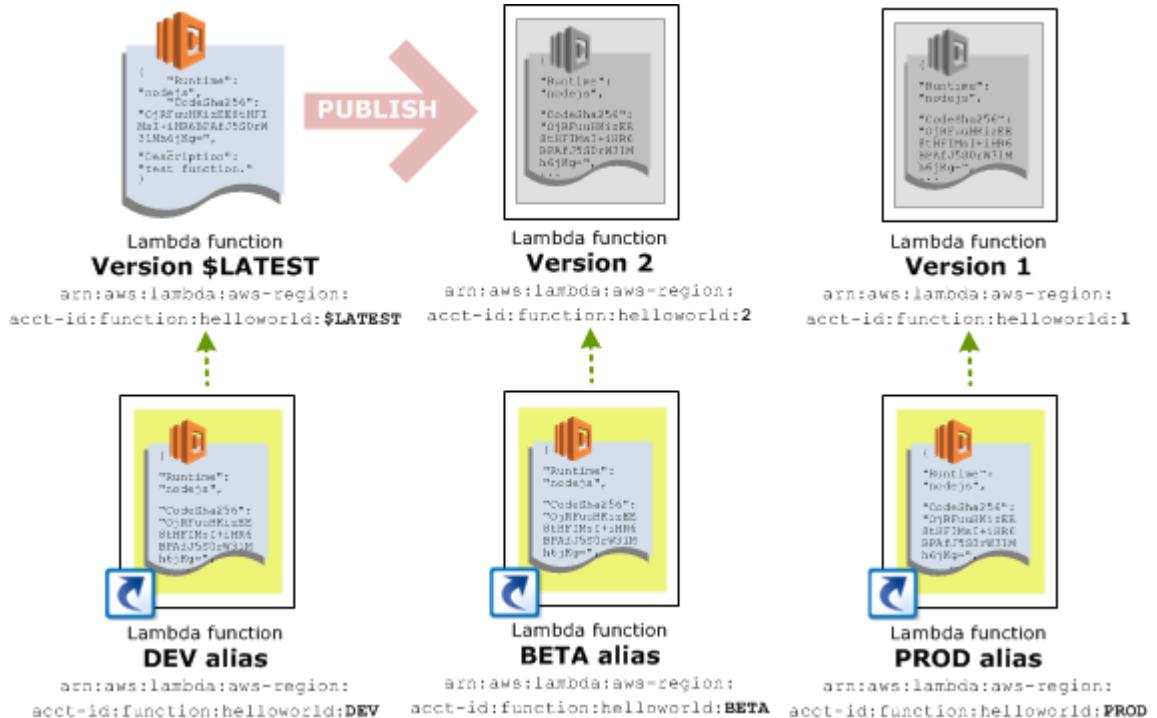
You next promote the Lambda function version in production to work with event sources in production environment.

After testing the BETA version of the function, you can define the production version by creating an alias that maps to version 1. In this approach, you point your production event sources to this specific version. You do this by creating a PROD alias and using the PROD alias ARN in all of your production event source mappings.



You continue development, publish more versions, and test.

As you develop your code, you can update the \$LATEST version by uploading updated code and then publish to beta testing by having the BETA alias point to it. This simple remapping of the beta alias lets you put version 2 of your Lambda function into beta without changing any of your event sources. This approach is how aliases enable you to control which versions of your function are used with specific event sources in your development environment.



If you want to try creating this setup using the AWS Command Line Interface, see [Tutorial: Using AWS Lambda Aliases \(p. 288\)](#).

## Related Topics

[Introduction to AWS Lambda Versioning \(p. 279\)](#)

[Traffic Shifting Using Aliases \(p. 295\)](#)

[Tutorial: Using AWS Lambda Aliases \(p. 288\)](#)

[Managing Versioning Using the AWS Management Console, the AWS CLI, or Lambda API Operations \(p. 293\)](#)

## Tutorial: Using AWS Lambda Aliases

This AWS CLI-based tutorial creates Lambda function versions and aliases that point to it as described in the [Example: Using Aliases to Manage Lambda Function Versions \(p. 284\)](#).

This example uses the us-west-2 (US West Oregon) region to create the Lambda function and aliases.

Create a Lambda function (`helloworld`).

```
aws lambda create-function \
--region region \
--function-name helloworld \
--zip-file fileb://file-path/helloworld.zip \
--role arn:aws:iam::account-id:role/lambda_basic_execution \
--handler helloworld.handler \
--runtime nodejs6.10 \
--profile adminuser
```

The response returns the configuration information showing `$LATEST` as the function version as shown in the following example response.

```
{
  "CodeSha256": "OjRFuuHKizEE8tHFIMsI+iHR6BPAfJ5S0rW31Mh6jKg=",
  "FunctionName": "helloworld",
  "CodeSize": 287,
  "MemorySize": 128,
  "FunctionArn": "arn:aws:lambda:us-west-2:account-id:function:helloworld",
  "Version": "$LATEST",
  "Role": "arn:aws:iam::account-id:role/lambda_basic_execution",
  "Timeout": 3,
  "LastModified": "2015-09-30T18:39:53.873+0000",
  "Handler": "helloworld.handler",
  "Runtime": "nodejs6.10",
  "Description": ""
}
```

1. Create a deployment package that you can upload to create your Lambda function:
  - a. Open a text editor, and then copy the following code.

```
console.log('Loading function');

exports.handler = function(event, context, callback) {
  console.log('value1 =', event.key1);
  console.log('value2 =', event.key2);
  console.log('value3 =', event.key3);
  callback(null, "message");
```

```
};
```

- b. Save the file as `helloworld.js`.
- c. Zip the `helloworld.js` file as `helloworld.zip`.
2. Create an AWS Identity and Access Management (IAM) role (execution role) that you can specify at the time you create your Lambda function:
  - a. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
  - b. Follow the steps in [IAM Roles](#) in the *IAM User Guide* to create an IAM role (execution role). As you follow the steps to create a role, note the following:
    - For **Select Role Type**, choose **AWS Service Roles**, and then choose **AWS Lambda**.
    - For **Attach Policy**, choose the policy named **AWSLambdaBasicExecutionRole**.
  - c. Write down the Amazon Resource Name (ARN) of the IAM role. You need this value when you create your Lambda function in the next step.
3. Create an alias (`DEV`) that points to the `$LATEST` version of the `helloworld` Lambda function.

```
aws lambda create-alias \
--region region \
--function-name helloworld \
--description "sample alias" \
--function-version "\$LATEST" \
--name DEV \
--profile adminuser
```

The response returns the alias information, including the function version it points to and the alias ARN. The ARN is the same as the function ARN with an alias name suffix. The following is an example response.

```
{
    "AliasArn": "arn:aws:lambda:us-west-2:account-id:function:helloworld:DEV",
    "FunctionVersion": "$LATEST",
    "Name": "DEV",
    "Description": "sample alias"
}
```

4. Publish a version of the `helloworld` Lambda function.

```
aws lambda publish-version \
--region region \
--function-name helloworld \
--profile adminuser
```

The response returns configuration information of the function version, including the version number, and the function ARN with the version suffix. The following is an example response.

```
{
    "CodeSha256": "OjRFuuHKizEE8tHFIMsI+iHR6BPAfJ5S0rW31Mh6jKg=",
    "FunctionName": "helloworld",
    "CodeSize": 287,
    "MemorySize": 128,
    "FunctionArn": "arn:aws:lambda:us-west-2:account-id:function:helloworld:1",
    "Version": "1",
    "Role": "arn:aws:iam::account-id:role/lambda_basic_execution",
    "Timeout": 3,
    "LastModified": "2015-10-03T00:48:00.435+0000",
```

```
    "Handler": "helloworld.handler",
    "Runtime": "nodejs6.10
  ,
  "Description": ""
}
```

5. Create an alias (**BETA**) for the for the `helloworld` Lambda function version 1.

```
aws lambda create-alias \
--region region \
--function-name helloworld \
--description "sample alias" \
--function-version 1 \
--name BETA \
--profile adminuser
```

Now you have two aliases for the `helloworld` function. The `DEV` alias points to the `$LATEST` function version, and the `BETA` alias points to version 1 of the Lambda function.

6. Suppose that you want to put the version 1 of the `helloworld` function in production. Create another alias (**PROD**) that points to version 1.

```
aws lambda create-alias \
--region region \
--function-name helloworld \
--description "sample alias" \
--function-version 1 \
--name PROD \
--profile adminuser
```

At this time, you have both the `BETA` and `PROD` aliases pointing to version 1 of the Lambda function.

7. You can now publish a newer version (for example, version 2), but first you need to update your code and upload a modified deployment package. If the `$LATEST` version is not changed, you cannot publish more than one version of it. Assuming you updated the deployment package, uploaded it, and published version 2, you can now change the `BETA` alias to point to version 2 of the Lambda function.

```
aws lambda update-alias \
--region region \
--function-name helloworld \
--function-version 2 \
--name BETA \
--profile adminuser
```

Now you have three aliases pointing to a different version of the Lambda function (`DEV` alias points to the `$LATEST` version, `BETA` alias points to version 2, and the `PROD` alias points to version 1 of the Lambda function).

For information about using the AWS Lambda console to manage versioning, see [Managing Versioning Using the AWS Management Console, the AWS CLI, or Lambda API Operations \(p. 293\)](#).

## Granting Permissions in a Push Model

In a push model (see [Event Source Mapping \(p. 149\)](#)), event sources such as Amazon S3 invoke your Lambda function. These event sources maintain a mapping that identifies the function version or alias that they invoke when events occur. Note the following:

- We recommend that you specify an existing Lambda function alias in the mapping configuration (see [Introduction to AWS Lambda Aliases \(p. 283\)](#)). For example, if the event source is Amazon S3, you

specify the alias ARN in the bucket notification configuration so that Amazon S3 can invoke the alias when it detects specific events.

- In the push model, you grant event sources permissions using a resource policy that you attach to your Lambda function. In versioning, the permissions you add are specific to the qualifier that you specify in the `AddPermission` request (see [Versioning, Aliases, and Resource Policies \(p. 291\)](#)).

For example, the following AWS CLI command grants Amazon S3 permissions to invoke the PROD alias of the helloworld Lambda function (note that the `--qualifier` parameter specifies the alias name).

```
aws lambda add-permission \
--region region \
--function-name helloworld \
--qualifier PROD \
--statement-id 1 \
--principal s3.amazonaws.com \
--action lambda:InvokeFunction \
--source-arn arn:aws:s3:::examplebucket \
--source-account 111111111111 \
--profile adminuser
```

In this case, Amazon S3 is now able to invoke the PROD alias and AWS Lambda can then execute the helloworld Lambda function version that the PROD alias points to. For this to work, you must use the PROD alias ARN in the S3 bucket's notification configuration.

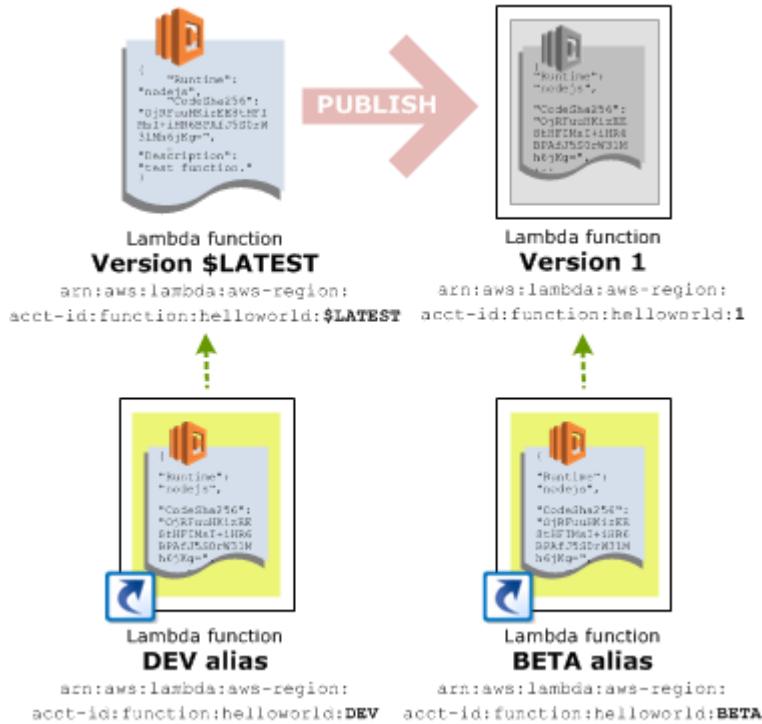
For information about how to handle Amazon S3 events, see [Tutorial: Using AWS Lambda with Amazon S3 \(p. 174\)](#).

**Note**

If you use the AWS Lambda console to add an event source for your Lambda function, the console adds the necessary permissions for you.

## Versioning, Aliases, and Resource Policies

With versioning and aliases you can access a Lambda function using various ARNs. For example, consider the following scenario.



You can invoke for example the helloworld function version 1 using any of the following two ARNs:

- Using the qualified function ARN as shown following.

```
arn:aws:lambda:aws-region:acct-id:function:helloworld:1
```

#### Note

An unqualified function ARN (a function ARN without a version or alias suffix) maps to the \$LATEST version.

- Using the BETA alias ARN as shown following.

```
arn:aws:lambda:aws-region:acct-id:function:helloworld:BETA
```

In a *push* model, event sources (such as Amazon S3 and custom applications) can invoke any of the Lambda function versions as long you grant the necessary permissions to these event sources by using an access policy associated with the Lambda function. For more information about the push model, see [Event Source Mapping \(p. 149\)](#).

Assuming that you grant permission, the next question is, "can an event source invoke a function version using any of the associated ARNs?" The answer is, it depends on how you identified function in your add permissions request (see [AddPermission \(p. 398\)](#)). The key to understanding this is that the permission you grant apply only to the ARN used in the add permission request:

- If you use a qualified function name (such as helloworld:1), the permission is valid for invoking the helloworld function version 1 *only* using its qualified ARN (using any other ARNs results in a permission error).
- If you use an alias name (such as helloworld:BETA), the permission is valid only for invoking the helloworld function using the BETA alias ARN (using any other ARNs results in a permission error, including the function version ARN to which the alias points).

- If you use an unqualified function name (such as `helloworld`), the permission is valid only for invoking the `helloworld` function using the unqualified function ARN (using any other ARNs will result in a permission error).

**Note**

Note that even though the access policy is only on the unqualified ARN, the code and configuration of the invoked Lambda function is still from function version `$LATEST`. The unqualified function ARN maps to the `$LATEST` version but the permissions you add are ARN-specific.

- If you use a qualified function name using the `$LATEST` version (`helloworld:$LATEST`), the permission is valid for invoking the `helloworld` function version `$LATEST` *only* using its qualified ARN (using unqualified ARN results in a permission error).

## Managing Versioning Using the AWS Management Console, the AWS CLI, or Lambda API Operations

You can manage Lambda function versioning programmatically using AWS SDKs (or make the AWS Lambda API calls directly, if you need to), using AWS Command Line Interface (AWS CLI), or the AWS Lambda console.

AWS Lambda provides the following APIs to manage versioning and aliases:

[PublishVersion \(p. 472\)](#)

[ListVersionsByFunction \(p. 469\)](#)

[CreateAlias \(p. 403\)](#)

[UpdateAlias \(p. 487\)](#)

[DeleteAlias \(p. 420\)](#)

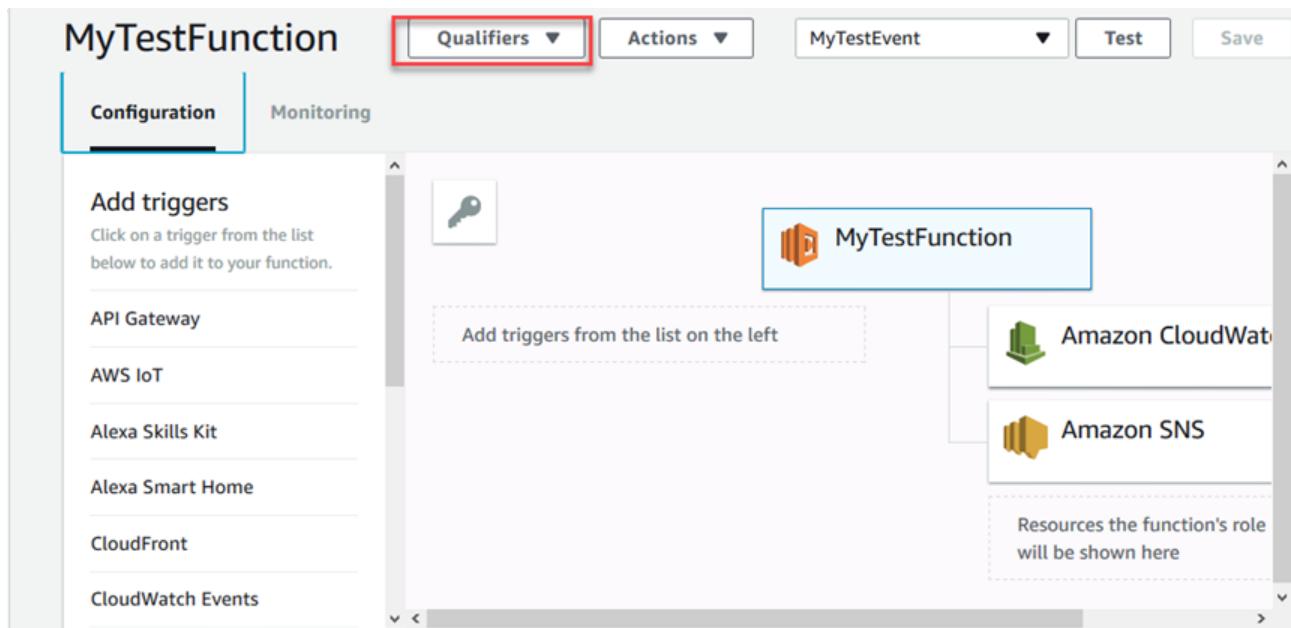
[GetAlias \(p. 432\)](#)

[ListAliases \(p. 458\)](#)

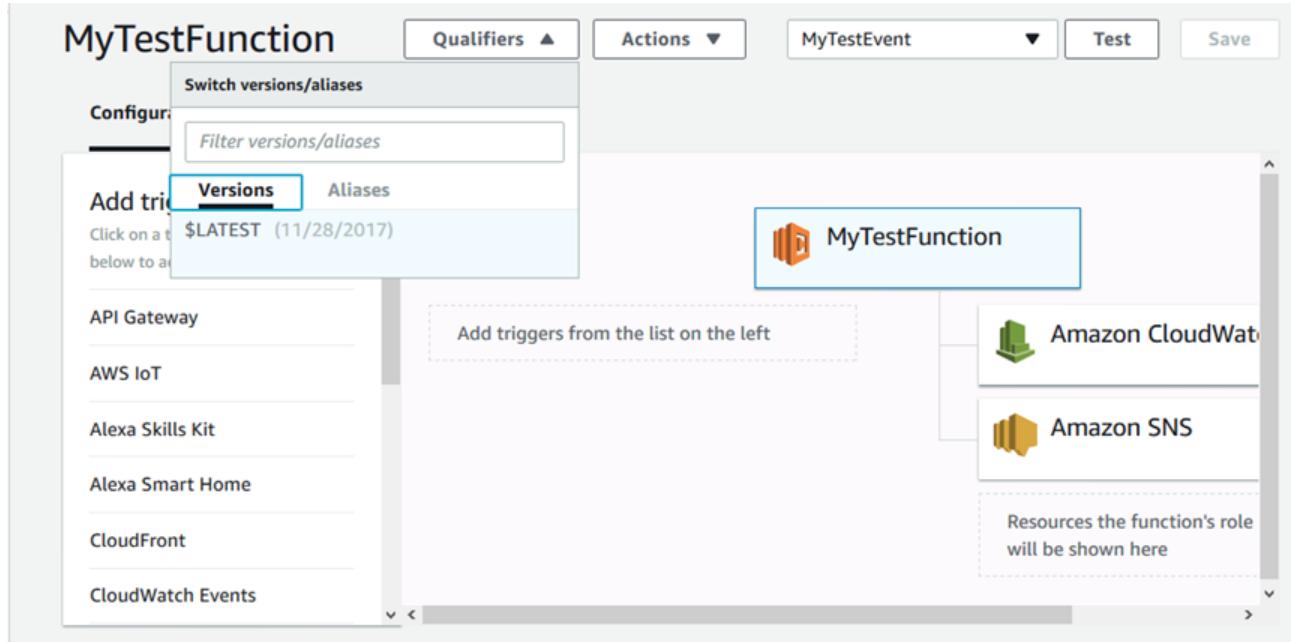
In addition to these APIs, existing relevant APIs also support versioning related operations.

For an example of how you can use the AWS CLI, see [Tutorial: Using AWS Lambda Aliases \(p. 288\)](#).

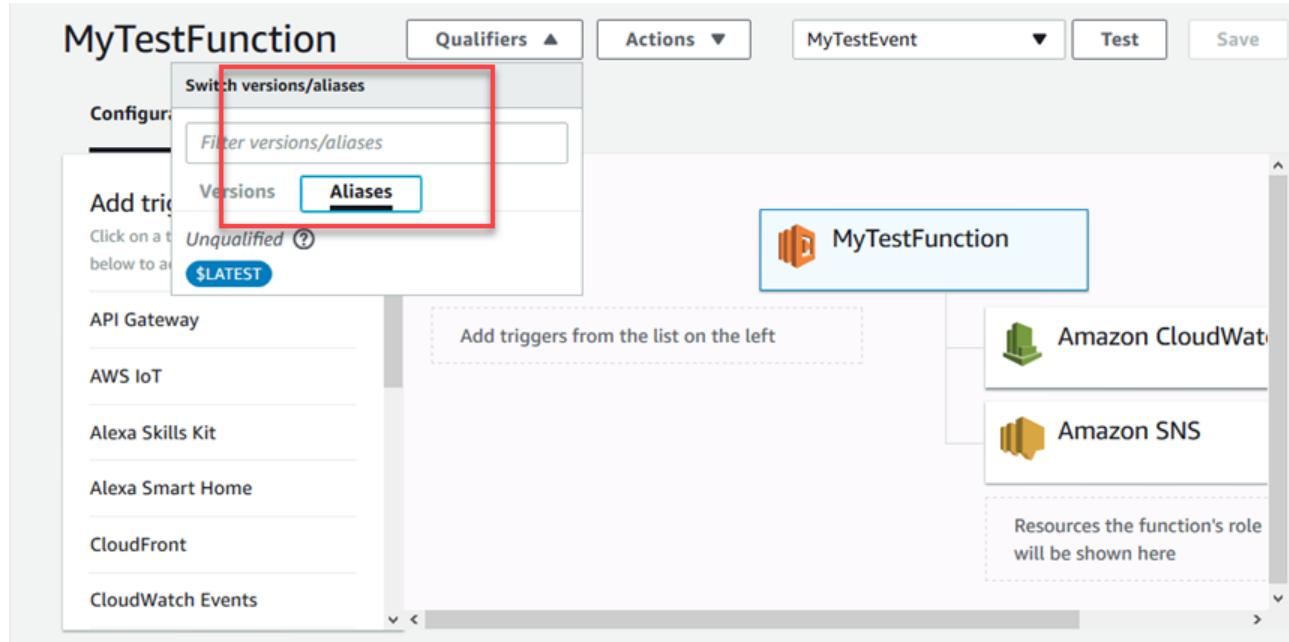
This section explains how you can use the AWS Lambda console to manage versioning. In the AWS Lambda console, choose a function and then choose **Qualifiers**.



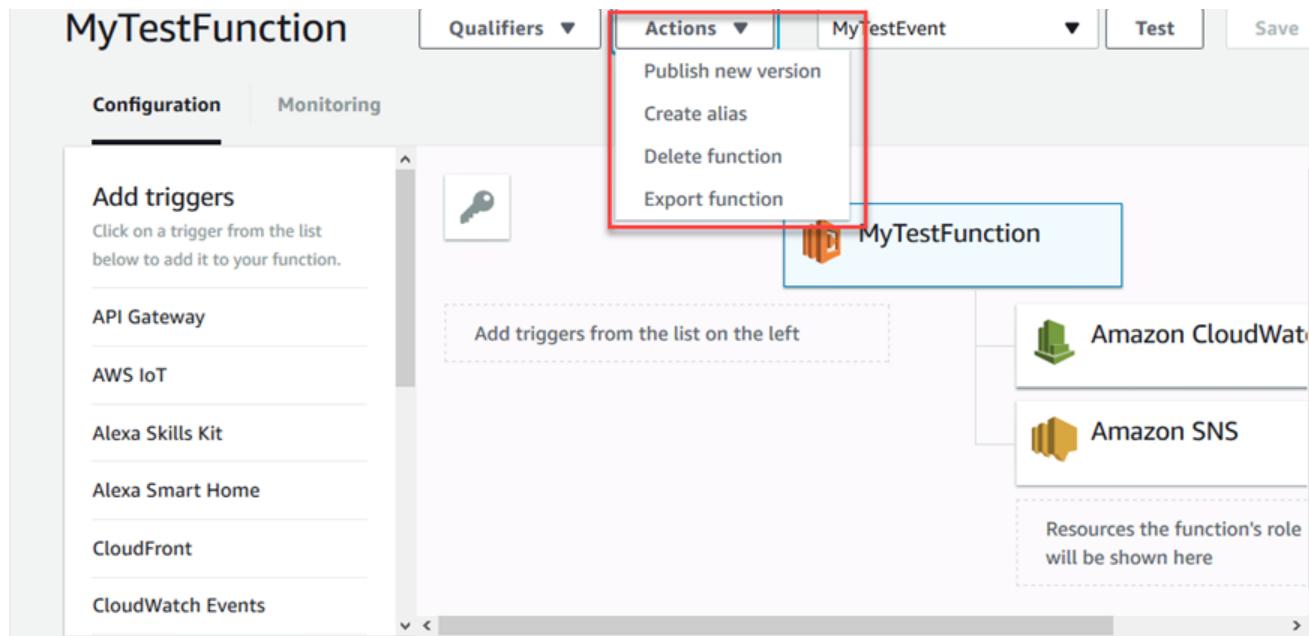
The expanded **Qualifiers** menu displays a **Versions** and **Aliases** tab, as shown in the following screenshot. In the **Versions** pane, you can see a list of versions for the selected function. If you have not previously published a version for the selected function, the **Versions** pane lists only the **\$LATEST** version, as shown following.



Choose the **Aliases** tab to see a list of aliases for the function. Initially, you won't have any aliases, as shown following.



Now you can publish a version or create aliases for the selected Lambda function by using the **Actions** menu.



To learn about versioning and aliases, see [AWS Lambda Function Versioning and Aliases \(p. 277\)](#).

## Traffic Shifting Using Aliases

By default, an alias points to a single Lambda function version. When the alias is updated to point to a different function version, incoming request traffic in turn instantly points to the updated version. This exposes that alias to any potential instabilities introduced by the new version. To minimize this impact, you can implement the `routing-config` parameter of the Lambda alias that allows you to point to two

different versions of the Lambda function and dictate what percentage of incoming traffic is sent to each version.

For example, you can specify that only 2 percent of incoming traffic is routed to the new version while you analyze its readiness for a production environment, while the remaining 98 percent is routed to the original version. As the new version matures, you can gradually update the ratio as necessary until you have determined the new version is stable. You can then update the alias to route all traffic to the new version.

#### Note

You can point an alias to a maximum of two Lambda function versions. In addition:

- Both versions should have the same [Dead Letter Queues \(p. 385\)](#) configuration (or no DLQ configuration).
- Both versions should have the same IAM execution role.
- When pointing an alias to more than one version, the alias cannot point to `$LATEST`.

## Traffic Shifting Using an Alias (CLI)

To configure an alias to shift traffic between two function versions based on weights by using the [CreateAlias \(p. 403\)](#) operation, you need to configure the `routing-config` parameter. The example following points an alias to two different Lambda function versions, with version 2 receiving 2 percent of the invocation traffic and the remaining 98 percent invoking version 1.

```
aws lambda create-alias --name alias name --function-name function-name \  
--function-version 1  
--routing-config AdditionalVersionWeights={"2":0.02}
```

You can update the percentage of incoming traffic to your new version (version 2) by using the [UpdateAlias \(p. 487\)](#) operation. For example, you can boost the invocation traffic to your new version to 5 percent, as shown following.

```
aws lambda update-alias --name alias name --function-name function-name \  
--routing-config AdditionalVersionWeights={"2":0.05}
```

To route all traffic to version 2, again use the `UpdateAlias` operation to change the `function-version` property to point to version 2. Then set the `routing-config` parameter to an empty string, as shown following.

```
aws lambda update-alias --name alias name --function-name function-name \  
--function-version 2 --routing-config ''
```

## Traffic Shifting Using an Alias (Console)

You can configure traffic shifting with an alias by using the Lambda console as described below:

1. Open your Lambda function and verify that you have at least two previously published versions. Otherwise, you can go to [Introduction to AWS Lambda Versioning \(p. 279\)](#) to learn more about versioning, and publish your first function version.
2. For **Actions**, choose **Create alias**.
3. In the **Create a new alias** window, specify a value for **Name\***, optionally for **Description**, and for **Version\*** of the Lambda function that the alias will point to. Here the version is 1.
4. Under **Additional version**, specify the following:
  - a. Specify a second Lambda function version.

- b. Type 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 automatically is assigned 90 percent.
5. Choose **Create**.

## Determining Which Version Has Been Invoked

When your alias is shifting traffic between two function versions, there are two ways to determine which Lambda function version has been invoked:

1. **CloudWatch Logs** – Lambda automatically emits a START log entry that contains the invoked version ID to CloudWatch Logs for every function invocation. An example follows.

```
19:44:37 START RequestId: request id Version: $version
```

Lambda uses the `Executed Version` dimension to filter the metric data by the executed version. This only applies to alias invocations. For more information, see [AWS Lambda CloudWatch Dimensions \(p. 322\)](#).

2. **Response payload (synchronous invocations)** – Responses to synchronous function invocations include an `x-amz-executed-version` header to indicate which function version has been invoked.

### Topics

- [Using the AWS Serverless Application Model \(AWS SAM\) \(p. 297\)](#)
- [Automating Deployment of Lambda-based Applications \(p. 306\)](#)

## Using the AWS Serverless Application Model (AWS SAM)

The AWS Serverless Application Model (AWS SAM) is a model to define serverless applications. AWS SAM is natively supported by AWS CloudFormation and defines simplified syntax for expressing serverless resources. The specification currently covers APIs, Lambda functions and Amazon DynamoDB tables. SAM is available under Apache 2.0 for AWS partners and customers to adopt and extend within their own toolsets. For details on the specification, see the [AWS Serverless Application Model](#).

## Serverless Resources Within AWS SAM

An AWS CloudFormation template with serverless resources conforming to the AWS SAM model is referred to as a SAM file or template.

The examples following illustrate how to leverage AWS SAM to declare common components of a serverless application. Note that the `Handler` and `Runtime` parameter values should match the ones you used when you created the function in the previous section.

### Lambda function

The following shows the notation you use to describe a Lambda function:

```
AWSTemplateFormatVersion: '2010-09-09'  
Transform: AWS::Serverless-2016-10-31  
Resources:
```

```
FunctionName:
  Type: AWS::Serverless::Function
  Properties:
    Handler: index.handler
    Runtime: runtime
    CodeUri: s3://bucketName/codepackage.zip
```

The `Handler` value of the `Handler` property points to the module containing the code your Lambda function will execute when invoked. The `index` value of the `Handler` property indicates the name of the file containing the code. You can declare as many functions as your serverless application requires.

You can also declare environment variables, which are configuration settings you can set for your application. The following shows an example of a serverless app with two Lambda functions and an environment variable that points to a DynamoDB table. You can update environment variables without needing to modify, repackage, or redeploy your Lambda function code. For more information, see [Environment Variables \(p. 377\)](#).

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Resources:
  PutFunction:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs6.10
      Policies: AWSLambdaDynamoDBExecutionRole
      CodeUri: s3://bucketName/codepackage.zip
      Environment:
        Variables:
          TABLE_NAME: !Ref Table
  DeleteFunction:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs6.10
      Policies: AWSLambdaDynamoDBExecutionRole
      CodeUri: s3://bucketName/codepackage.zip
      Environment:
        Variables:
          TABLE_NAME: !Ref Table
  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: streamview type
```

Note the notation at the top:

```
AWSTemplateFormatVersion: '2010-09-09'  
Transform: AWS::Serverless-2016-10-31
```

This is required in order to include objects defined by the AWS Serverless Application Model within an AWS CloudFormation template.

## SimpleTable

SimpleTable is a resource that creates a DynamoDB table with a single-attribute primary key. You can use this simplified version if the data your serverless application is interacting with only needs to be accessed by a single-valued key. You could update the previous example to use a SimpleTable, as shown following:

```
AWSTemplateFormatVersion: '2010-09-09'  
Transform: AWS::Serverless-2016-10-31  
Resources:  
  TableName:  
    Type: AWS::Serverless::SimpleTable  
    Properties:  
      PrimaryKey:  
        Name: id  
        Type: String  
      ProvisionedThroughput:  
        ReadCapacityUnits: 5  
        WriteCapacityUnits: 5
```

## Events

Events are AWS resources that trigger the Lambda function, such as an Amazon API Gateway endpoint or an Amazon SNS notification. The Events property is an array, which allows you to set multiple events per function. The following shows the notation you use to describe a Lambda function with a DynamoDB table as an event source:

```
AWSTemplateFormatVersion: '2010-09-09'  
Transform: AWS::Serverless-2016-10-31  
Resources:  
  FunctionName:  
    Type: AWS::Serverless::Function  
    Properties:  
      Handler: index.handler  
      Runtime: nodejs6.10  
    Events:  
      Stream:  
        Type: DynamoDB  
        Properties:  
          Stream: !GetAtt DynamoDBTable.StreamArn  
          BatchSize: 100  
          StartingPosition: TRIM_HORIZON  
  TableName:  
    Type: AWS::DynamoDB::Table  
    Properties:  
      AttributeDefinitions:  
        - AttributeName: id  
          AttributeType: S  
      KeySchema:
```

```
- AttributeName: id
  KeyType: HASH
ProvisionedThroughput:
  ReadCapacityUnits: 5
  WriteCapacityUnits: 5
```

As mentioned preceding, you can set multiple event sources that will trigger the Lambda function. The example following shows a Lambda function that can be triggered by either an HTTP PUT or POST event.

## API

There are two ways to define an API using AWS SAM. The following uses Swagger to configure the underlying Amazon API Gateway resources:

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Resources:
  Api:
    Type: AWS::Serverless::Api
    Properties:
      StageName: prod
      DefinitionUri: swagger.yml
```

In the next example, the `AWS::Serverless::Api` resource type is implicitly added from the union of API events defined on `AWS::Serverless::Function` resources.

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Resources:
  GetFunction:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.get
      Runtime: nodejs6.10
      CodeUri: s3://bucket/api_backend.zip
      Policies: AmazonDynamoDBReadOnlyAccess
      Environment:
        Variables:
          TABLE_NAME: !Ref Table
  Events:
    GetResource:
      Type: Api
      Properties:
        Path: /resource/{resourceId}
        Method: get

  PutFunction:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.put
      Runtime: nodejs6.10
      CodeUri: s3://bucket/api_backend.zip
      Policies: AmazonDynamoDBFullAccess
      Environment:
        Variables:
          TABLE_NAME: !Ref Table
  Events:
    PutResource:
      Type: Api
      Properties:
```

```
Path: /resource/{resourceId}
Method: put

DeleteFunction:
  Type: AWS::Serverless::Function
  Properties:
    Handler: index.delete
    Runtime: nodejs6.10
    CodeUri: s3://bucket/api_backend.zip
    Policies: AmazonDynamoDBFullAccess
    Environment:
      Variables:
        TABLE_NAME: !Ref Table
    Events:
      DeleteResource:
        Type: Api
        Properties:
          Path: /resource/{resourceId}
          Method: delete

Table:
  Type: AWS::Serverless::SimpleTable
```

In the example preceding, AWS CloudFormation will automatically generate an Amazon API Gateway API with the path "/resource/{resourceId}" and with the methods GET, PUT and DELETE.

## Permissions

You can supply an Amazon Resource Name (ARN) for an AWS Identity and Access Management (IAM) role to be used as this function's execution role, as shown following:

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Resources:
  FunctionName:
    Type: AWS::Serverless::Function
    Properties:
      Role:role arn
```

Alternatively, you could supply one or more managed policies to the Lambda function resource. AWS CloudFormation will then create a new role with the managed policies plus the default Lambda basic execution policy.

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Resources:
  FunctionName:
    Type: AWS::Serverless::Function
    Properties:
      Policies: AmazonDynamoDBFullAccess
```

If none of these are supplied, a default execution role is created with Lambda basic execution permissions.

### Note

In addition to using the serverless resources, you can also use conventional AWS CloudFormation syntax for expressing resources in the same template. Any resources not included in the current SAM model can still be created in the AWS CloudFormation template

using AWS CloudFormation syntax. In addition, you can use AWS CloudFormation syntax to express serverless resources as an alternative to using the SAM model. For information about specifying a Lambda function using conventional CloudFormation syntax as part of your SAM template, see [AWS::Lambda::Function](#) in the AWS CloudFormation User Guide.

For a list of complete serverless application examples, see [Examples of How to Use AWS Lambda \(p. 173\)](#).

## Create a Simple App (sam init)

To get started with a project in SAM, you can use the `sam init` command provided by the SAM CLI to get a fully deployable, boilerplate serverless application in any of the supported runtimes. `sam init` provides a quick way for you to get started with creating a Lambda-based application and augment into a production application by using other commands in the SAM CLI.

To use `sam init`, navigate to a directory where you want the serverless application to be created. Using the SAM CLI, run the following command (using the runtime of your choice. The following example uses Python for demonstration purposes.):

```
$ sam init --runtime python
[+] Initializing project structure...
[SUCCESS] - Read sam-app/README.md for further instructions on how to proceed
[*] Project initialization is now complete
```

This will create a folder in the current directory titled `sam-app`. This folder will contain an AWS SAM template, along with your function code file and a `README` file that provides further guidance on how to proceed with your SAM application. The SAM template defines the AWS Resources that your application will need to run in the AWS Cloud.

The folder structure will include the following:

- A `hello_world` directory that includes an `app.py` file that contains sample code:

```
import json

import requests

def lambda_handler(event, context):
    """Sample pure Lambda function

    Arguments:
        event LambdaEvent -- Lambda Event received from Invoke API
        context LambdaContext -- Lambda Context runtime methods and attributes

    Returns:
        dict -- {'statusCode': int, 'body': dict}
    """
    ip = requests.get('http://checkip.amazonaws.com/')

    return {
        "statusCode": 200,
        "body": json.dumps({
            'message': 'hello world',
            'location': ip.text.replace('\n', ''),
        })
    }
```

- A sample template YAML file that describes your SAM application:

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Description: >
    sam-app

    Sample SAM Template for sam-app

# More info about Globals: https://github.com/awslabs/serverless-application-model/blob/
master/docs/globals.rst
Globals:
    Function:
        Timeout: 3

Resources:

    HelloWorldFunction:
        Type: AWS::Serverless::Function # More info about Function Resource:
        https://github.com/awslabs/serverless-application-model/blob/master/
        versions/2016-10-31.md#awsserverlessfunction
            Properties:
                CodeUri: hello_world/build/
                Handler: app.lambda_handler
                Runtime: python2.7
                Environment: # More info about Env Vars: https://github.com/awslabs/
                serverless-application-model/blob/master/versions/2016-10-31.md#environment-object
                    Variables:
                        PARAM1: VALUE
            Events:
                HelloWorld:
                    Type: Api # More info about API Event Source: https://github.com/
                    awslabs/serverless-application-model/blob/master/versions/2016-10-31.md#api
                        Properties:
                            Path: /hello
                            Method: get

Outputs:

    HelloWorldApi:
        Description: "API Gateway endpoint URL for Prod stage for Hello World function"
        Value: !Sub "https://${ServerlessRestApi}.execute-api.${AWS::Region}.amazonaws.com/
        Prod/hello/"

    HelloWorldFunction:
        Description: "Hello World Lambda Function ARN"
        Value: !GetAtt HelloWorldFunction.Arn

    HelloWorldFunctionIamRole:
        Description: "Implicit IAM Role created for Hello World function"
        Value: !GetAtt HelloWorldFunctionRole.Arn
```

## Next Step

[Create Your Own Serverless Application \(p. 303\)](#)

## Create Your Own Serverless Application

In the following tutorial, you create a simple serverless application that consists of a single Node.js function that returns the name of an Amazon S3 bucket you specify as an environment variable. Follow these steps:

1. Copy and paste the following Node.js code into a text file and save it as `index.js`. This represents your Lambda function.

```
var AWS = require('aws-sdk');

exports.handler = function(event, context, callback) {
  var bucketName = process.env.S3_BUCKET;
  callback(null, bucketName);
}
```

2. Paste the following into a text file and save it as `example.yaml`. Note that the `Runtime` parameter uses `nodejs6.10` but you can also specify `nodejs8.10`.

```
AWS::TemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Resources:
  TestFunction:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs6.10
      Environment:
        Variables:
          S3_BUCKET: bucket-name
```

3. Create a folder called `examplefolder` and place the `example.yaml` file and the `index.js` file inside the folder.

Your `example` folder now contains the following two files that you can then use to package the serverless application:

- `example.yaml`
- `index.js`

## Packaging and Deployment

After you create your Lambda function handler and your `example.yaml` file, you can use the AWS CLI to package and deploy your serverless application.

### Packaging

To package your application, create an Amazon S3 bucket that the `package` command will use to upload your ZIP deployment package (if you haven't specified one in your `example.yaml` file). You can use the following command to create the Amazon S3 bucket:

```
aws s3 mb s3://bucket-name --region region
```

Next, open a command prompt and type the following:

```
sam package \
--template-file path/example.yaml \
--output-template-file serverless-output.yaml \
--s3-bucket s3-bucket-name
```

The `package` command returns an AWS SAM template, in this case `serverless-output.yaml` that contains the `CodeUri` that points to the deployment zip in the Amazon S3 bucket that you specified. This template represents your serverless application. You are now ready to deploy it.

## Deployment

To deploy the application, run the following command:

```
sam deploy \
--template-file serverless-output.yaml \
--stack-name new-stack-name \
--capabilities CAPABILITY_IAM
```

Note that the value you specify for the `--template-file` parameter is the name of the SAM template that was returned by the package command. In addition, the `--capabilities` parameter is optional. The `AWS::Serverless::Function` resource will implicitly create a role to execute the Lambda function if one is not specified in the template. You use the `--capabilities` parameter to explicitly acknowledge that AWS CloudFormation is allowed to create roles on your behalf.

When you run the `sam deploy` command, it creates an AWS CloudFormation ChangeSet, which is a list of changes to the AWS CloudFormation stack, and then deploys it. Some stack templates might include resources that can affect permissions in your AWS account, for example, by creating new AWS Identity and Access Management (IAM) users. For those stacks, you must explicitly acknowledge their capabilities by specifying the `--capabilities` parameter. For more information, see [CreateChangeSet](#) in the *AWS CloudFormation API Reference*.

To verify your results, open the AWS CloudFormation console to view the newly created AWS CloudFormation stack and the Lambda console to view your function.

For a list of complete serverless application examples, see [Examples of How to Use AWS Lambda \(p. 173\)](#).

## Exporting a Serverless Application

You can export a serverless application and re-deploy it to, for example, a different AWS region or development stage, using the Lambda console. When you export a Lambda function, you will be provided with a ZIP deployment package and a SAM template that represents your serverless application. You can then use the `package` and `deploy` commands described in the previous section for re-deployment.

You can also select one of Lambda blueprints to create a ZIP package for you to package and deploy. Follow the steps following to do this:

### To export a serverless application using the Lambda console

1. Sign in to the AWS Management Console and open the AWS Lambda console at <https://console.aws.amazon.com/lambda/>.
2. Do any of the following:
  - **Create a function using a Lambda blueprint** – Choose a blueprint and follow the steps to create a Lambda function. For an example, see [Create a Simple Lambda Function \(p. 9\)](#). When you reach the **Review** page, choose **Export function**.
  - **Create a function** – Choose **Create function**, and then create your function. After your Lambda function is created, you can export it by selecting the function. Choose **Actions**, then choose **Export function**.
  - **Open an existing Lambda function** – Open the function by choosing the **Function name**, choose **Actions**, choose **Export function**.
3. In the **Export your function** window, you have the following options:
  - Choose **Download AWS SAM file**, which defines the Lambda function and other resources that comprise your serverless application.

- Choose **Download deployment package**, which contains your Lambda function code and any dependent libraries.

Use the AWS SAM file and the ZIP deployment package and follow the steps in [Packaging and Deployment \(p. 304\)](#) to re-deploy the serverless application.

## Automating Deployment of Lambda-based Applications

In the previous section, you learned how to create a SAM template, generate your deployment package, and use the AWS CLI to manually deploy your serverless application. In this section, you will leverage the following AWS services to fully automate the deployment process.

- **CodePipeline:** You use CodePipeline to model, visualize, and automate the steps required to release your serverless application. For more information, see [What is AWS CodePipeline?](#)
- **CodeBuild:** You use CodeBuild to build, locally test, and package your serverless application. For more information, see [What is AWS CodeBuild?](#)
- **AWS CloudFormation:** You use AWS CloudFormation to deploy your application. For more information, see [What is AWS CloudFormation?](#)
- **CodeDeploy:** You use [AWS CodeDeploy](#) to gradually deploy updates to your serverless applications. For more information on how to do this, see [Gradual Code Deployment \(p. 311\)](#).

The sections below demonstrate how to incorporate all these tools to incorporate your serverless applications.

## Next Step

[Building a Pipeline for Your Serverless Application \(p. 306\)](#)

## Building a Pipeline for Your Serverless Application

In the following tutorial, you will create an AWS CodePipeline that automates the deployment of your serverless application. First, you will need to set up a **source stage** to trigger your pipeline. For the purposes of this tutorial:

- We will use GitHub. For instructions on how to create a GitHub repository, see [Create a Repository in GitHub](#).
- You will need to create an AWS CloudFormation role and add the **AWSLambdaExecute** policy to that role, as outlined below:
  1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
  2. Follow the steps in [Creating a Role to Delegate Permissions to an AWS Service](#) in the *IAM User Guide* to create an IAM role (execution role) and go to the **To create a role for an AWS service** section. As you follow the steps to create a role, note the following:
    - In **Select Role Type**, choose **AWS Service Roles**, and then choose **CloudFormation**. Choose **Next: Permissions**.
    - In **Attach permissions policies**, use the search bar to find and then choose **AWSLambdaExecute**. Choose **Next: Review**.

- In **Role Name**, use a name that is unique within your AWS account (for example, **cloudformation-lambda-execution-role**) and then choose **Create role**.
- Open the role you just created and under the **Permissions** tab, choose **Add inline policy**.
- In **Create Policy** choose the **JSON** tab and enter the following:

**Note**

Make sure to replace the **region** and **id** placeholders with your region and account id.

```
{  
  "Statement": [  
    {  
      "Action": [  
        "s3:GetObject",  
        "s3:GetObjectVersion",  
        "s3:GetBucketVersioning"  
      ],  
      "Resource": "*",  
      "Effect": "Allow"  
    },  
    {  
      "Action": [  
        "s3:PutObject"  
      ],  
      "Resource": [  
        "arn:aws:s3:::codepipeline*"  
      ],  
      "Effect": "Allow"  
    },  
    {  
      "Action": [  
        "lambda:*"  
      ],  
      "Resource": [  
        "arn:aws:lambda:region:id:function:/*"  
      ],  
      "Effect": "Allow"  
    },  
    {  
      "Action": [  
        "apigateway:/*"  
      ],  
      "Resource": [  
        "arn:aws:apigateway:region::/*"  
      ],  
      "Effect": "Allow"  
    },  
    {  
      "Action": [  
        "iam:GetRole",  
        "iam:CreateRole",  
        "iam:DeleteRole",  
        "iam:PutRolePolicy"  
      ],  
      "Resource": [  
        "arn:aws:iam:id:role/*"  
      ],  
      "Effect": "Allow"  
    },  
    {  
      "Action": [  
        "iam:AttachRolePolicy",  
        "iam:DeleteRolePolicy",  
        "iam:DetachRolePolicy"  
      ],  
    }]
```

```

    "Resource": [
        "arn:aws:iam::id:role/*"
    ],
    "Effect": "Allow"
},
{
    "Action": [
        "iam:PassRole"
    ],
    "Resource": [
        "*"
    ],
    "Effect": "Allow"
},
{
    "Action": [
        "cloudformation>CreateChangeSet"
    ],
    "Resource": [
        "arn:aws:cloudformation:region:aws:transform/Serverless-2016-10-31"
    ],
    "Effect": "Allow"
},
{
    "Action": [
        "codedeploy>CreateApplication",
        "codedeploy>DeleteApplication",
        "codedeploy:RegisterApplicationRevision"
    ],
    "Resource": [
        "arn:aws:codedeploy:region:id:application:/*"
    ],
    "Effect": "Allow"
},
{
    "Action": [
        "codedeploy>CreateDeploymentGroup",
        "codedeploy>CreateDeployment",
        "codedeploy:GetDeployment"
    ],
    "Resource": [
        "arn:aws:codedeploy:region:id:deploymentgroup:/*"
    ],
    "Effect": "Allow"
},
{
    "Action": [
        "codedeploy:GetDeploymentConfig"
    ],
    "Resource": [
        "arn:aws:codedeploy:region:id:deploymentconfig:/*"
    ],
    "Effect": "Allow"
}
],
"Version": "2012-10-17"
}

```

- Choose **Validate Policy** and then choose **Apply Policy**.

## Step 1: Set Up Your Repository

You can use any of the Lambda supported runtimes when setting up a repository. The following example uses Node.js.

To set up your repository, do the following:

- Add an *index.js* file containing the code following:

```
var time = require('time');
exports.handler = (event, context, callback) => {
    var currentTime = new Date();
    currentTime.settimezone("America/Los_Angeles");
    callback(null, {
        statusCode: '200',
        body: 'The time in Los Angeles is: ' + currentTime.toString(),
    });
};
```

- Add a *samTemplate.yaml* file, containing the content following. This is the SAM template that defines the resources in your application. This SAM template defines a Lambda function that is triggered by API Gateway. Note that the runtime parameter uses nodejs6.10 but you can also specify nodejs8.10. For more information about AWS SAM see [AWS Serverless Application Model](#).

```
AWSTemplateFormatVersion: '2010-09-09'
Transform: AWS::Serverless-2016-10-31
Description: Outputs the time
Resources:
  TimeFunction:
    Type: AWS::Serverless::Function
    Properties:
      Handler: index.handler
      Runtime: nodejs6.10
      CodeUri: ../
    Events:
      MyTimeApi:
        Type: Api
        Properties:
          Path: /TimeResource
          Method: GET
```

- Add a *buildspec.yml* file. A build spec is a collection of build commands and related settings, in YAML format, that AWS CodeBuild uses to run a build. For more information, see [Build Specification Reference for AWS CodeBuild](#). In this example, the build action will be:
  - Use [npm](#) to install the time package.
  - Run the Package command to prepare your deployment package for subsequent deployment steps in your pipeline. For more information on the package command, see [Uploading Local Artifacts to an S3 Bucket](#)

```
version: 0.1
phases:
  install:
    commands:
      - npm install time
      - aws cloudformation package --template-file samTemplate.yaml --s3-bucket bucket-name
                                                --output-template-file outputSamTemplate.yaml
  artifacts:
    type: zip
    files:
      - samTemplate.yaml
      - outputSamTemplate.yaml
```

Note that you need to supply the `--s3-bucket` parameter value with the name of your Amazon S3 bucket, similar to the step you would take if you were manually going to package the deployment package with SAM, as discussed in the [Packaging \(p. 304\)](#) step of the previous tutorial.

## Step 2: Create Your Pipeline

Follow the steps following to create your AWS CodePipeline.

1. Sign in to the AWS Management Console and open the AWS CodePipeline console.
2. Choose **Get Started Now**.
3. In **Pipeline name**: enter a name for your pipeline and then choose **Next step**.
4. In **Source provider**: choose **GitHub**.
5. Choose **Connect to GitHub**; and then choose the **Repository** and **Branch** you want to connect to. Every git push to the branch you select will trigger your pipeline. Choose **Next step**.
6. Choose **AWS CodeBuild** as your **Build provider**.
7. Choose **Create a new build project** and enter a project name.
8. Choose **Ubuntu** as the operating system.
9. Choose **Node.js** as the runtime.
10. In **Version** choose `aws/codebuild/nodejs:version`
11. In **Build specification** choose `Use the buildspec.yml in the source code root directory`
12. Choose **Save build project**.

**Note**

A service role for AWS CodeBuild will automatically be created on your behalf.

Choose **Next step**.

13. In **Deployment provider\*** choose **AWS CloudFormation**.

By selecting this option, AWS CloudFormation commands will be used to deploy the SAM template. For more information see [Serverless Resources Within AWS SAM \(p. 297\)](#).

14. In **Action mode**: choose **Create or replace a change set**.
15. In **Stack name**: enter **MyBetaStack**.
16. In **Change set name**: enter **MyChangeSet**.
17. In **Template file**: enter **outputSamTemplate.yaml**.
18. In **Capabilities**: choose **CAPABILITY\_IAM**.
19. In **Role** select the AWS CloudFormation role you created at the beginning of this tutorial and then choose **Next step**.
20. Choose **Create role**. Choose **Next** and then choose **Allow**. Choose **Next step**.
21. Review your pipeline and then choose **Create pipeline**.

## Step 3: Update the Generated Service Policy

Complete the following steps to allow CodeBuild to upload build artifacts to your Amazon S3 bucket.

1. Go to the IAM Management Console.
2. Choose **Roles**.

3. Open the service role that was generated for your project, typically **code-build-project-name-service-role**.
4. Under the **Permissions** tab, choose **Add inline policy**.
5. In **service**, choose **Choose a service**.
6. In **Select a service below**, choose **S3**.
7. In **Actions**, choose **Select actions**.
8. Expand **Write** under **Access level groups** and then choose **PutObject**.
9. Choose **Resources** and then choose the **Any** checkbox.
10. Choose **Review policy**.
11. Enter a **Name\*** and then choose **Create policy**. Then return to the pipeline you created in the previous section.

## Step 4: Complete Your Beta Deployment Stage

Use the following steps to complete your Beta stage.

1. Choose **Edit**.
2. Choose the + icon next to **MyBetaStack**.
3. In **Action category**, if not already selected, choose **Deploy**.
4. In **Deployment provider\***, if not already selected, choose **AWS CloudFormation**.
5. In **Action mode\*** choose **Execute a change set**. This is similar to the step you would take if you were manually going to deploy the package, as discussed in the [Deployment \(p. 305\)](#) step of the previous tutorial. `CreateChangeSet` transforms the SAM template to the full AWS CloudFormation format and `deployChangeSet` deploys the AWS CloudFormation template.
6. In **Stack name\*** enter or choose **MyBetaStack**.
7. In **Change set name\*** enter **MyChangeSet**.
8. Choose **Add action**.
9. Choose **Save pipeline changes**.
10. Choose **Save and continue**.

Your pipeline is ready. Any git push to the branch you connected to this pipeline is going to trigger a deployment. To test your pipeline and deploy your application for the first time, do one of the following:

- Perform a git push to the branch connected to your pipeline.
- Go the AWS CodePipeline console, choose the name of the pipeline you created and then choose **Release change**.

## Next Step

[Gradual Code Deployment \(p. 311\)](#)

## Gradual Code Deployment

If you use AWS SAM to create your serverless application, it comes built-in with [AWS CodeDeploy](#) for safe Lambda deployments. With just a few lines of configuration, SAM will do the following for you:

- Deploy new versions of your Lambda function and automatically create aliases that point to the new version.

- Gradually shift customer traffic to the new version until you are satisfied it is working as expected or roll back the update.
- Define pre-traffic and post-traffic test functions to verify the newly deployed code is configured correctly and your application operates as expected.
- Roll back the deployment if CloudWatch alarms are triggered.

This can all be done by updating your SAM template. The example below demonstrates a simple version of using Code Deploy to gradually shift customers to your newly deployed version:

```
Resources:
MyLambdaFunction:
  Type: AWS::Serverless::Function
  Properties:
    Handler: index.handler
    Runtime: nodejs4.3
    CodeUri: s3://bucket/code.zip

  AutoPublishAlias: live

  DeploymentPreference:
    Type: Canary10Percent10Minutes
    Alarms:
      # A list of alarms that you want to monitor
      - !Ref AliasErrorMetricGreaterThanZeroAlarm
      - !Ref LatestVersionErrorMetricGreaterThanZeroAlarm
    Hooks:
      # Validation Lambda functions that are run before & after traffic shifting
      PreTraffic: !Ref PreTrafficLambdaFunction
      PostTraffic: !Ref PostTrafficLambdaFunction
```

The above revisions to a SAM template do the following:

- **AutoPublishAlias** - By adding this property and specifying an alias name, AWS SAM will do the following:
  - Detect when new code is being deployed based on changes to the Lambda function's Amazon S3 URI.
  - Create and publish an updated version of that function with the latest code.
  - Create an alias with a name you provide (unless an alias already exists) and points to the updated version of the Lambda function. Function invocations should use the alias qualifier to take advantage of this. If you are not familiar with Lambda function versioning and aliases, see [AWS Lambda Function Versioning and Aliases \(p. 277\)](#).
- **Deployment Preference Type** - In the above example, 10 percent of your customer traffic will be immediately shifted to your new version and after 10 minutes all traffic will be shifted to the new version. However, if either your pre- and post hook tests fail or a CloudWatch alarm is triggered, CodeDeploy will roll back your deployment. The table below outlines other traffic-shifting options available beyond the one used above. Note the following:
  - **Canary**: Traffic is shifted in two increments. You can choose from predefined canary options that specify the percentage of traffic shifted to your updated Lambda function version in the first increment and the interval, in minutes, before the remaining traffic is shifted in the second increment.
  - **Linear**: Traffic is shifted in equal increments with an equal number of minutes between each increment. You can choose from predefined linear options that specify the percentage of traffic shifted in each increment and the number of minutes between each increment.
  - **All-at-once**: All traffic is shifted from the original Lambda function to the updated Lambda function version at once.

Deployment Preference Type
Canary10Percent30Minutes
Canary10Percent5Minutes
Canary10Percent10Minutes
Canary10Percent15Minutes
Linear10PercentEvery10Minutes
Linear10PercentEvery1Minute
Linear10PercentEvery2Minutes
Linear10PercentEvery3Minutes
AllAtOnce

- **Alarms** - CloudWatch alarms that will be triggered by any errors raised by the deployment and automatically roll back your deployment. For instance, if the updated code you are deploying is creating errors within the application or any [AWS Lambda](#) or custom CloudWatch metrics you have specified have breached the alarm threshold.
- **Hooks** - Pre-traffic and Post-traffic test functions that run sanity checks before traffic-shifting starts to the new version and after traffic-shifting completes.
  - **PreTraffic:** Before traffic shifting starts, CodeDeploy will invoke the pre-traffic hook Lambda function. This Lambda function must call back to CodeDeploy denoting success or failure. On failure, it will abort and report a failure back to AWS CloudFormation. On success, CodeDeploy will proceed to traffic shifting.
  - **PostTraffic:** After traffic shifting completes, CodeDeploy will invoke the post-traffic hook Lambda function. This is similar to pre-traffic hook, where the function must call back to CodeDeploy to report a success or failure. Use post-traffic hooks to run integration tests or other validation actions.

For more information, see [SAM Reference to Safe Deployments](#).

# Monitoring and Troubleshooting Lambda-based Applications

AWS Lambda will automatically track the behavior of your Lambda function invocations and provide feedback that you can monitor. In addition, it provides metrics that allows you to analyze the full function invocation spectrum, including event source integration and whether downstream resources perform as expected. The following sections provide guidance on the tools you can use analyze your Lambda function invocation behavior:

## Topics

- [Using Amazon CloudWatch \(p. 314\)](#)
- [Using AWS X-Ray \(p. 322\)](#)

## Using Amazon CloudWatch

AWS Lambda automatically monitors Lambda functions on your behalf, reporting metrics through Amazon CloudWatch. To help you monitor your code as it executes, Lambda automatically tracks the number of requests, the latency per request, and the number of requests resulting in an error and publishes the associated CloudWatch metrics. You can leverage these metrics to set CloudWatch custom alarms. For more information about CloudWatch, see the [Amazon CloudWatch User Guide](#).

You can view request rates and error rates for each of your Lambda functions by using the AWS Lambda console, the CloudWatch console, and other Amazon Web Services (AWS) resources. The following topics describe Lambda CloudWatch metrics and how to access them.

- [Accessing Amazon CloudWatch Metrics for AWS Lambda \(p. 316\)](#)
- [AWS Lambda Metrics \(p. 319\)](#)

You can insert logging statements into your code to help you validate that your code is working as expected. Lambda automatically integrates with Amazon CloudWatch Logs and pushes all logs from your code to a CloudWatch Logs group associated with a Lambda function (`/aws/lambda/<function name>`). To learn more about log groups and accessing them through the CloudWatch console, see the [Monitoring System, Application, and Custom Log Files](#) in the [Amazon CloudWatch User Guide](#). For information about how to access CloudWatch log entries, see [Accessing Amazon CloudWatch Logs for AWS Lambda \(p. 318\)](#).

### Note

If your Lambda function code is executing, but you don't see any log data being generated after several minutes, this could mean your execution role for the Lambda function did not grant permissions to write log data to CloudWatch Logs. For information about how to make sure that you have set up the execution role correctly to grant these permissions, see [Manage Permissions: Using an IAM Role \(Execution Role\) \(p. 362\)](#).

## AWS Lambda Troubleshooting Scenarios

This sections describes examples of how to monitor and troubleshoot your Lambda functions using the logging and monitoring capabilities of CloudWatch.

## Troubleshooting Scenario 1: Lambda Function Not Working as Expected

In this scenario, you have just finished [Tutorial: Using AWS Lambda with Amazon S3 \(p. 174\)](#). However, the Lambda function you created to upload a thumbnail image to Amazon S3 when you create an S3 object is not working as expected. When you upload objects to Amazon S3, you see that the thumbnail images are not being uploaded. You can troubleshoot this issue in the following ways.

### To determine why your Lambda function is not working as expected

1. Check your code and verify that it is working correctly. An increased error rate would indicate that it is not.

You can test your code locally as you would any other Node.js function, or you can test it within the Lambda console using the console's test invoke functionality, or you can use the AWS CLI `Invoke` command. Each time the code is executed in response to an event, it writes a log entry into the log group associated with a Lambda function, which is `/aws/lambda/<function name>`.

Following are some examples of errors that might show up in the logs:

- If you see a `stack trace` in your log, there is probably an error in your code. Review your code and debug the error that the stack trace refers to.
- If you see a `permissions denied` error in the log, the IAM role you have provided as an execution role may not have the necessary permissions. Check the IAM role and verify that it has all of the necessary permissions to access any AWS resources that your code references. To ensure that you have correctly set up the execution role, see [Manage Permissions: Using an IAM Role \(Execution Role\) \(p. 362\)](#).
- If you see a `timeout exceeded` error in the log, your timeout setting exceeds the run time of your function code. This may be because the timeout is too low, or the code is taking too long to execute.
- If you see a `memory exceeded` error in the log, your memory setting is too low. Set it to a higher value. For information about memory size limits, see [CreateFunction \(p. 412\)](#). When you change the memory setting, it can also change how you are charged for [AWS Lambda product website](#) duration.

For information about pricing, see the [AWS Lambda product website](#).

2. Check your Lambda function and verify that it is receiving requests.

Even if your function code is working as expected and responding correctly to test invokes, the function may not be receiving requests from Amazon S3. If Amazon S3 is able to invoke the function, you should see an increase in your CloudWatch requests metrics. If you do not see an increase in your CloudWatch requests, check the access permissions policy associated with the function.

## Troubleshooting Scenario 2: Increased Latency in Lambda Function Execution

In this scenario, you have just finished [Tutorial: Using AWS Lambda with Amazon S3 \(p. 174\)](#). However, the Lambda function you created to upload a thumbnail image to Amazon S3 when you create an S3 object is not working as expected. When you upload objects to Amazon S3, you can see that the thumbnail images are being uploaded, but your code is taking much longer to execute than expected. You can troubleshoot this issue in a couple of different ways. For example, you could monitor the latency CloudWatch metric for the Lambda function to see if the latency is increasing. Or you could see an increase in the CloudWatch errors metric for the Lambda function, which might be due to timeout errors.

## To determine why there is increased latency in the execution of a Lambda function

1. Test your code with different memory settings.

If your code is taking too long to execute, it could be that it does not have enough compute resources to execute its logic. Try increasing the memory allocated to your function and testing the code again, using the Lambda console's test invoke functionality. You can see the memory used, code execution time, and memory allocated in the function log entries. Changing the memory setting can change how you are charged for duration. For information about pricing, see [AWS Lambda](#).

2. Investigate the source of the execution bottleneck that is using logs.

You can test your code locally, as you would with any other Node.js function, or you can test it within Lambda using the test invoke capability on the Lambda console, or using the `asyncInvoke` command by using AWS CLI. Each time the code is executed in response to an event, it writes a log entry into the log group associated with a Lambda function, which is named `aws/lambda/<function name>`. Add logging statements around various parts of your code, such as callouts to other services, to see how much time it takes to execute different parts of your code.

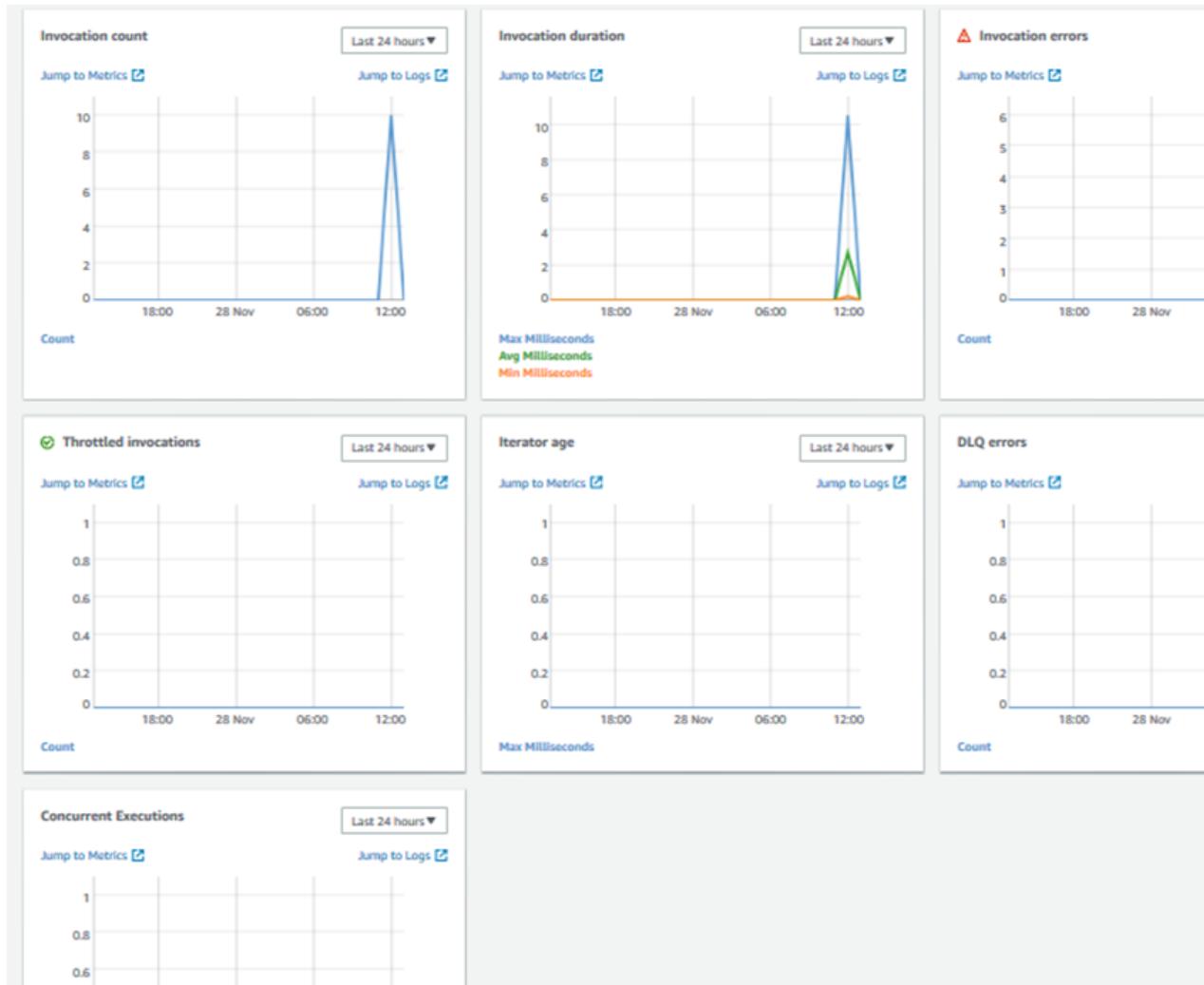
## Accessing Amazon CloudWatch Metrics for AWS Lambda

AWS Lambda automatically monitors functions on your behalf, reporting metrics through Amazon CloudWatch. These metrics include total requests, latency, and error rates. For more information about Lambda metrics, see [AWS Lambda Metrics \(p. 319\)](#). For more information about CloudWatch, see the [Amazon CloudWatch User Guide](#).

You can monitor metrics for Lambda and view logs by using the Lambda console, the CloudWatch console, the AWS CLI, or the CloudWatch API. The following procedures show you how to access metrics using these different methods.

### To access metrics using the Lambda console

1. Sign in to the AWS Management Console and open the AWS Lambda console at <https://console.aws.amazon.com/lambda/>.
2. On the **Functions** page, choose the function name and then choose the **Monitoring** tab.



A graphical representation of the metrics for the Lambda function are shown.

3. Choose **Jump to logs** to view the logs.

### To access metrics using the CloudWatch console

1. Open the CloudWatch console at <https://console.aws.amazon.com/cloudwatch/>.
2. From the navigation bar, choose a region.
3. In the navigation pane, choose **Metrics**.
4. In the **CloudWatch Metrics by Category** pane, choose **Lambda Metrics**.
5. (Optional) In the graph pane, choose a statistic and a time period, and then create a CloudWatch alarm using these settings.

### To access metrics using the AWS CLI

Use the `list-metrics` and `get-metric-statistics` commands.

### To access metrics using the CloudWatch CLI

Use the `mon-list-metrics` and `mon-get-stats` commands.

### To access metrics using the CloudWatch API

Use the [ListMetrics](#) and [GetMetricStatistics](#) operations.

## 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, 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>`. To learn more about log groups and accessing them through the CloudWatch console, see the [Monitoring System, Application, and Custom Log Files](#) in the *Amazon CloudWatch User Guide*.

You can view logs for Lambda by using the Lambda console, the CloudWatch console, the AWS CLI, or the CloudWatch API. The following procedure show you how to view the logs by using the Lambda console.

**<step>**

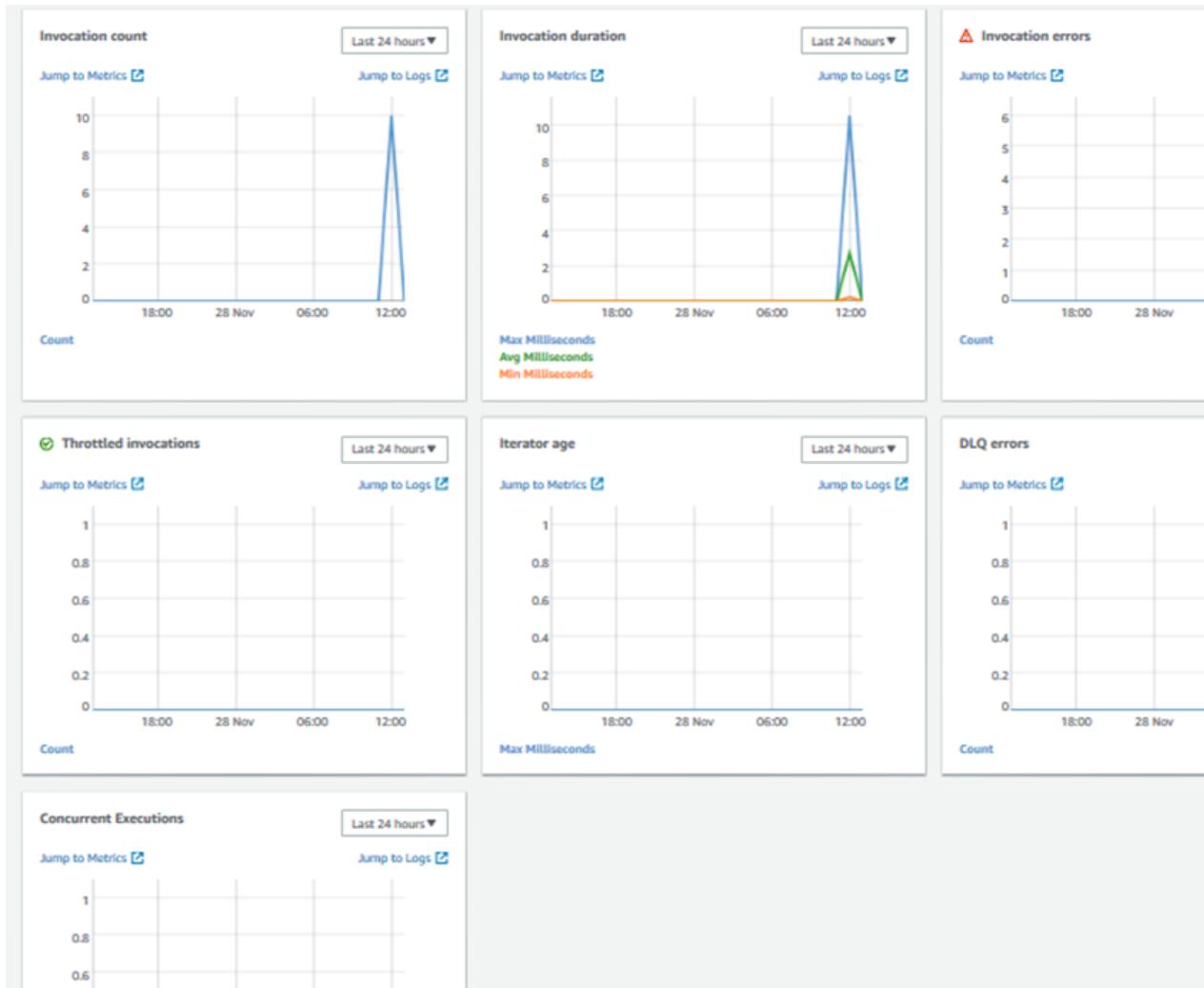
If you have not created a Lambda function before, see [Getting Started \(p. 3\)](#).  
**</step>**

#### Note

There is no additional charge for using Lambda logs; however, standard CloudWatch Logs charges apply. For more information, see [CloudWatch Pricing](#).

### To view logs using the Lambda console

1. Sign in to the AWS Management Console and open the AWS Lambda console at <https://console.aws.amazon.com/lambda/>.
2. On the **Functions** page, choose the function name and then choose the **Monitoring** tab.



A graphical representation of the metrics for the Lambda function are shown.

3. Choose **Jump to logs** to view the logs.

For more information on accessing CloudWatch Logs, see the following guides:

- [Amazon CloudWatch User Guide](#)
- [Amazon CloudWatch Logs API Reference](#)
- [Monitoring Log Files in the Amazon CloudWatch User Guide](#)

## AWS Lambda Metrics

This topic describes the AWS Lambda namespace, metrics, and dimensions. AWS Lambda automatically monitors functions on your behalf, reporting metrics through Amazon CloudWatch. These metrics include total invocations, errors, duration, throttles, DLQ errors and Iterator age for stream-based invocations.

CloudWatch is basically a metrics repository. A metric is the fundamental concept in CloudWatch and represents a time-ordered set of data points. You (or AWS services) publish metrics data points into CloudWatch and you retrieve statistics about those data points as an ordered set of time-series data.

Metrics are uniquely defined by a name, a namespace, and one or more dimensions. Each data point has a time stamp, and, optionally, a unit of measure. When you request statistics, the returned data stream is identified by namespace, metric name, and dimension. For more information about CloudWatch, see the [Amazon CloudWatch User Guide](#).

## AWS Lambda CloudWatch Metrics

The AWS/Lambda namespace includes the following metrics.

Metric	Description
Invocations	<p>Measures the number of times a function is invoked in response to an event or invocation API call. This replaces the deprecated RequestCount metric. This includes successful and failed invocations, but does not include throttled attempts. This equals the billed requests for the function. Note that AWS Lambda only sends these metrics to CloudWatch if they have a nonzero value.</p> <p>Units: Count</p>
Errors	<p>Measures the number of invocations that failed due to errors in the function (response code 4XX). This replaces the deprecated ErrorCount metric. Failed invocations may trigger a retry attempt that succeeds. This includes:</p> <ul style="list-style-type: none"> <li>• Handled exceptions (for example, context.fail(error))</li> <li>• Unhandled exceptions causing the code to exit</li> <li>• Out of memory exceptions</li> <li>• Timeouts</li> <li>• Permissions errors</li> </ul> <p>This does not include invocations that fail due to invocation rates exceeding default concurrent limits (error code 429) or failures due to internal service errors (error code 500).</p> <p>Units: Count</p>
Dead Letter Error	<p>Incremented when Lambda is unable to write the failed event payload to your configured Dead Letter Queues. This could be due to the following:</p> <ul style="list-style-type: none"> <li>• Permissions errors</li> <li>• Throttles from downstream services</li> <li>• Misconfigured resources</li> <li>• Timeouts</li> </ul> <p>Units: Count</p>
Duration	<p>Measures the elapsed wall clock time from when the function code starts executing as a result of an invocation to when it stops executing. This replaces the deprecated Latency metric. The maximum data point value possible is the function timeout configuration. The billed duration will be</p>

Metric	Description
	<p>rounded up to the nearest 100 millisecond. Note that AWS Lambda only sends these metrics to CloudWatch if they have a nonzero value.</p> <p>Units: Milliseconds</p>
Throttles	<p>Measures the number of Lambda function invocation attempts that were throttled due to invocation rates exceeding the customer's concurrent limits (error code 429). Failed invocations may trigger a retry attempt that succeeds.</p> <p>Units: Count</p>
IteratorAge	<p>Emitted for stream-based invocations only (functions triggered by an Amazon DynamoDB stream or Kinesis stream). Measures the age of the last record for each batch of records processed. Age is the difference between the time Lambda received the batch, and the time the last record in the batch was written to the stream.</p> <p>Units: Milliseconds</p>
ConcurrentExecutions	<p>Emitted as an aggregate metric for all functions in the account, and for functions that have a custom concurrency limit specified. Not applicable for versions or aliases. Measures the sum of concurrent executions for a given function at a given point in time. Must be viewed as an average metric if aggregated across a time period.</p> <p>Units: Count</p>
UnreservedConcurrency	<p>Emitted as an aggregate metric for all functions in the account only. Not applicable for functions, versions, or aliases. Represents the sum of the concurrency of the functions that do not have a custom concurrency limit specified. Must be viewed as an average metric if aggregated across a time period.</p> <p>Units: Count</p>

### Errors/Invocations Ratio

When calculating the error rate on Lambda function invocations, it's important to distinguish between an invocation request and an actual invocation. It is possible for the error rate to exceed the number of billed Lambda function invocations. Lambda reports an invocation metric only if the Lambda function code is executed. If the invocation request yields a throttling or other initialization error that prevents the Lambda function code from being invoked, Lambda will report an error, but it does not log an invocation metric.

- Lambda emits `Invocations=1` when the function is executed. If the Lambda function is not executed, nothing is emitted.
- Lambda emits a data point for `Errors` for each invoke request. `Errors=0` means that there is no function execution error. `Errors=1` means that there is a function execution error.
- Lambda emits a data point for `Throttles` for each invoke request. `Throttles=0` means there is no invocation throttle. `Throttles=1` means there is an invocation throttle.

## AWS Lambda CloudWatch Dimensions

You can use the dimensions in the following table to refine the metrics returned for your Lambda functions.

Dimension	Description
FunctionName	Filters the metric data by Lambda function.
Resource	Filters the metric data by Lambda function resource, such as function version or alias.
Version	Filters the data you request for a Lambda version.
Alias	Filters the data you request for a Lambda alias.
Executed Version	Filters the metric data by Lambda function versions. This only applies to alias invocations.

## Using AWS X-Ray

A typical Lambda-based application consists of one or more functions triggered by events such as object uploads to Amazon S3, Amazon SNS notifications, and API actions. Once triggered, those functions usually call downstream resources such as DynamoDB tables or Amazon S3 buckets, or make other API calls. AWS Lambda leverages Amazon CloudWatch to automatically emit metrics and logs for all invocations of your function. However, this mechanism might not be convenient for tracing the event source that invoked your Lambda function, or for tracing downstream calls that your function made. For a complete overview of how tracing works, see [AWS X-Ray](#).

## Tracing Lambda-Based Applications with AWS X-Ray

AWS X-Ray is an AWS service that allows you to detect, analyze, and optimize performance issues with your AWS Lambda applications. X-Ray collects metadata from the Lambda service and any upstream or downstream services that make up your application. X-Ray uses this metadata to generate a detailed service graph that illustrates performance bottlenecks, latency spikes, and other issues that impact the performance of your Lambda application.

After using the [Lambda on the AWS X-Ray Service Map \(p. 322\)](#) to identify a problematic resource or component, you can zoom in and view a visual representation of the request. This visual representation covers the time from when an event source triggers a Lambda function until the function execution has completed. X-Ray provides you with a breakdown of your function's operations, such as information regarding downstream calls your Lambda function made to other services. In addition, X-Ray integration with Lambda provides you with visibility into the AWS Lambda service overhead. It does so by displaying specifics such as your request's dwell time and number of invocations.

### Note

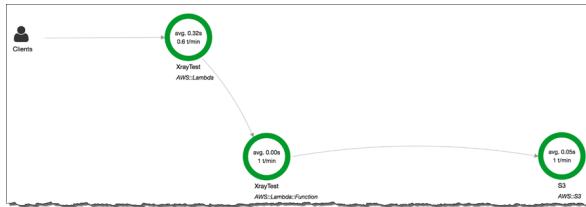
Only services that currently integrate with X-Ray show as standalone traces, outside of your Lambda trace. For a list of services that currently support X-Ray, see [Integrating AWS X-Ray with Other AWS Services](#).

## Lambda on the AWS X-Ray Service Map

X-Ray displays three types of nodes on the service map for requests served by Lambda:

- **Lambda service (AWS::Lambda)** – This type of node represents the time the request spent in the Lambda service. Timing starts when Lambda first receives the request and ends when the request leaves the Lambda service.
- **Lambda function (AWS::Lambda::Function)** – This type of node represents the Lambda function's execution time.
- **Downstream service calls** – In this type, each downstream service call from within the Lambda function is represented by a separate node.

In the diagram following, the nodes represent (from left to right): The Lambda service, the user function, and a downstream call to Amazon S3:



For more information, see [Viewing the Service Map](#).

## Lambda as an AWS X-Ray Trace

From the service map, you can zoom in to see a trace view of your Lambda function. The trace will display in-depth information regarding your function invocations, represented as segments and subsegments:

- **Lambda service segment** – This segment represents different information depending on the event source used to invoke the function:
  - **Synchronous and stream event sources** – The service segment measures the time from when the Lambda service receives the request/event and ends when the request leaves the Lambda service (after the final invocation for the request is completed).
  - **Asynchronous** – The service segment represents the response time, that is, the time it took the Lambda service to return a 202 response to the client.

The Lambda service segment can include two types of subsegments:

- **Dwell time (asynchronous invocations only)** – Represents the time the function spends in the Lambda service before being invoked. This subsegment starts when the Lambda service receives the request/event and ends when the Lambda function is invoked for the first time.
- **Attempt** – Represents a single invocation attempt, including any overhead introduced by the Lambda service. Examples of overhead are time spent initializing the function's code and function execution time.
- **Lambda function segment** – Represents execution time for the function for a given invocation attempt. It starts when the function handler starts executing and ends when the function terminates. This segment can include three types of subsegments:
  - **Initialization** – The time spent running the initialization code of the function, defined as the code outside the Lambda function handler or static initializers.
  - **Downstream calls** – Calls made to other AWS services from the Lambda function's code.
  - **Custom subsegments** – Custom subsegments or user annotations that you can add to the Lambda function segment by using the X-Ray SDK.

**Note**

For each traced invocation, Lambda emits the Lambda service segment and all of its subsegments. These segments are emitted regardless of the runtime and require you to use the XRay SDK for AWS API calls.

## Setting Up AWS X-Ray with Lambda

Following, you can find detailed information on how to set up X-Ray with Lambda.

### Before You Begin

To enable tracing on your Lambda function using the Lambda CLI, you must first add tracing permissions to your function's execution role. To do so, take the following steps:

- Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
- Find the execution role for your Lambda function.
- Attach the following managed policy: `AWSXrayWriteOnlyAccess`

To learn more about these policies, see [AWS X-Ray](#).

If you are changing the tracing mode to active using the Lambda console, tracing permissions are added automatically, as explained in the next section.

## Tracing

The path of a request through your application is tracked with a trace ID. A *trace* collects all of the segments generated by a single request, typically an HTTP GET or POST request.

There are two modes of tracing for a Lambda function:

- **Pass Through:** This is the default setting for all Lambda functions if you have added tracing permissions to your function's execution role. This approach means the Lambda function is only traced if X-Ray has been enabled on an upstream service, such as AWS Elastic Beanstalk.
- **Active:** When a Lambda function has this setting, Lambda automatically samples invocation requests, based on the sampling algorithm specified by X-Ray.

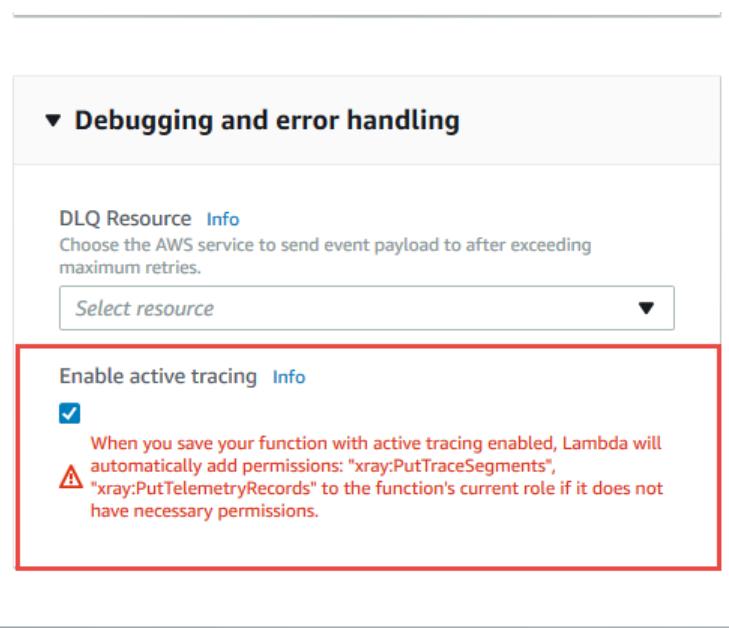
**Note**

X-Ray applies a sampling algorithm to ensure that tracing is efficient, while still providing a representative sample of the requests that your application serves. The default sampling algorithm is 1 request per minute, with 5 percent of requests sampled past that limit. However, if the traffic volume to your function is low, you may see an increased rate of sampling.

You can change the tracing mode for your Lambda function by using either the Lambda Management Console or the Lambda [CreateFunction](#) (p. 412) or [UpdateFunctionConfiguration](#) (p. 502) API actions.

If you use the Lambda console, the following applies:

- When you change a function's tracing mode to active, tracing permissions are automatically attached to the function's execution role. If you receive an error stating Lambda couldn't add the `AWSXrayWriteOnlyAccess` policy to your function's execution role, sign in to the IAM console at <https://console.aws.amazon.com/iam/> and manually add the policy.
- To enable active tracing, go to the **Configuration** tab your function and select the **Enable active tracing** box.



If you use the Lambda [CreateFunction \(p. 412\)](#) or [UpdateFunctionConfiguration \(p. 502\)](#) API actions:

- If you want the tracing mode to be active, set the `TracingConfig` parameter's `Mode` property to `Active`. Again, any new function has its tracing mode set to `PassThrough` by default.
- Any new or updated Lambda function has its `$LATEST` version set to the value you specify.

**Note**

You receive an error if you haven't added tracing permissions to your function's execution role. For more information, see [Before You Begin \(p. 324\)](#).

## Emitting Trace Segments from a Lambda Function

For each traced invocation, Lambda will emit the Lambda service segment and all of its subsegments. In addition, Lambda will emit the Lambda function segment and the init subsegment. These segments will be emitted regardless of the function's runtime, and with no code changes or additional libraries required. If you want your Lambda function's X-Ray traces to include custom segments, annotations, or subsegments for downstream calls, you might need to include additional libraries and annotate your code.

Note that any instrumentation code must be implemented inside the Lambda function handler and not as part of the initialization code.

The following examples explain how to do this in the supported runtimes:

- [Node.js \(p. 326\)](#)
- [Java \(p. 327\)](#)
- [Python \(p. 328\)](#)
- [Go \(p. 330\)](#)

## Node.js

In Node.js, you can have Lambda emit subsegments to X-Ray to show you information about downstream calls to other AWS services made by your function. To do so, you first need to include the [the AWS X-Ray SDK for Node.js](#) in your deployment package. In addition, wrap your AWS SDK `require` statement in the following manner:

```
var AWSXRay = require('aws-xray-sdk-core');
var AWS = AWSXRay.captureAWS(require('aws-sdk'));
```

Then, use the `AWS` variable defined in the preceding example to initialize any service client that you want to trace with X-Ray, for example:

```
s3Client = AWS.S3();
```

After following these steps, any call made from your function using `s3Client` results in an X-Ray subsegment that represents that call. As an example, you can run the Node.js function following to see how the trace looks in X-Ray:

```
var AWSXRay = require('aws-xray-sdk-core');
var AWS = AWSXRay.captureAWS(require('aws-sdk'));

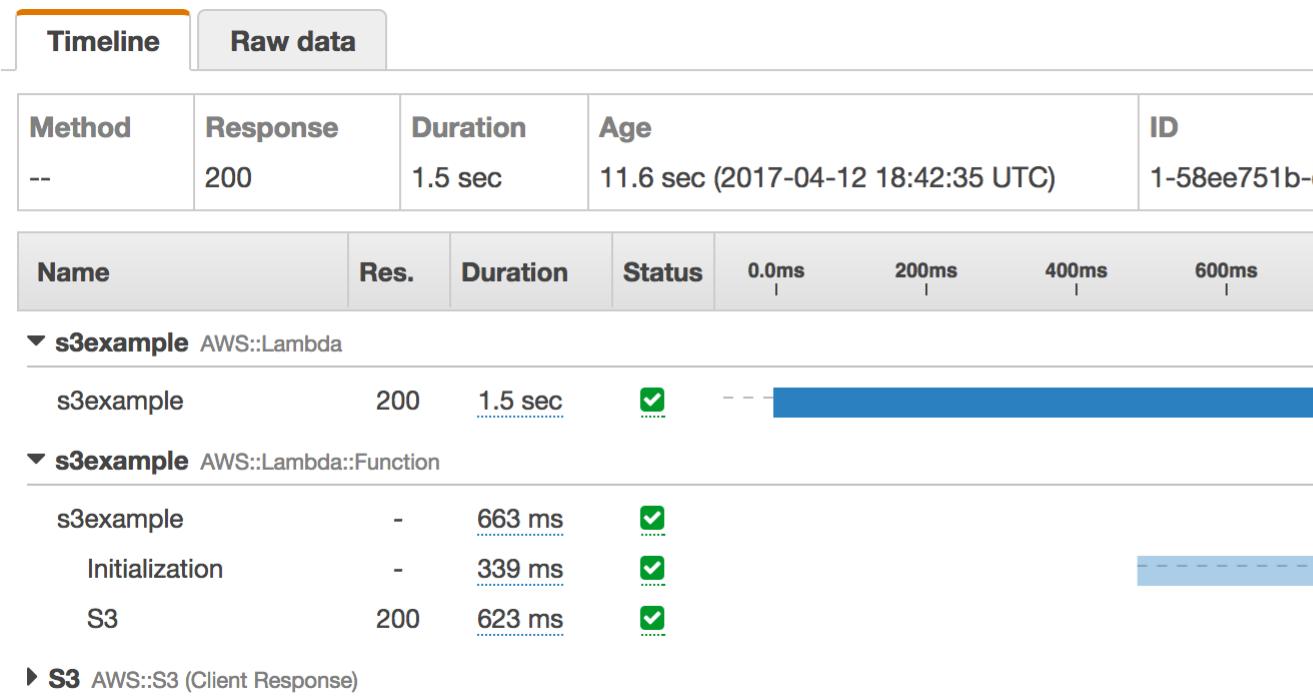
s3 = new AWS.S3({signatureVersion: 'v4'});

exports.handler = (event, context, callback) => {

    var params = {Bucket: BUCKET_NAME, Key: BUCKET_KEY, Body: BODY};

    s3.putObject(params, function(err, data) {
        if (err)
            { console.log(err) }
        else {
            console.log('success!')
        }
    });
};
```

Following is what a trace emitted by the code preceding looks like (asynchronous invocation):



## Java

In Java, you can have Lambda emit subsegments to X-Ray to show you information regarding downstream calls to other AWS services made by your function. To take advantage of this capability, include the [AWS X-Ray SDK for Java](#) in your deployment package. No code changes are needed. As long as you are using an AWS SDK version 1.11.48 or later, there is no need to add any additional code lines for downstream calls from your function to be traced.

The AWS SDK will dynamically import the X-Ray SDK to emit subsegments for downstream calls made by your function. By using the X-Ray SDK for Java, you can instrument your code in order to emit custom subsegments and or add annotations to your X-Ray segments.

The following example uses the X-Ray SDK for Java to instrument a Lambda function to emit a custom subsegment and send custom annotation to X-Ray:

```
package uptime;

import java.io.IOException;
import java.time.Instant;
import java.util.HashMap;
import java.util.Map;

import org.apache.commons.logging.Log;
import org.apache.commons.logging.LogFactory;
import org.apache.http.HttpResponse;
import org.apache.http.client.HttpClient;
import org.apache.http.client.methods.HttpGet;

import com.amazonaws.regions.Regions;
import com.amazonaws.services.dynamodbv2.AmazonDynamoDB;
import com.amazonaws.services.dynamodbv2.AmazonDynamoDBClientBuilder;
import com.amazonaws.services.dynamodbv2.model.AttributeValue;
```

```

import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.xray.AWSXRay;
import com.amazonaws.xray.proxies.apache.http.HttpClientBuilder;

public class Hello {
    private static final Log logger = LogFactory.getLog(Hello.class);

    private static final AmazonDynamoDB dynamoClient;
    private static final HttpClient httpClient;

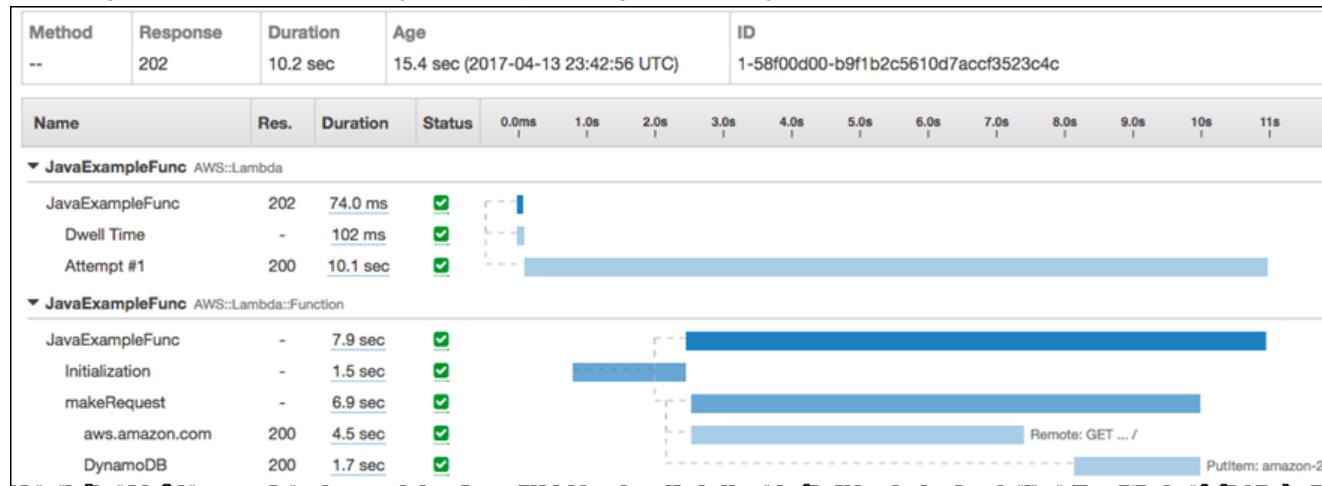
    static {
        dynamoClient =
AmazonDynamoDBClientBuilder.standard().withRegion(Regions.US_EAST_1).build();
        httpClient = HttpClientBuilder.create().build();
    }
    public void checkUptime(Context context) {
        AWSXRay.createSubsegment("makeRequest", (subsegment) -> {

            HttpGet request = new HttpGet("https://aws.amazon.com/");
            boolean is2xx = false;

            try {
                HttpResponse response = httpClient.execute(request);
                is2xx = (response.getStatusLine().getStatusCode() / 100) == 2;
                subsegment.putAnnotation("statusCode",
response.getStatusLine().getStatusCode());
            } catch (IOException ioe) {
                logger.error(ioe);
            }
            Map<String,AttributeValue> item = new HashMap<>();
            item.put("Timestamp", new AttributeValue().withN("" +
Instant.now().getEpochSecond()));
            item.put("2xx", new AttributeValue().withBOOL(is2xx));
            dynamoClient.putItem("amazon-2xx", item);
        });
    }
}

```

Following is what a trace emitted by the code preceding looks like (synchronous invocation):



## Python

In Python, you can have Lambda emit subsegments to X-Ray to show you information about downstream calls to other AWS services made by your function. To do so, you first need to include the [the AWS X-Ray](#)

SDK for Python in your deployment package. In addition, you can patch the `boto3` (or `botocore` if you are using sessions), so any client you create to access other AWS services will automatically be traced by X-Ray.

```
import boto3
from aws_xray_sdk.core import xray_recorder
from aws_xray_sdk.core import patch

patch(['boto3'])
```

Once you've patched the module you are using to create clients, you can use it to create your traced clients, in the case below Amazon S3:

```
s3_client = boto3.client('s3')
```

The X-Ray SDK for Python creates a subsegment for the call and records information from the request and response. You can use the `aws_xray_sdk.core.xray_recorder` to create subsegments automatically by decorating your Lambda functions or manually by calling `xray_recorder.begin_subsegment()` and `xray_recorder.end_subsegment()` inside the function, as shown in the following Lambda function.

```
import boto3
from aws_xray_sdk.core import xray_recorder
from aws_xray_sdk.core import patch

patch(['boto3'])

s3_client = boto3.client('s3')

def lambda_handler(event, context):
    bucket_name = event['bucket_name']
    bucket_key = event['bucket_key']
    body = event['body']

    put_object_into_s3(bucket_name, bucket_key, body)
    get_object_from_s3(bucket_name, bucket_key)

# Define subsegments manually
def put_object_into_s3(bucket_name, bucket_key, body):
    try:
        xray_recorder.begin_subsegment('put_object')
        response = s3_client.put_object(Bucket=bucket_name, Key=bucket_key, Body=body)
        status_code = response['ResponseMetadata']['HTTPStatusCode']
        xray_recorder.current_subsegment().put_annotation('put_response', status_code)
    finally:
        xray_recorder.end_subsegment()

# Use decorators to automatically set the subsegments
@xray_recorder.capture('get_object')
def get_object_from_s3(bucket_name, bucket_key):
    response = s3_client.get_object(Bucket=bucket_name, Key=bucket_key)
    status_code = response['ResponseMetadata']['HTTPStatusCode']
    xray_recorder.current_subsegment().put_annotation('get_response', status_code)
```

### Note

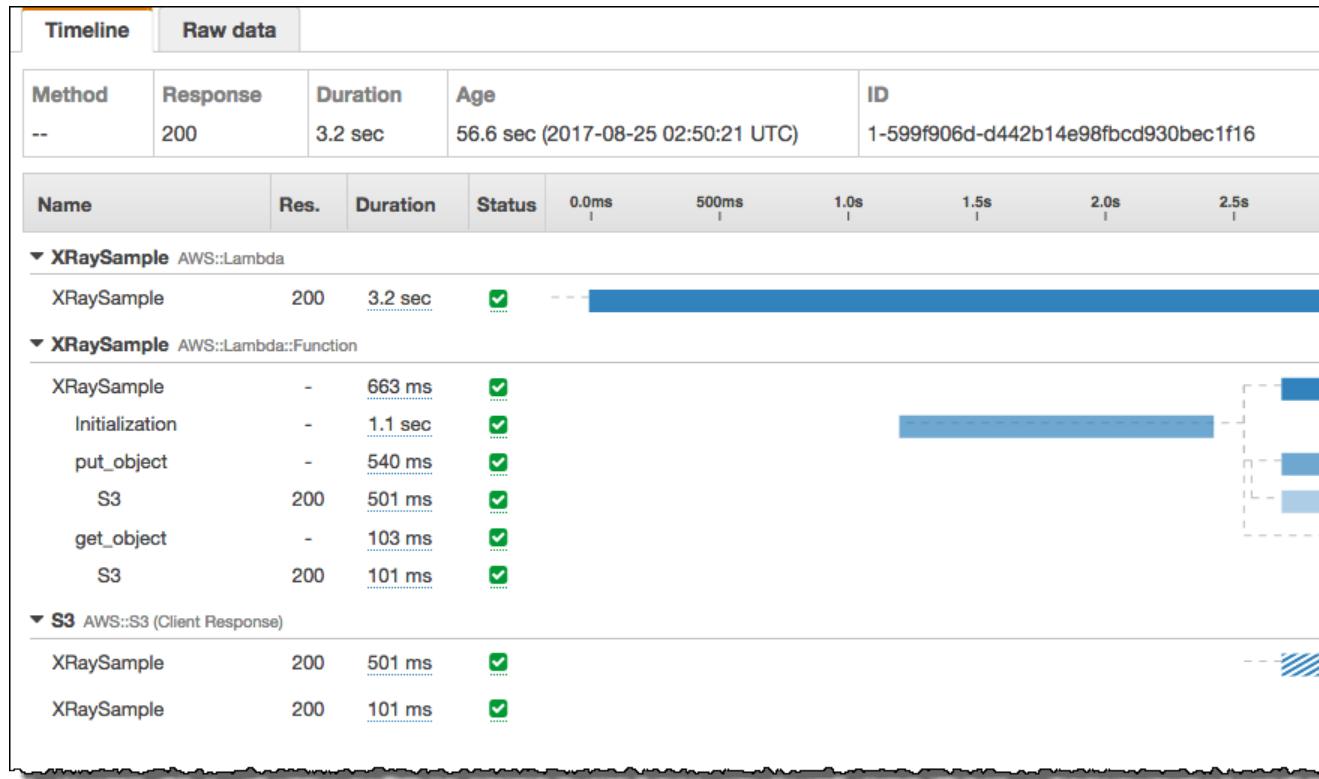
The X-Ray SDK for Python allows you to patch the following modules:

- `botocore`
- `boto3`

- requests
- sqlite3
- mysql

You can use `patch_all()` to patch all of them at once.

Following is what a trace emitted by the code preceding looks like (synchronous invocation):



## Go

You can use the [X-Ray SDK for Go](#) with your Lambda function. If your handler includes [The Context Object \(Go\) \(p. 62\)](#) as its first argument, that object can be passed to the X-Ray SDK. Lambda passes values through this context that the SDK can use to attach subsegments to the Lambda invoke service segment. Subsegments created with the SDK will appear as a part of your Lambda traces.

### Installing the X-Ray SDK for Go

Use the following command to install the X-Ray SDK for Go. (The SDK's non-testing dependencies will be included).

```
go get -u github.com/aws/aws-xray-sdk-go/...
```

If you want to include the test dependencies, use the following command:

```
go get -u -t github.com/aws/aws-xray-sdk-go/...
```

You can also use [Glide](#) to manage dependencies.

```
glide install
```

### Configuring the X-Ray SDK for Go

The following code sample illustrates how to configure the X-Ray SDK for Go in your Lambda function:

```
import (
    "github.com/aws/aws-xray-sdk-go/xray"
)
func myHandlerFunction(ctx context.Context, sample string) {
    xray.Configure(xray.Config{
        LogLevel:      "info",           // default
        ServiceVersion: "1.2.3",
    })
    ... //remaining handler code
}
```

## Create a subsegment

The following code illustrates how to start a subsegment:

```
// Start a subsegment
ctx, subSeg := xray.BeginSubsegment(ctx, "subsegment-name")
// ...
// Add metadata or annotation here if necessary
// ...
subSeg.Close(nil)
```

## Capture

The following code illustrates how to trace and capture a critical code path:

```
func criticalSection(ctx context.Context) {
    // This example traces a critical code path using a custom subsegment
    xray.Capture(ctx, "MyService.criticalSection", func(ctx1 context.Context) error {
        var err error

        section.Lock()
        result := someLockedResource.Go()
        section.Unlock()

        xray.AddMetadata(ctx1, "ResourceResult", result)
    })
}
```

## Tracing HTTP Requests

You can also use the `xray.Client()` method if you want to trace an HTTP client, as shown below:

```
func myFunction (ctx context.Context) ([]byte, error) {
    resp, err := ctxhttp.Get(ctx, xray.Client(nil), "https://aws.amazon.com")
    if err != nil {
        return nil, err
    }
    return ioutil.ReadAll(resp.Body), nil
}
```

# The AWS X-Ray Daemon in the Lambda Environment

The [AWS X-Ray Daemon](#) is a software application that gathers raw segment data and relays it to the AWS X-Ray service. The daemon works in conjunction with the AWS X-Ray SDKs so that data sent by the SDKs can reach the X-Ray service.

When you trace your Lambda function, the X-Ray daemon automatically runs in the Lambda environment to gather trace data and send it to X-Ray. When tracing, the X-Ray daemon consumes a maximum of 16 MB or 3 percent of your function's memory allocation. For example, if you allocate 128 MB of memory to your Lambda function, the X-Ray daemon has 16 MB of your function's memory allocation. If you allocate 1024 MB to your Lambda function, the X-Ray daemon has 31 MB allocated to it (3 percent). For more information, see [The AWS X-Ray Daemon](#).

**Note**

Lambda will try to terminate the X-Ray daemon to avoid exceeding your function's memory limit. For example, assume you have allocated 128 MB to your Lambda function, which means the X-Ray daemon will have 16 MB allocated to it. That leaves your Lambda function with a memory allocation of 112 MB. However, if your function exceeds 112 MB, the X-Ray daemon will be terminated to avoid throwing an out-of-memory error.

## Using Environment Variables to Communicate with AWS X-Ray

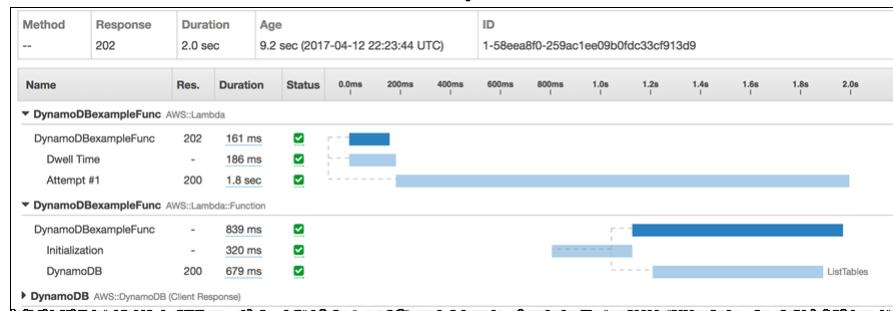
AWS Lambda automatically generates three environment variables to facilitate communication with the X-Ray daemon, and set the configuration of the X-Ray SDK:

- **\_X\_AMZN\_TRACE\_ID:** Contains the tracing header, which includes the sampling decision, trace ID, and parent segment ID. (To learn more about these properties, see [Tracing Header](#).) If Lambda receives a tracing header when your function is invoked, that header will be used to populate the `_X_AMZN_TRACE_ID` environment variable. If a tracing header was not received, Lambda will generate one for you.
- **AWS\_XRAY\_CONTEXT\_MISSING:** The X-Ray SDK uses this variable to determine its behavior in the event that your function tries to record X-Ray data, but a tracing header is not available. Lambda sets this value to `LOG_ERROR` by default.
- **AWS\_XRAY\_DAEMON\_ADDRESS:** This environment variable exposes the X-Ray daemon's address in the following format: `IP_ADDRESS:PORT`. You can use the X-Ray daemon's address to send trace data to the X-Ray daemon directly, without using the X-Ray SDK.

## Lambda Traces in the AWS X-Ray Console: Examples

The following shows Lambda traces for two different Lambda functions. Each trace showcases a trace structure for a different invocation type: asynchronous and synchronous.

- **Async** - The example following shows an asynchronous Lambda request with one successful invocation and one downstream call to DynamoDB.



The Lambda service segment encapsulates the response time, which is the time it took to return a response (for example, 202) to the client. It includes subsegments for the time spent in the Lambda service queue (dwell time) and each invocation attempt. (Only one invocation attempt appears in

the example preceding.) Each attempt subsegment in the service segment will have a corresponding user function segment. In this example, the user function segment contains two subsegments: the initialization subsegment representing the function's initialization code that is run before the handler, and a downstream call subsegment representing a `ListTables` call to DynamoDB.

Status codes and error messages are displayed for each Invocation subsegment and for each downstream call.

- **Synchronous** - The example following shows a synchronous request with one downstream call to Amazon S3.

Timeline		Raw data						
Method	Response	Duration	Age					ID
Name	Res.	Duration	Status	0.0ms	200ms	400ms	600ms	
<b>s3example</b> AWS::Lambda								
s3example	200	1.5 sec						
<b>s3example</b> AWS::Lambda::Function								
s3example	-	663 ms						
Initialization	-	339 ms						
S3	200	623 ms						
<b>S3</b> AWS::S3 (Client Response)								

The Lambda service segment captures the entire time the request spends in the Lambda service. The service segment will have a corresponding User function segment. In this example, the User function segment contains a subsegment representing the function's initialization code (code run before the handler), and a subsegment representing the `PutObject` call to Amazon S3.

#### Note

If you want to trace HTTP calls, you need to use an HTTP client. For more information, see [Tracing Calls to Downstream HTTP Web Services with the X-Ray SDK for Java](#) or [Tracing Calls to Downstream HTTP Web Services with the X-Ray SDK for Node.js](#).

# Administering Lambda-based Applications

AWS Lambda integrates with many of the administration tools that AWS offers, including AWS tagging, AWS CloudTrail, and AWS IAM. The sections below offer guidance on how to manage your Lambda-based applications, including organizing your Lambda based applications using tags, auditing activity on your AWS using CloudTrail, and introduce you to the AWS Security Model for how to secure your Lambda-based applications. We also discuss an administration task unique to AWS Lambda, which is managing the concurrent execution behavior of a Lambda function.

The sections below offer guidance on how to organize and track your Lambda function invocations and introduce you to the AWS Security Model for how to secure your Lambda-based applications:

## Tagging Lambda Functions

Lambda functions can span multiple applications across separate regions. To simplify the process of tracking the frequency and cost of each function invocation, you can use tags. Tags are key-value pairs that you attach to AWS resources to better organize them. They are particularly useful when you have many resources of the same type, which in the case of AWS Lambda, is a function. By using tags, customers with hundreds of Lambda functions can easily access and analyze a specific set by filtering on those that contain the same tag. Two of the key advantages of tagging your Lambda functions are:

- **Grouping and Filtering:** By applying tags, you can use the Lambda console or CLI to isolate a list of Lambda functions contained within a specific application or billing department. For more information, see [Filtering on Tagged Lambda Functions \(p. 336\)](#).
- **Cost allocation:** Because Lambda's support for tagging is integrated with AWS Billing, you can break down bills into dynamic categories and map functions to specific cost centers. For example, if you tag all Lambda functions with a "Department" key, then all AWS Lambda costs can be broken down by department. You can then provide an individual department value, such "Department 1" or "Department 2" to direct the function invocation cost to the appropriate cost center. Cost allocation is surfaced via detailed billing reports, making it easier for you to categorize and track your AWS costs.

### Topics

- [Tagging Lambda Functions for Billing \(p. 334\)](#)
- [Applying Tags to Lambda Functions \(p. 335\)](#)
- [Filtering on Tagged Lambda Functions \(p. 336\)](#)
- [Tag Restrictions \(p. 337\)](#)

## Tagging Lambda Functions for Billing

You can use tags to organize your AWS bill to reflect your own cost structure. To do this, you can add tag keys whose values will be included in the cost allocation report. For more information about setting up a cost allocation report that includes the tag keys you select to be included as line items in the report, see [The Monthly Cost Allocation Report](#) in [About AWS Account Billing](#).

To see the cost of your combined resources, you can organize your billing information based on functions that have the same tag key values. For example, you can tag several Lambda functions with a specific application name, and then organize your billing information to see the total cost of that application across several services. For more information, see [Using Cost Allocation Tags](#) in the *AWS Billing and Cost Management User Guide*.

**Important**

In AWS Lambda the only resource that can be tagged is a function. You cannot tag an alias or a specific function version. Any invocation of a function's alias or version will be billed as an invocation of the original function.

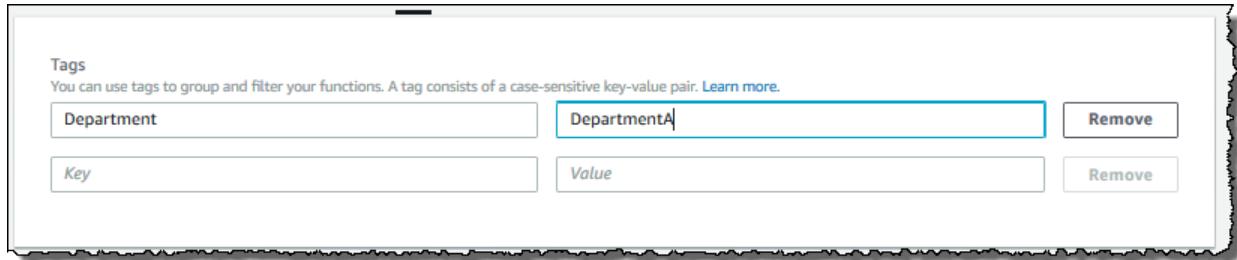
## Applying Tags to Lambda Functions

How you tag your Lambda functions depends on how you create the function. You can apply them using the Lambda console or CLI, as explained in the following sections:

- [Applying Tags to Lambda Functions Using the Console \(p. 335\)](#)
- [Applying Tags to Lambda Functions Using the CLI \(p. 335\)](#)

### Applying Tags to Lambda Functions Using the Console

You can add tags to your function under the **Tags** section in the **configuration** tab.



To remove tags from an existing function, open the function, choose the **Tags** section and then choose the **Remove** button next to key-value pair.



### Applying Tags to Lambda Functions Using the CLI

When you create a new Lambda function using the [CreateFunction \(p. 412\)](#) command, you can add tags by populating the `Tags` parameter. Specify multiple tag values by enclosing them in quotation marks, as shown below:

**Note**

If you have not already created the `adminuser` profile, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#).

```
$ aws lambda create-function \
--region region \
--function-name function-name
--role role-arn \
```

```
--handler handler-name \
--runtime runtime-value \
--runtime runtime \
--tags "DEPARTMENT=Department A, Department B" \
--profile adminuser \
--timeout 10 \
--memory-size 1024
```

To apply or add more tags to an existing function, you can use the [TagResource \(p. 483\)](#) API and supply it with the Lambda function ARN (Amazon Resource Name) along with the key-value pairs that comprise your tags.

```
$ aws lambda tag-resource \
--resource function arn \
--tags DEPARTMENT="Department C, Department D"
```

Conversely, if you want to remove any or all tags from a Lambda function, you use the [UntagResource \(p. 485\)](#) API and again supply the function ARN (Amazon Resource Name), along with a list of tag keys to be removed from the function.

```
$ aws lambda untag-resource \
--resource function arn \
--tagkeys list of tag keys to be removed
```

## Filtering on Tagged Lambda Functions

Once you have grouped your Lambda functions by using tags, you can leverage the filtering capabilities provided by the Lambda console or the AWS CLI to view them based on your specific requirements.

### Filtering Lambda Functions Using the Console

The Lambda console contains a search field that allows you to filter the list of functions based on a specified set of function attributes, including **Tags**. Suppose you have two functions named **MyFunction** and **MyFunction2** that have a **Tags** key called **Department**. To view those functions, choose the search field and notice the automatic filtering that includes a list of the **Tags** keys:



The screenshot shows the AWS Lambda console interface. At the top, there's a search bar labeled 'Filter by tags and attributes or search by keyword'. Below the search bar is a table header with columns: 'Function attributes' (with checkboxes for 'Description', 'Function name', 'Runtime', 'Tags', and 'Department'), 'Runtime' (dropdown menu), and 'Code size'. Under the 'Tags' column, there are three entries: 'mbda function.', 'Node.js 6.10', '333 bytes'; 'mbda function.', 'Node.js 6.10', '333 bytes'; and 'mbda function.', 'Python 2.7', '360 bytes'. The 'Tags' checkbox is checked, and the 'Department' checkbox is also checked, which is highlighted in blue.

Choose the **Department** key. Lambda will return any function that contains that key.

Now suppose that the key value of the **MyFunction** tag is "Department A" and the key value of **MyFunction2** is "Department B". You can narrow your search by choosing the value of the **Department** key, in this case **Department A**, as shown below.

The screenshot shows the AWS Lambda 'Functions' list page with a search bar at the top containing 'tag:Department'. Below the search bar, there is a table listing two Lambda functions: 'DepartmentA' and 'DepartmentB'. The table includes columns for 'Runtime' (Node.js 6.10) and 'Code size' (333 bytes). A dropdown menu is open next to the search bar, showing options like '(all values)' and '(empty)', with 'tag:Department' selected.

Function	Runtime	Code size
DepartmentA	Node.js 6.10	333 bytes
DepartmentB	Node.js 6.10	333 bytes

This will return only **MyFunction**.

You can further narrow your search by including the other accepted **Function attributes**, including **Description**, **Function name** or **Runtime**.

**Note**

You are limited to a maximum of 50 tags per Lambda function. If you delete the Lambda function, the associated tags will also be deleted.

## Filtering Lambda Functions Using the CLI

If you want to view the tags that are applied to a specific Lambda function, you can use either of the following Lambda API commands:

- [ListTags \(p. 467\)](#): You supply your Lambda function ARN (Amazon Resource Name) to view a list of the tags associated with this function:

```
$ aws lambda list-tags \
--resource function arn \
--region region \
--profile adminuser
```

- [GetFunction \(p. 438\)](#): You supply your Lambda function name to view a list of the tags associated with this function:

```
$ aws lambda get-function \
--function-name function name \
--region region \
--profile adminuser
```

You can also use the AWS Tagging Service's [GetResources](#) API to filter your resources by tags. The GetResources API 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 the AWS Tagging Service, see [Working with Resource Groups](#).

## Tag Restrictions

The following restrictions 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 your tagging schema will be used 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: `+ - = . _ : / @.`

## Logging AWS Lambda API Calls By Using AWS CloudTrail

AWS Lambda is integrated with AWS CloudTrail, a service that captures API calls made by or on behalf of AWS Lambda in your AWS account and delivers the log files to an Amazon S3 bucket that you specify. CloudTrail captures API calls made from the AWS Lambda console or from the AWS Lambda API. Using the information collected by CloudTrail, you can determine what request was made to AWS Lambda, the source IP address from which the request was made, who made the request, when it was made, and so on. To learn more about CloudTrail, including how to configure and enable it, see the [AWS CloudTrail User Guide](#).

### AWS Lambda Information in CloudTrail

When CloudTrail logging is enabled in your AWS account, API calls made to AWS Lambda actions are tracked in log files. AWS Lambda records are written together with other AWS service records in a log file. CloudTrail determines when to create and write to a new file based on a time period and file size.

The following actions are supported:

- [AddPermission \(p. 398\)](#)
- [CreateEventSourceMapping \(p. 407\)](#)
- [CreateFunction \(p. 412\)](#)

(The `ZipFile` parameter is omitted from the CloudTrail logs for `CreateFunction`.)

- [DeleteEventSourceMapping \(p. 422\)](#)
- [DeleteFunction \(p. 425\)](#)
- [GetEventSourceMapping \(p. 435\)](#)
- [GetFunction \(p. 438\)](#)
- [GetFunctionConfiguration \(p. 442\)](#)
- [GetPolicy \(p. 447\)](#)
- [ListEventSourceMappings \(p. 461\)](#)
- [ListFunctions \(p. 464\)](#)
- [RemovePermission \(p. 480\)](#)
- [UpdateEventSourceMapping \(p. 491\)](#)
- [UpdateFunctionCode \(p. 495\)](#)

(The `ZipFile` parameter is omitted from the CloudTrail logs for `UpdateFunctionCode`.)

- [UpdateFunctionConfiguration \(p. 502\)](#)

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 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 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 AWS Lambda log files from multiple AWS regions and multiple AWS accounts into a single S3 bucket. For more information, see [Working with CloudTrail Log Files](#).

## Understanding AWS 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.

```
{  
  "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"
}
]
```

**Note**

The `eventName` may include date and version information, such as `"GetFunction20150331"`, but it is still referring to the same public API. For more information, see [Services Supported by CloudTrail Event History](#) in the *AWS CloudTrail User Guide*.

## 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. This feature is not enabled by default and incurs additional charges if enabled. You can do this using the AWS CloudTrail console or [Invoke \(p. 450\)](#) CLI operation. For more information on this option, see [Logging Data and Management Events for Trails](#).

## Authentication and Access Control for AWS Lambda

Access to AWS Lambda requires credentials that AWS can use to authenticate your requests. Those credentials must have permissions to access AWS resources, such as an AWS Lambda function or an Amazon S3 bucket. The following sections provide details on how you can use [AWS Identity and Access Management \(IAM\)](#) and Lambda to help secure your resources by controlling who can access them:

- [Authentication \(p. 340\)](#)
- [Access Control \(p. 341\)](#)

## Authentication

You can access AWS as any of the following types of identities:

- **AWS account root user** – When you first create an AWS account, you begin with a single 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, even the administrative ones. Instead, adhere to the [best practice of using the AWS account root user](#).

root user only to create your first IAM user. Then securely lock away the root user credentials and use them to perform only a few account and service management tasks.

- **IAM user** – An [IAM user](#) is an identity within your AWS account that has specific custom permissions (for example, permissions to create a function in Lambda). You can use an IAM user name and password to sign in to secure AWS webpages like the [AWS Management Console](#), [AWS Discussion Forums](#), or the [AWS Support Center](#).

In addition to a user name and password, you can also generate [access keys](#) for each user. You can use these keys when you access AWS services programmatically, either through [one of the several SDKs](#) or by using the [AWS Command Line Interface \(CLI\)](#). The SDK and CLI tools use the access keys to cryptographically sign your request. If you don't use AWS tools, you must sign the request yourself. Lambda supports *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](#).

- **IAM role** – An [IAM role](#) is an IAM identity that you can create in your account that has specific permissions. It is similar to an *IAM user*, but it is not associated with a specific person. An IAM role enables you to obtain temporary access keys that can be used to access AWS services and resources. IAM roles with temporary credentials are useful in the following situations:
  - **Federated user access** – Instead of creating an IAM user, you can use existing user identities from AWS Directory Service, your enterprise user directory, or a web identity provider. These are known as *federated users*. AWS assigns a role to a federated user when access is requested through an [identity provider](#). For more information about federated users, see [Federated Users and Roles](#) in the *IAM User Guide*.
  - **AWS service access** – You can use an IAM role in your account to grant an AWS service permissions to access your account's resources. For example, you can create a role that allows Amazon Redshift to access an Amazon S3 bucket on your behalf and then load data from that bucket into an Amazon Redshift cluster. For more information, see [Creating a Role to Delegate Permissions to an AWS Service](#) in the *IAM User Guide*.
  - **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 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*.

## Access Control

You can have valid credentials to authenticate your requests, but unless you have permissions you cannot create or access AWS Lambda resources. For example, you must have permissions to create a Lambda function, add an event source, and publish a version of your Lambda function.

The following sections describe how to manage permissions for AWS Lambda. We recommend that you read the overview first.

- [Overview of Managing Access Permissions to Your AWS Lambda Resources \(p. 342\)](#)

- [Using Identity-Based Policies \(IAM Policies\) for AWS Lambda \(p. 346\)](#)
- [Using Resource-Based Policies for AWS Lambda \(Lambda Function Policies\) \(p. 358\)](#)

## Overview of Managing Access Permissions to Your AWS Lambda Resources

Every AWS resource is owned by an AWS account, and permissions to create or access a resource are governed by permissions policies. An account administrator can attach permissions policies to IAM identities (that is, users, groups, and roles), and some services (such as AWS Lambda) also support attaching permissions policies to resources.

### Note

An *account administrator* (or administrator user) is a user with administrator privileges. For more information, see [IAM Best Practices](#) in the *IAM User Guide*.

When granting permissions, you decide who is getting the permissions, the resources they get permissions for, and the specific actions that you want to allow on those resources.

### Topics

- [AWS Lambda Resources and Operations \(p. 342\)](#)
- [Understanding Resource Ownership \(p. 343\)](#)
- [Managing Access to Resources \(p. 343\)](#)
- [Specifying Policy Elements: Actions, Effects, Resources, and Principals \(p. 345\)](#)
- [Specifying Conditions in a Policy \(p. 345\)](#)

## AWS Lambda Resources and Operations

In AWS Lambda, the primary resources are a *Lambda function* and an *event source mapping*. You create an event source mapping in the AWS Lambda pull model to associate a Lambda function with an event source. For more information, see [Event Source Mapping \(p. 149\)](#).

AWS Lambda also supports additional resource types, *alias* and *version*. However, you can create aliases and versions only in the context of an existing Lambda function. These are referred to as *subresources*.

These resources and subresources have unique Amazon Resource Names (ARNs) associated with them as shown in the following table.

Resource Type	ARN Format
Function	arn:aws:lambda: <i>region:account-id:function:function-name</i>
Function alias	arn:aws:lambda: <i>region:account-id:function:function-name:alias-name</i>
Function version	arn:aws:lambda: <i>region:account-id:function:function-name:version</i>
Event source mapping	arn:aws:lambda: <i>region:account-id:event-source-mapping:event-source-mapping-id</i>

AWS Lambda provides a set of operations to work with the Lambda resources. For a list of available operations, see [Actions \(p. 396\)](#).

## Understanding Resource Ownership

A *resource owner* is the AWS account that created the resource. That is, the resource owner is the AWS account of the *principal entity* (the root account, an IAM user, or an IAM role) that authenticates the request that creates the resource. The following examples illustrate how this works:

- If you use the root account credentials of your AWS account to create a Lambda function, your AWS account is the owner of the resource (in Lambda, the resource is the Lambda function).
- If you create an IAM user in your AWS account and grant permissions to create a Lambda function to that user, the user can create a Lambda function. However, your AWS account, to which the user belongs, owns the Lambda function resource.
- If you create an IAM role in your AWS account with permissions to create a Lambda function, anyone who can assume the role can create a Lambda function. Your AWS account, to which the role belongs, owns the Lambda function resource.

## Managing Access to Resources

A *permissions policy* describes who has access to what. The following section explains the available options for creating permissions policies.

### Note

This section discusses using IAM in the context of AWS Lambda. It doesn't provide detailed information about the IAM service. For complete IAM documentation, see [What Is IAM?](#) in the *IAM User Guide*. For information about IAM policy syntax and descriptions, see [AWS IAM Policy Reference](#) in the *IAM User Guide*.

Policies attached to an IAM identity are referred to as *identity-based* policies (IAM policies) and policies attached to a resource are referred to as *resource-based* policies. AWS Lambda supports both identity-based (IAM policies) and resource-based policies.

### Topics

- [Identity-Based Policies \(IAM Policies\) \(p. 343\)](#)
- [Resource-Based Policies \(Lambda Function Policies\) \(p. 344\)](#)

## Identity-Based Policies (IAM Policies)

You can attach policies to IAM identities. For example, you can do the following:

- **Attach a permissions policy to a user or a group in your account** – An account administrator can use a permissions policy that is associated with a particular user to grant permissions for that user to create a Lambda function.
- **Attach a permissions policy to a role (grant cross-account permissions)** – You can attach an identity-based permissions policy to an IAM role to grant cross-account permissions. For example, the administrator in Account A can create a role to grant cross-account permissions to another AWS account (for example, Account B) or an AWS service as follows:
  1. Account A administrator creates an IAM role and attaches a permissions policy to the role that grants permissions on resources in Account A.
  2. Account A administrator attaches a trust policy to the role identifying Account B as the principal who can assume the role.
  3. Account B administrator can then delegate permissions to assume the role to any users in Account B. Doing this allows users in Account B to create or access resources in Account A. The principal in the trust policy can also be an AWS service principal if you want to grant an AWS service permissions to assume the role.

For more information about using IAM to delegate permissions, see [Access Management](#) in the *IAM User Guide*.

The following is an example policy that grants permissions for the `lambda>ListFunctions` action on all resources. In the current implementation, Lambda doesn't support identifying specific resources using the resource ARNs (also referred to as resource-level permissions) for some of the API actions, so you must specify a wildcard character (\*).

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Sid": "ListExistingFunctions",  
            "Effect": "Allow",  
            "Action": [  
                "lambda>ListFunctions"  
            ],  
            "Resource": "*"  
        }  
    ]  
}
```

For more information about using identity-based policies with Lambda, see [Using Identity-Based Policies \(IAM Policies\) for AWS Lambda \(p. 346\)](#). For more information about users, groups, roles, and permissions, see [Identities \(Users, Groups, and Roles\)](#) in the *IAM User Guide*.

## Resource-Based Policies (Lambda Function Policies)

Each Lambda function can have resource-based permissions policies associated with it. For Lambda, a Lambda function is the primary resource and these policies are referred to as *Lambda function policies*. You can use a Lambda function policy to grant cross-account permissions as an alternative to using identity-based policies with IAM roles. For example, you can grant Amazon S3 permissions to invoke your Lambda function by simply adding permissions to the Lambda function policy instead of creating an IAM role.

### Important

Lambda function policies are primarily used when you are setting up an event source in AWS Lambda to grant a service or an event source permissions to invoke your Lambda function (see [Invoke \(p. 450\)](#)). An exception to this is when an event source (for example, Amazon DynamoDB or Kinesis) uses the pull model, where permissions are managed in the Lambda function execution role instead. For more information, see [Event Source Mapping \(p. 149\)](#).

The following is an example Lambda function policy that has one statement. The statement allows the Amazon S3 service principal permission for the `lambda:InvokeFunction` action on a Lambda function called `HelloWorld`. The condition ensures that the bucket where the event occurred is owned by the same account that owns the Lambda function.

```
{  
    "Policy":{  
        "Version":"2012-10-17",  
        "Statement": [  
            {  
                "Effect":"Allow",  
                "Principal":{  
                    "Service":"s3.amazonaws.com"  
                },  
                "Action":"lambda:InvokeFunction",  
                "Resource":"arn:aws:lambda:region:account-id:function:HelloWorld",  
                "Condition":{  
                    "StringEquals":{  
                        "aws:SourceOwner": "account-id"  
                    }  
                }  
            }  
        ]  
    }  
}
```

```
"Sid": "65baafc90-6a1f-42a8-a7ab-8aa9bc877985",
"Condition": {
    "StringEquals": {
        "AWS:SourceAccount": "account-id"
    },
    "ArnLike": {
        "AWS:SourceArn": "arn:aws:s3:::ExampleBucket"
    }
}
}
```

For more information about using resource-based policies with Lambda, see [Using Resource-Based Policies for AWS Lambda \(Lambda Function Policies\) \(p. 358\)](#). For additional information about using IAM roles (identity-based policies) as opposed to resource-based policies, see [How IAM Roles Differ from Resource-based Policies](#) in the *IAM User Guide*.

## Specifying Policy Elements: Actions, Effects, Resources, and Principals

For each AWS Lambda resource (see [AWS Lambda Resources and Operations \(p. 342\)](#)), the service defines a set of API operations (see [Actions \(p. 396\)](#)). To grant permissions for these API operations, Lambda defines a set of actions that you can specify in a policy. Note that, performing an API operation can require permissions for more than one action. When granting permissions for specific actions, you also identify the resource on which the actions are allowed or denied.

The following are the most basic policy elements:

- **Resource** – In a policy, you use an Amazon Resource Name (ARN) to identify the resource to which the policy applies. For more information, see [AWS Lambda Resources and Operations \(p. 342\)](#).
- **Action** – You use action keywords to identify resource operations that you want to allow or deny. For example, the `lambda:InvokeFunction` permission allows the user permissions to perform the AWS Lambda `Invoke` operation.
- **Effect** – You specify the effect when the user requests the specific action—this can be either allow or deny. If you don't explicitly grant access to (allow) a resource, access is implicitly denied. You can also explicitly deny access to a resource, which you might do to make sure that a user cannot access it, even if a different policy grants access.
- **Principal** – In identity-based policies (IAM policies), the user that the policy is attached to is the implicit principal. For resource-based policies, you specify the user, account, service, or other entity that you want to receive permissions (applies to resource-based policies only).

To learn more about IAM policy syntax and descriptions, see [AWS IAM Policy Reference](#) in the *IAM User Guide*.

For a table showing all of the AWS Lambda API actions and the resources that they apply to, see [Lambda API Permissions: Actions, Resources, and Conditions Reference \(p. 363\)](#).

## Specifying Conditions in a Policy

When you grant permissions, you can use the IAM policy language to specify the conditions when a policy should take effect. For example, you might want a policy to be applied only after a specific date. For more information about specifying conditions in a policy language, see [Condition](#) in the *IAM User Guide*.

To express conditions, you use predefined condition keys. There are no condition keys specific to Lambda. However, there are AWS-wide condition keys that you can use as appropriate. For a complete list of AWS-wide keys, see [Available Keys for Conditions](#) in the *IAM User Guide*.

## Using Identity-Based Policies (IAM Policies) for AWS Lambda

This topic provides examples of identity-based policies in which an account administrator can attach permissions policies to IAM identities (that is, users, groups, and roles).

### Important

We recommend that you first review the introductory topics that explain the basic concepts and options available for you to manage access to your AWS Lambda resources. For more information, see [Overview of Managing Access Permissions to Your AWS Lambda Resources](#) (p. 342).

The sections in this topic cover the following:

- [Permissions Required to Use the AWS Lambda Console \(p. 347\)](#)
- [AWS Managed \(Predefined\) Policies for AWS Lambda \(p. 347\)](#)
- [Customer Managed Policy Examples \(p. 347\)](#)

The following shows an example of a permissions policy.

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Sid": "CreateFunctionPermissions",  
            "Effect": "Allow",  
            "Action": [  
                "lambda:CreateFunction"  
            ],  
            "Resource": "*"  
        },  
        {  
            "Sid": "PermissionToPassAnyRole",  
            "Effect": "Allow",  
            "Action": [  
                "iam:PassRole"  
            ],  
            "Resource": "arn:aws:iam::account-id:role/*"  
        }  
    ]  
}
```

The policy has two statements:

- The first statement grants permissions for the AWS Lambda action (`lambda:CreateFunction`) on a resource by using the Amazon Resource Name (ARN) for the Lambda function. Currently, AWS Lambda doesn't support permissions for this particular action at the resource-level. Therefore, the policy specifies a wildcard character (\*) as the `Resource` value.
- The second statement grants permissions for the IAM action (`iam:PassRole`) on IAM roles. The wildcard character (\*) at the end of the `Resource` value means that the statement allows permission for the `iam:PassRole` action on any IAM role. To limit this permission to a specific role, replace the wildcard character (\*) in the resource ARN with the specific role name.

The policy doesn't specify the `Principal` element because in an identity-based policy you don't specify the principal who gets the permission. When you attach policy to a user, the user is the implicit principal. When you attach a permission policy to an IAM role, the principal identified in the role's trust policy gets the permissions.

For a table showing all of the AWS Lambda API actions and the resources and conditions that they apply to, see [Lambda API Permissions: Actions, Resources, and Conditions Reference \(p. 363\)](#).

## Permissions Required to Use the AWS Lambda Console

The AWS Lambda console provides an integrated environment for you to create and manage Lambda functions. The console provides many features and workflows that often require permissions to create a Lambda function in addition to the API-specific permissions documented in the [Lambda API Permissions: Actions, Resources, and Conditions Reference \(p. 363\)](#). For more information about these additional console permissions, see [Permissions Required to Use the AWS Lambda Console \(p. 351\)](#).

## AWS Managed (Predefined) Policies for AWS Lambda

AWS addresses many common use cases by providing standalone IAM policies that are created and administered by AWS. Managed policies grant necessary permissions for common use cases so you can avoid having to investigate what permissions are needed. For more information, see [AWS Managed Policies](#) in the *IAM User Guide*.

The following AWS managed policies, which you can attach to users in your account, are specific to AWS Lambda and are grouped by use case scenario:

- **AWSLambdaReadOnlyAccess** – Grants read-only access to AWS Lambda resources. Note that this policy doesn't grant permission for the `lambda:InvokeFunction` action. If you want a user to invoke a Lambda function, you can also attach the **AWSLambdaRole** AWS managed policy.
- **AWSLambdaFullAccess** – Grants full access to AWS Lambda resources.
- **AWSLambdaRole** – Grants permissions to invoke any Lambda function.

### Note

You can review these permissions policies by signing in to the IAM console and searching for specific policies there.

In addition, there are other AWS-managed policies that are suitable for use with IAM role (execution role) you specify at the time of creating a Lambda function. For more information, see [AWS Lambda Permissions Model \(p. 361\)](#).

You can also create your own custom IAM policies to allow permissions for AWS Lambda API actions and resources. You can attach these custom policies to the IAM users or groups that require those permissions or to custom execution roles (IAM roles) that you create for your Lambda functions.

## Customer Managed Policy Examples

The examples in this section provide a group of sample policies that you can attach to a user. If you are new to creating policies, we recommend that you first create an IAM user in your account and attach the policies to the user in sequence, as outlined in the steps in this section.

You can use the console to verify the effects of each policy as you attach the policy to the user. Initially, the user doesn't have permissions and the user won't be able to do anything in the console. As you attach policies to the user, you can verify that the user can perform various actions in the console.

We recommend that you use two browser windows: one to create the user and grant permissions, and the other to sign in to the AWS Management Console using the user's credentials and verify permissions as you grant them to the user.

For examples that show how to create an IAM role that you can use as an execution role for your Lambda function, see [Creating IAM Roles](#) in the *IAM User Guide*.

### Example Steps

- [Step 1: Create an IAM User \(p. 348\)](#)
- [Step 2: Allow a User to List Lambda Functions \(p. 348\)](#)
- [Step 3: Allow a User to View Details of a Lambda Function \(p. 348\)](#)
- [Step 4: Allow a User to Invoke a Lambda Function \(p. 349\)](#)
- [Step 5: Allow a User to Monitor a Lambda Function and View CloudWatch Logs \(p. 349\)](#)
- [Step 6: Allow a User to Create a Lambda Function \(p. 350\)](#)

## Step 1: Create an IAM User

First, you need to create an IAM user, add the user to an IAM group with administrative permissions, and then grant administrative permissions to the IAM user that you created. You can then access AWS using a special URL and that IAM user's credentials.

For instructions, see [Creating Your First IAM User and Administrators Group](#) in the *IAM User Guide*.

## Step 2: Allow a User to List Lambda Functions

An IAM user in your account must have permissions for the `lambda>ListFunctions` action before the user can see anything in the console. When you grant these permissions, the console can show the list of Lambda functions in the AWS account created in the specific AWS Region the user belongs to.

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Sid": "ListExistingFunctions",  
            "Effect": "Allow",  
            "Action": [  
                "lambda>ListFunctions"  
            ],  
            "Resource": "*"  
        }  
    ]  
}
```

## Step 3: Allow a User to View Details of a Lambda Function

A user can select a Lambda function and view details of the function (such as aliases, versions, and other configuration information), provided that the user has permissions for the following AWS Lambda actions:

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Sid": "DisplayFunctionDetailsPermissions",  
            "Effect": "Allow",  
            "Action": [  
                "lambda>ListVersionsByFunction",  
                "lambda>ListAliases",  
            ]  
        }  
    ]  
}
```

```
        "lambda:GetFunction",
        "lambda:GetFunctionConfiguration",
        "lambda>ListEventSourceMapping",
        "lambda:GetPolicy"
    ],
    "Resource": "*"
}
]
```

## Step 4: Allow a User to Invoke a Lambda Function

If you want to allow a user permissions to manually invoke a function, you need to grant permissions for the `lambda:InvokeFunction` action, as shown following:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "InvokePermission",
            "Effect": "Allow",
            "Action": [
                "lambda:InvokeFunction"
            ],
            "Resource": "*"
        }
    ]
}
```

## Step 5: Allow a User to Monitor a Lambda Function and View CloudWatch Logs

When a user invokes a Lambda function, AWS Lambda executes it and returns results. The user needs additional permissions to monitor the Lambda function.

To enable the user to see the Lambda function's CloudWatch metrics on the console's **Monitoring** tab, or on the grid view on the console home page, you must grant the following permissions:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "CloudWatchPermission",
            "Effect": "Allow",
            "Action": [
                "cloudwatch:GetMetricStatistics"
            ],
            "Resource": "*"
        }
    ]
}
```

To enable a user to click the links to CloudWatch Logs in the AWS Lambda console and view log output in CloudWatch Logs, you must grant the following permissions:

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

```

        "Effect": "Allow",
        "Action": [
            "cloudwatchlog:DescribeLogGroups",
            "cloudwatchlog:DescribeLogStreams",
            "cloudwatchlog:GetLogEvents"
        ],
        "Resource": "arn:aws:logs:region:account-id:log-group:/aws/lambda/*"
    }
]
}

```

## Step 6: Allow a User to Create a Lambda Function

If you want a user to be able to create a Lambda function, you must grant the following permissions. The permissions for IAM-related actions are required because when a user creates a Lambda function, the user needs to select an IAM execution role, which AWS Lambda assumes to execute the Lambda function.

```

{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "ListExistingRolesAndPolicies",
            "Effect": "Allow",
            "Action": [
                "iam>ListRolePolicies",
                "iam>ListRoles"
            ],
            "Resource": "*"
        },
        {
            "Sid": "CreateFunctionPermissions",
            "Effect": "Allow",
            "Action": [
                "lambda>CreateFunction"
            ],
            "Resource": "*"
        },
        {
            "Sid": "PermissionToPassAnyRole",
            "Effect": "Allow",
            "Action": [
                "iam>PassRole"
            ],
            "Resource": "arn:aws:iam:account-id:role/*"
        }
    ]
}

```

If you want a user to be able to create an IAM role when the user is creating a Lambda function, the user needs permissions to perform the `iam:PutRolePolicy` action, as shown following:

```

{
    "Sid": "CreateARole",
    "Effect": "Allow",
    "Action": [
        "iam>CreateRole",
        "iam>CreatePolicy",
        "iam>PutRolePolicy",
        "iam>AttachRolePolicy"
    ],
    "Resource": "arn:aws:iam:account-id:role/*"
}

```

}

### Important

Each IAM role has a permissions policy attached to it, which grants specific permissions to the role. Regardless of whether the user creates a new role or uses an existing role, the user must have permissions for all of the actions granted in the permissions policy associated with the role. You must grant the user additional permissions accordingly.

## Permissions Required to Use the AWS Lambda Console

To take advantage of the integrated experience provided by the AWS Lambda console, a user must often have more permissions than the API-specific permissions described in the references table, depending on what you want the user to be able to do. For more information about Lambda API operations, see [Lambda API Permissions: Actions, Resources, and Conditions Reference \(p. 363\)](#).

For example, suppose you allow an IAM user in your account permissions to create a Lambda function to process Amazon S3 object-created events. To enable the user to configure Amazon S3 as the event source, the console drop-down list will display a list of your buckets. However, the console can show the bucket list only if the signed-in user has permissions for the relevant Amazon S3 actions.

The following sections describe required additional permissions for different integration points.

If you are new to managing permissions, we recommend that you start with the example walkthrough where you create an IAM user, grant the user incremental permissions, and verify the permissions work using the AWS Lambda console (see [Customer Managed Policy Examples \(p. 347\)](#)).

### Topics

- [Amazon API Gateway \(p. 351\)](#)
- [Amazon CloudWatch Events \(p. 352\)](#)
- [Amazon CloudWatch Logs \(p. 353\)](#)
- [Amazon Cognito \(p. 353\)](#)
- [Amazon DynamoDB \(p. 354\)](#)
- [Amazon Kinesis Data Streams \(p. 355\)](#)
- [Amazon S3 \(p. 356\)](#)
- [Amazon SNS \(p. 356\)](#)
- [AWS IoT \(p. 357\)](#)

### Note

All of these permissions policies grant the specific AWS services permissions to invoke a Lambda function. The user who is configuring this integration must have permissions to invoke the Lambda function. Otherwise, the user can't set the configuration. You can attach the `AWSLambdaRole` AWS managed (predefined) permissions policy to the user to provide these permissions.

## Amazon API Gateway

When you configure an API endpoint in the console, the console makes several API Gateway API calls. These calls require permissions for the `apigateway:*` action, as shown following:

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Sid": "ApiGatewayPermissions",  
            "Action": "apigateway:  
                CreateDeployment,  
                CreateRestAPI,  
                CreateStage,  
                GetDeployment,  
                GetRestAPI,  
                GetStage,  
                ListDeployments,  
                ListRestAPIs,  
                ListStages,  
                UpdateDeployment,  
                UpdateRestAPI,  
                UpdateStage  
            "Effect": "Allow",  
            "Resource": "*"  
        }  
    ]  
}
```

```

    "Effect": "Allow",
    "Action": [
        "apigateway:/*"
    ],
    "Resource": "*"
},
{
    "Sid": "AddPermissionToFunctionPolicy",
    "Effect": "Allow",
    "Action": [
        "lambda:AddPermission",
        "lambda:RemovePermission",
        "lambda:GetPolicy"
    ],
    "Resource": "arn:aws:lambda:region:account-id:function:/*"
},
{
    "Sid": "ListEventSourcePerm",
    "Effect": "Allow",
    "Action": [
        "lambda>ListEventSourceMappings"
    ],
    "Resource": "*"
}
]
}

```

## Amazon CloudWatch Events

You can schedule when to invoke a Lambda function. After you select an existing CloudWatch Events rule (or create a new one), AWS Lambda creates a new target in CloudWatch that invokes your Lambda function. For target creation to work, you need to grant the following additional permissions:

```

{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "EventPerms",
            "Effect": "Allow",
            "Action": [
                "events:PutRule",
                "events>ListRules",
                "events>ListRuleNamesByTarget",
                "events:PutTargets",
                "events:RemoveTargets",
                "events:DescribeRule",
                "events:TestEventPattern",
                "events>ListTargetsByRule",
                "events>DeleteRule"
            ],
            "Resource": "arn:aws:events:region:account-id:/*"
        },
        {
            "Sid": "AddPermissionToFunctionPolicy",
            "Effect": "Allow",
            "Action": [
                "lambda:AddPermission",
                "lambda:RemovePermission",
                "lambda:GetPolicy"
            ],
            "Resource": "arn:aws:lambda:region:account-id:function:/*"
        }
    ]
}

```

```
}
```

## Amazon CloudWatch Logs

You can have the Amazon CloudWatch Logs service publish events and invoke your Lambda function. When you configure this service as an event source, the console lists log groups in your account. For this listing to occur, you need to grant the `logs:DescribeLogGroups` permissions, as shown following:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "CloudWatchLogsPerms",
            "Effect": "Allow",
            "Action": [
                "logs:FilterLogEvents",
                "logs:DescribeLogGroups",
                "logs:PutSubscriptionFilter",
                "logs:DescribeSubscriptionFilters",
                "logs>DeleteSubscriptionFilter",
                "logs:TestMetricFilter"
            ],
            "Resource": "arn:aws:logs:region:account-id:*"
        },
        {
            "Sid": "AddPermissionToFunctionPolicy",
            "Effect": "Allow",
            "Action": [
                "lambda:AddPermission",
                "lambda:RemovePermission",
                "lambda:GetPolicy"
            ],
            "Resource": "arn:aws:lambda:region:account-id:function:*function-name*
        },
        {
            "Sid": "ListEventSourceMappingsPerms",
            "Effect": "Allow",
            "Action": [
                "lambda>ListEventSourceMappings"
            ],
            "Resource": "*"
        }
    ]
}
```

### Note

The additional permissions shown are required for managing subscription filters.

## Amazon Cognito

The console lists identity pools in your account. After you select a pool, you can configure the pool to have the **Cognito sync trigger** as the event source type. To do this, you need to grant the following additional permissions:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "CognitoPerms1",
            "Effect": "Allow",
            "Action": [
                "cognito-sync:PutIdentityPoolSyncEvent"
            ],
            "Resource": "arn:aws:cognito-sync:region:identity-pool-id:*"
        }
    ]
}
```

```

        "cognito-identity>ListIdentityPools"
    ],
    "Resource": [
        "arn:aws:cognito-identity:region:account-id:/*"
    ]
},
{
    "Sid": "CognitoPerms2",
    "Effect": "Allow",
    "Action": [
        "cognito-sync:GetCognitoEvents",
        "cognito-sync:SetCognitoEvents"
    ],
    "Resource": [
        "arn:aws:cognito-sync:region:account-id:/*"
    ]
},
{
    "Sid": "AddPermissionToFunctionPolicy",
    "Effect": "Allow",
    "Action": [
        "lambda:AddPermission",
        "lambda:RemovePermission",
        "lambda:GetPolicy"
    ],
    "Resource": "arn:aws:lambda:region:account-id:function:/*"
},
{
    "Sid": "ListEventSourcePerms",
    "Effect": "Allow",
    "Action": [
        "lambda>ListEventSourceMappings"
    ],
    "Resource": "*"
}
]
}

```

## Amazon DynamoDB

The console lists all of the tables in your account. After you select a table, the console checks to see if a DynamoDB stream exists for that table. If not, it creates the stream. If you want the user to be able to configure a DynamoDB stream as an event source for a Lambda function, you need to grant the following additional permissions:

```

{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "DDBpermissions1",
            "Effect": "Allow",
            "Action": [
                "dynamodb:DescribeStream",
                "dynamodb:DescribeTable",
                "dynamodb:UpdateTable"
            ],
            "Resource": "arn:aws:dynamodb:region:account-id:table/*"
        },
        {
            "Sid": "DDBpermissions2",
            "Effect": "Allow",
            "Action": [
                "dynamodb>ListStreams",
                "dynamodb>ListTables"
            ]
        }
    ]
}

```

```

        ],
        "Resource": "*"
    },
    {
        "Sid": "LambdaGetPolicyPerm",
        "Effect": "Allow",
        "Action": [
            "lambda:GetPolicy"
        ],
        "Resource": "arn:aws:lambda:region:account-id:function:*"
    },
    {
        "Sid": "LambdaEventSourcePerms",
        "Effect": "Allow",
        "Action": [
            "lambda>CreateEventSourceMapping",
            "lambda>DeleteEventSourceMapping",
            "lambda:GetEventSourceMapping",
            "lambda>ListEventSourceMappings",
            "lambda:UpdateEventSourceMapping"
        ],
        "Resource": "*"
    }
]
}

```

### Important

For a Lambda function to read from a DynamoDB stream, the execution role associated with the Lambda function must have the correct permissions. Therefore, the user must also have the same permissions before you can grant the permissions to the execution role. You can grant these permissions by attaching the `AWSLambdaDynamoDBExecutionRole` predefined policy, first to the user and then to the execution role.

## Amazon Kinesis Data Streams

The console lists all Kinesis streams in your account. After you select a stream, the console creates event source mappings in AWS Lambda. For this to work, you need to grant the following additional permissions:

```

{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "PermissionForDescribeStream",
            "Effect": "Allow",
            "Action": [
                "kinesis:DescribeStream"
            ],
            "Resource": "arn:aws:kinesis:region:account-id:stream/*"
        },
        {
            "Sid": "PermissionForListStreams",
            "Effect": "Allow",
            "Action": [
                "kinesis>ListStreams"
            ],
            "Resource": "*"
        },
        {
            "Sid": "PermissionForGetFunctionPolicy",
            "Effect": "Allow",
            "Action": [
                "lambda:GetPolicy"
            ]
        }
    ]
}

```

```

        ],
        "Resource": "arn:aws:lambda:region:account-id:function:*"  

    },  

    {  

        "Sid": "LambdaEventSourcePerms",  

        "Effect": "Allow",  

        "Action": [  

            "lambda>CreateEventSourceMapping",  

            "lambda>DeleteEventSourceMapping",  

            "lambda:GetEventSourceMapping",  

            "lambda>ListEventSourceMappings",  

            "lambda:UpdateEventSourceMapping"  

        ],  

        "Resource": "*"
    }
}
]
}

```

## Amazon S3

The console prepopulates the list of buckets in the AWS account and finds the bucket location for each bucket. When you configure Amazon S3 as an event source, the console updates the bucket notification configuration. For this to work, you need to grant the following additional permissions:

```

{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "S3Permissions",
            "Effect": "Allow",
            "Action": [
                "s3:GetBucketLocation",
                "s3:GetBucketNotification",
                "s3:PutBucketNotification",
                "s3>ListAllMyBuckets"
            ],
            "Resource": "arn:aws:s3:::*"  

        },
        {
            "Sid": "AddPermissionToFunctionPolicy",
            "Effect": "Allow",
            "Action": [
                "lambda>AddPermission",
                "lambda:RemovePermission"
            ],
            "Resource": "arn:aws:lambda:region:account-id:function:*"  

        }
    ]
}

```

## Amazon SNS

The console lists Amazon Simple Notification Service (Amazon SNS) topics in your account. After you select a topic, AWS Lambda subscribes your Lambda function to that Amazon SNS topic. For this work, you need to grant the following additional permissions:

```

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

```

```

    "Action": [
        "sns>ListSubscriptions",
        "sns>ListSubscriptionsByTopic",
        "sns>ListTopics",
        "sns>Subscribe",
        "sns>Unsubscribe"
    ],
    "Resource": "arn:aws:sns:region:account-id:*"
},
{
    "Sid": "AddPermissionToFunctionPolicy",
    "Effect": "Allow",
    "Action": [
        "lambda>AddPermission",
        "lambda>RemovePermission",
        "lambda>GetPolicy"
    ],
    "Resource": "arn:aws:lambda:region:account-id:function:*"
},
{
    "Sid": "LambdaListESMappingsPerms",
    "Effect": "Allow",
    "Action": [
        "lambda>ListEventSourceMappings"
    ],
    "Resource": "*"
}
]
}

```

## AWS IoT

The console lists all of the AWS IoT rules. After you select a rule, the console populates the rest of the information associated with that rule in the user interface. If you select an existing rule, the console updates it with information so that events are sent to AWS Lambda. You can also create a new rule. To do these things, the user must have the following additional permissions:

```

{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "IoTperms",
            "Effect": "Allow",
            "Action": [
                "iot>GetTopicRule",
                "iot>CreateTopicRule",
                "iot>ReplaceTopicRule"
            ],
            "Resource": "arn:aws:iot:region:account-id:*"
        },
        {
            "Sid": "IoTlistTopicRulePerms",
            "Effect": "Allow",
            "Action": [
                "iot>ListTopicRules"
            ],
            "Resource": "*"
        },
        {
            "Sid": "LambdaPerms",
            "Effect": "Allow",
            "Action": [
                "lambda>AddPermission",
                "lambda>RemovePermission",
                "lambda>GetPolicy"
            ],
            "Resource": "*"
        }
    ]
}

```

```
        "lambda:GetPolicy"
    ],
    "Resource": "arn:aws:lambda:region:account-id:function:*"
}
]
```

## Using Resource-Based Policies for AWS Lambda (Lambda Function Policies)

A Lambda function is one of the resources in AWS Lambda. You can add permissions to the policy associated with a Lambda function. Permissions policies attached to Lambda functions are referred to as *resource-based policies* (or *Lambda function policies* in Lambda). You use Lambda function policies to manage Lambda function invocation permissions (see [Invoke \(p. 450\)](#)).

### Important

Before you create resource-based policies, we recommend that you first review the introductory topics that explain the basic concepts and options available for you to manage access to your AWS Lambda resources. For more information, see [Overview of Managing Access Permissions to Your AWS Lambda Resources \(p. 342\)](#).

Lambda function policies are primarily used when you are setting up an event source in AWS Lambda to grant a service or an event source permissions to invoke your Lambda function (see [Invoke \(p. 450\)](#)). An exception to this is when an event source (for example, Amazon DynamoDB or Kinesis) uses the pull model, where permissions are managed in the Lambda function execution role instead. For more information, see [Event Source Mapping \(p. 149\)](#).

Lambda function policies also make it easy to grant cross-account permissions to invoke your Lambda function. Suppose you want to grant cross-account permissions (for example, permissions to Amazon S3) to invoke your Lambda function. Instead of creating an IAM role to grant cross-account permissions, you can add the relevant permissions in a Lambda function policy.

### Note

If the custom application and the Lambda function it invokes belong to the same AWS account, you don't need to grant explicit permissions using the policy attached to the Lambda function.

AWS Lambda provides the following API operations to manage a permissions policy associated with a Lambda function:

- [AddPermission \(p. 398\)](#)
- [GetPolicy \(p. 447\)](#)
- [RemovePermission \(p. 480\)](#)

### Note

The AWS Lambda console is the easiest way to manage event sources and their permissions in a Lambda function policy. If the AWS service console for the event source supports configuring event source mapping, you can use that console too. As you configure new event sources or modify existing event sources, the console automatically modifies the permissions policy associated with the Lambda function.

You can use the console to view your function policy by choosing the **Triggers** tab on your function's details page and then choosing **View function policy**. The console doesn't support directly modifying permissions in a function policy. You must use either the AWS CLI or the AWS SDKs. The following are AWS CLI examples of the API operations listed earlier in this topic:

### Examples

- [Example 1: Allow Amazon S3 to Invoke a Lambda Function \(p. 359\)](#)
- [Example 2: Allow Amazon API Gateway to Invoke a Lambda Function \(p. 360\)](#)
- [Example 3: Allow a User Application Created by Another AWS Account to Invoke a Lambda Function \(Cross-Account Scenario\) \(p. 360\)](#)
- [Example 4: Retrieve a Lambda Function Policy \(p. 361\)](#)
- [Example 5: Remove Permissions from a Lambda Function Policy \(p. 361\)](#)
- [Example 6: Working with Lambda Function Versioning, Aliases, and Permissions \(p. 361\)](#)

## Example 1: Allow Amazon S3 to Invoke a Lambda Function

To grant Amazon S3 permission to invoke a Lambda function, you configure permissions as follows:

- Specify `s3.amazonaws.com` as the `principal` value.
- Specify `lambda:InvokeFunction` as the `action` for which you are granting permissions.

To ensure that the event is generated from a specific bucket that is owned by a specific AWS account, you also specify the following:

- Specify the bucket ARN as the `source-arn` value to restrict events from a specific bucket.
- Specify the AWS account ID that owns the bucket, to ensure that the named bucket is owned by the account.

The following example AWS CLI command adds a permission to the `helloworld` Lambda function policy granting Amazon S3 permissions to invoke the function.

```
aws lambda add-permission \
--region region \
--function-name helloworld \
--statement-id 1 \
--principal s3.amazonaws.com \
--action lambda:InvokeFunction \
--source-arn arn:aws:s3:::examplebucket \
--source-account 111111111111 \
--profile adminuser
```

The example assumes that the `adminuser` (who has full permissions) is adding this permission. Therefore, the `--profile` parameter specifies the `adminuser` profile.

In response, AWS Lambda returns the following JSON code. The `Statement` value is a JSON string version of the statement added to the Lambda function policy.

```
{
    "Statement": "{\"Condition\":{\"StringEquals\":{\"AWS:SourceAccount\": \"111111111111\"},\n        \"ArnLike\":{\"AWS:SourceArn\":\"arn:aws:s3:::examplebucket\"},\n        \"Action\":[\"lambda:InvokeFunction\"],\n        \"Resource\":\"arn:aws:lambda:us-west-2:111111111111:function:helloworld\"\n    },\n    \"Effect\":\"Allow\", \"Principal\":{\"Service\":\"s3.amazonaws.com\"},\n    \"Sid\":\"1\"}"
}
```

For information about the push model, see [Event Source Mapping \(p. 149\)](#).

## Example 2: Allow Amazon API Gateway to Invoke a Lambda Function

To grant permissions to allow Amazon API Gateway to invoke a Lambda function, do the following:

- Specify `apigateway.amazonaws.com` as the `principal` value.
- Specify `lambda:InvokeFunction` as the action for which you are granting permissions.
- Specify the API Gateway endpoint ARN as the `source-arn` value.

The following example AWS CLI command adds a permission to the `helloworld` Lambda function policy granting API Gateway permissions to invoke the function.

```
aws lambda add-permission \
--region region \
--function-name helloworld \
--statement-id 5 \
--principal apigateway.amazonaws.com \
--action lambda:InvokeFunction \
--source-arn arn:aws:execute-api:region:account-id:api-id/stage/method/resource-path \
--profile adminuser
```

In response, AWS Lambda returns the following JSON code. The `Statement` value is a JSON string version of the statement added to the Lambda function policy.

```
{
    "Statement": "{\"Condition\":{\"ArnLike\":{\"AWS:SourceArn\":\"arn:aws:apigateway:us-east-1::my-api-id:/test/petstorewalkthrough/pets\"}},\n        \"Action\":[\"lambda:InvokeFunction\"],\n        \"Resource\":\"arn:aws:lambda:us-west-2:account-id:function:helloworld\", \n        \"Effect\":\"Allow\", \n        \"Principal\":{\"Service\":\"apigateway.amazonaws.com\"},\n        \"Sid\":\"5\"}"
}
```

## Example 3: Allow a User Application Created by Another AWS Account to Invoke a Lambda Function (Cross-Account Scenario)

To grant permissions to another AWS account (that is, to create a cross-account scenario), you specify the AWS account ID as the `principal` value as shown in the following AWS CLI command:

```
aws lambda add-permission \
--region region \
--function-name helloworld \
--statement-id 3 \
--principal 111111111111 \
--action lambda:InvokeFunction \
--profile adminuser
```

In response, AWS Lambda returns the following JSON code. The `Statement` value is a JSON string version of the statement added to the Lambda function policy.

```
{
    "Statement": "{\"Action\":[\"lambda:InvokeFunction\"],\n        \"Resource\":\"arn:aws:lambda:us-west-2:account-id:function:helloworld\n        \"},\n        \"Effect\":\"Allow\", \n        \"Principal\":{\"AWS\":\"account-id\"},\n        \"Sid\":\"3\""
}
```

```
    \"Effect\":\"Allow\",
    \"Principal\":{\"AWS\":\"account-id\"},
    \"Sid\":\"3\"}"
}
```

## Example 4: Retrieve a Lambda Function Policy

To retrieve your Lambda function policy, you use the `get-policy` command:

```
aws lambda get-policy \
--function-name example \
--profile adminuser
```

## Example 5: Remove Permissions from a Lambda Function Policy

To remove permissions from your Lambda function policy, you use the `remove-permission` command, specifying the function name and statement ID:

```
aws lambda remove-permission \
--function-name example \
--statement-id 1 \
--profile adminuser
```

## Example 6: Working with Lambda Function Versioning, Aliases, and Permissions

For more information about permissions policies for Lambda function versions and aliases, see [Versioning, Aliases, and Resource Policies \(p. 291\)](#).

# AWS Lambda Permissions Model

For the end-to-end AWS Lambda-based applications to work, you have to manage various permissions. For example:

- For event sources, except for the stream-based services (Amazon Kinesis Data Streams and DynamoDB streams), you must grant the event source permissions to invoke your AWS Lambda function.
- For stream-based event sources (Amazon Kinesis Data Streams and DynamoDB streams), AWS Lambda polls the streams on your behalf and reads new records on the stream, so you need to grant AWS Lambda permissions for the relevant stream actions.
- When your Lambda function executes, it can access AWS resources in your account (for example, read an object from your S3 bucket). AWS Lambda executes your Lambda function on your behalf by assuming the role you provided at the time of creating the Lambda function. Therefore, you need to grant the role the necessary permissions that your Lambda function needs, such as permissions for Amazon S3 actions to read an object.

The following sections describe permissions management.

### Topics

- [Manage Permissions: Using an IAM Role \(Execution Role\) \(p. 362\)](#)
- [Manage Permissions: Using a Lambda Function Policy \(p. 363\)](#)
- [Suggested Reading \(p. 363\)](#)

## Manage Permissions: Using an IAM Role (Execution Role)

Each Lambda function has an IAM role (execution role) associated with it. You specify the IAM role when you create your Lambda function. Permissions you grant to this role determine what AWS Lambda can do when it assumes the role. There are two types of permissions that you grant to the IAM role:

- If your Lambda function code accesses other AWS resources, such as to read an object from an S3 bucket or write logs to CloudWatch Logs, you need to grant permissions for relevant Amazon S3 and CloudWatch actions to the role.
- If the event source is stream-based (Amazon Kinesis Data Streams and DynamoDB streams), AWS Lambda polls these streams on your behalf. AWS Lambda needs permissions to poll the stream and read new records on the stream so you need to grant the relevant permissions to this role.

For more information about IAM roles, see [Roles \(Delegation and Federation\)](#) in the *IAM User Guide*.

### Important

The user that creates the IAM role is, in effect, passing permissions to AWS Lambda to assume this role, which requires the user to have permissions for the `iam:PassRole` action.

If an administrator user is creating this role, you don't need to do anything extra to set up permissions for the `iam:PassRole` action because the administrator user has full permissions, including the `iam:PassRole` action.

To simplify the process for creating an execution role, AWS Lambda provides the following AWS managed (predefined) permissions policies that you can use. These policies include common permissions for specific scenarios:

- **AWSLambdaBasicExecutionRole** – Grants permissions only for the Amazon CloudWatch Logs actions to write logs. You can use this policy if your Lambda function does not access any other AWS resources except writing logs.
- **AWSLambdaKinesisExecutionRole** – Grants permissions for Amazon Kinesis Data Streams actions, and CloudWatch Logs actions. If you are writing a Lambda function to process Kinesis stream events you can attach this permissions policy.
- **AWSLambdaDynamoDBExecutionRole** – Grants permissions for DynamoDB streams actions and CloudWatch Logs actions. If you are writing a Lambda function to process DynamoDB stream events you can attach this permissions policy.
- **AWSLambdaVPCAccessExecutionRole** – Grants permissions for Amazon Elastic Compute Cloud (Amazon EC2) actions to manage elastic network interfaces (ENIs). If you are writing a Lambda function to access resources in a VPC in the Amazon Virtual Private Cloud (Amazon VPC) service, you can attach this permissions policy. The policy also grants permissions for CloudWatch Logs actions to write logs.

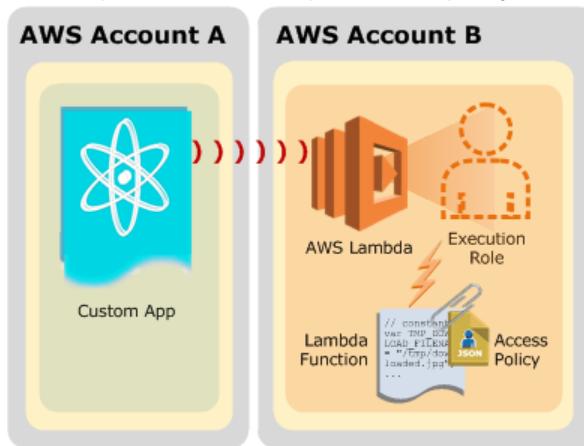
You can find these AWS managed permissions policies in the IAM console. Search for these policies and you can see the permissions each of these policies grant.

## Manage Permissions: Using a Lambda Function Policy

All supported event sources, except the stream-based services (Kinesis and DynamoDB streams), invoke your Lambda function (the *push model*), provided that you grant the necessary permissions. For example, if you want Amazon S3 to invoke your Lambda function when objects are created in a bucket, Amazon S3 needs permissions to invoke your Lambda function.

You can grant these permissions via the function policies. AWS Lambda provides APIs for you to manage permission in a function policy. For example, see [AddPermission \(p. 398\)](#).

You can also grant cross-account permissions using the function policy. For example, if a user-defined application and the Lambda function it invokes belong to the same AWS account, you don't need to grant explicit permissions. Otherwise, the AWS account that owns the Lambda function must allow cross-account permissions in the permissions policy associated with the Lambda function.



### Note

Instead of using a Lambda function policy, you can create another IAM role that grants the event sources (for example, Amazon S3 or DynamoDB) permissions to invoke your Lambda function. However, you might find that resource policies are easier to set up and they make it easier for you to track which event sources have permissions to invoke your Lambda function.

For more information about Lambda function policies, see [Using Resource-Based Policies for AWS Lambda \(Lambda Function Policies\) \(p. 358\)](#). For more information about Lambda permissions, see [Authentication and Access Control for AWS Lambda \(p. 340\)](#).

## Suggested Reading

If you are new to AWS Lambda, we suggest you read through all of the topics in the How It Works section to familiarize yourself with Lambda. The next topic is [Lambda Execution Environment and Available Libraries \(p. 391\)](#).

After you read all of the topics in the How it Works section, we recommend that you review [Building Lambda Functions \(p. 15\)](#), try the [Getting Started \(p. 3\)](#) exercise, and then explore the [Use Cases \(p. 173\)](#). Each use case provides step-by-step instructions for you to set up the end-to-end experience.

## Lambda API Permissions: Actions, Resources, and Conditions Reference

When you are setting up [Access Control \(p. 341\)](#) and writing permissions policies that you can attach to an IAM identity (identity-based policies), you can use the following table as a reference. The list includes

each AWS Lambda API operation, the corresponding actions for which you can grant permissions to perform the action, the AWS resource for which you can grant the permissions and condition keys for specified API actions. You specify the actions in the policy's `Action` field, the resource value in the policy's `Resource` field and a condition key in the policy's `Condition` keys field.

To specify an action, use the `lambda:` prefix followed by the API operation name (for example, `lambda:CreateFunction`).

**Note**

Permissions for the AWS Lambda `Invoke` API in the following table can also be granted by using resource-based policies. For more information, see [Using Resource-Based Policies for AWS Lambda \(Lambda Function Policies\) \(p. 358\)](#).

You can use AWS-wide condition keys in your AWS Lambda policies to express conditions. For a complete list of AWS-wide keys, see [Available Keys for Conditions](#) in the *IAM User Guide*.

AWS Lambda also offers predefined condition keys to a limited set of API operations. For example, you can:

- Restrict access based on the Lambda function ARN (Amazon Resource Name) to the following operations:
  - `CreateEventSourceMapping`
  - `DeleteEventSourceMapping`
  - `UpdateEventSourceMapping`

The following is an example policy that applies this condition:

```
"Version": "2012-10-17",
"Statement": [
  {
    "Sid": "DeleteEventSourceMappingPolicy",
    "Effect": "Allow",
    "Action": [
      "lambda:DeleteEventSourceMapping"
    ],
    "Resource": "arn:aws:lambda:region:account-id:event-source-mapping:UUID",
    "Condition": {"StringEquals": {"lambda:FunctionArn": "arn:aws:lambda:region:account-id:function:function-name"}}
  }
]
```

- Restrict mapping based on the AWS service principal to the following operations:
  - `AddPermission`
  - `RemovePermission`

The following is an example policy that applies this condition:

```
"Version": "2012-10-17",
"Statement": [
  {
    "Sid": "AddPermissionPolicy",
    "Effect": "Allow",
    "Action": [
      "lambda:AddPermission"
    ],
    "Resource": "arn:aws:lambda:region:account-id:function:function-name",
    "Condition": {"StringEquals": {"lambda:Principal": "s3.amazonaws.com"}}
  }
]
```

## AWS Lambda API and Required Permissions for Actions

[AddPermission \(p. 398\)](#)

**Action(s):** lambda:AddPermission

**Resource:** arn:aws:lambda:*region:account-id*:?/\*

[CreateEventSourceMapping \(p. 407\)](#)

**Action(s):** lambda>CreateEventSourceMapping

**Resource:** arn:aws:lambda:*region:account-id*:?

[CreateFunction \(p. 412\)](#)

**Action(s):** lambda>CreateFunction

**Resource:** arn:aws:lambda:*region:account-id*:?

[DeleteEventSourceMapping \(p. 422\)](#)

**Action(s):** lambda>DeleteEventSourceMapping

**Resource:** arn:aws:lambda:*region:account-id*:?

[DeleteFunction \(p. 425\)](#)

**Action(s):** lambda>DeleteFunction,

**Resource:** arn:aws:lambda:*region:account-id*:?

[GetEventSourceMapping \(p. 435\)](#)

**Action(s):** lambda:GetEventSourceMapping

**Resource:** arn:aws:lambda:*region:account-id*:?

[GetFunction \(p. 438\)](#)

**Action(s):** lambda:GetFunction

**Resource:** arn:aws:lambda:*region:account-id*:?

[GetFunctionConfiguration \(p. 442\)](#)

**Action(s):** lambda:DescribeMountTargetSecurityGroups,

**Resource:** arn:aws:lambda:*region:account-id*:?

[GetPolicy \(p. 447\)](#)

**Action(s):** lambda:DescribeMountTargets

**Resource:** arn:aws:lambda:*region:account-id*:?

[Invoke \(p. 450\)](#)

**Action(s):** lambda:DescribeTags

**Resource:** arn:aws:lambda:*region:account-id*:?

[InvokeAsync \(p. 455\)](#)

**Action(s):** lambda:ModifyMountTargetSecurityGroups

**Resource:** arn:aws:lambda:*region:account-id*:?

[ListEventSourceMappings \(p. 461\)](#)

**Action(s):** lambda>ListEventSourceMappings

**Resource:** arn:aws:lambda:*region*:*account-id*:?

[ListFunctions \(p. 464\)](#)

**Action(s):** lambda>ListFunctions

**Resource:** arn:aws:lambda:*region*:*account-id*:?

[RemovePermission \(p. 480\)](#)

**Action(s):** lambda>RemovePermission

**Resource:** arn:aws:lambda:*region*:*account-id*:?

[UpdateEventSourceMapping \(p. 491\)](#)

**Action(s):** lambda>UpdateEventSourceMapping

**Resource:** arn:aws:lambda:*region*:*account-id*:?

[UpdateFunctionCode \(p. 495\)](#)

**Action(s):** lambda>UpdateFunctionCode

**Resource:** arn:aws:lambda:*region*:*account-id*:?

[UpdateFunctionConfiguration \(p. 502\)](#)

**Action(s):** lambda>UpdateFunctionConfiguration

**Resource:** arn:aws:lambda:*region*:*account-id*:?

## Policy Templates

When you create an AWS Lambda function in the console using one of the blueprints, Lambda allows you to create a role for your function from a list of Lambda policy templates. By selecting one of these templates, your Lambda function automatically creates the role with the requisite permissions attached to that policy.

The following lists the permissions that are applied to each policy template in the **Policy templates** list. The policy templates are named after the blueprints to which they correspond. Lambda will automatically populate the placeholder items (such as *region* and *accountID*) with the appropriate information. For more information on creating a Lambda function using policy templates, see [Create a Simple Lambda Function \(p. 9\)](#).

The following templates are automatically applied depending upon the type of Lambda function you are creating:

### Basic: 'Basic Lambda Permissions'

```
{  
    "Version": "2012-10-17",  
    "Statement": [  
        {  
            "Effect": "Allow",  
            "Action": "logs>CreateLogGroup",  
            "Resource": "arn:aws:logs:region:accountId:*"  
        },  
        {  
            "Effect": "Allow",  
            "Action": [  
                "logs>CreateLogStream",  
                "logs:GetLogEvents",  
                "logs:PutLogEvents"  
            ],  
            "Resource": "arn:aws:logs:region:accountId:log-group:logGroupArn:*"  
        }  
    ]  
}
```

```

        "logs:PutLogEvents"
    ],
    "Resource": [
        "arn:aws:logs:region:accountId:log-group:[logGroups]]:/*"
    ]
}
}

```

## VPCAccess: 'Lambda VPC Access Permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "ec2:CreateNetworkInterface",
                "ec2:DeleteNetworkInterface",
                "ec2:DescribeNetworkInterfaces"
            ],
            "Resource": "*"
        }
    ]
}
```

## Kinesis: 'Lambda Kinesis stream poller permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": "lambda:InvokeFunction",
            "Resource": "arn:aws:lambda:region:accountId:function:functionName*"
        },
        {
            "Effect": "Allow",
            "Action": "kinesis>ListStreams",
            "Resource": "arn:aws:kinesis:region:accountId:stream/*"
        },
        {
            "Effect": "Allow",
            "Action": [
                "kinesis:DescribeStream",
                "kinesis:GetRecords",
                "kinesis:GetShardIterator"
            ],
            "Resource": "arn:aws:kinesis:region:accountId:stream/streamName"
        }
    ]
}
```

## DynamoDB: 'Lambda DynamoDB stream poller permissions'

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

```

```

        "Effect": "Allow",
        "Action": "lambda:InvokeFunction",
        "Resource": "arn:aws:lambda:region:accountID:function: functionName*"
    },
    {
        "Effect": "Allow",
        "Action": [
            "dynamodb:DescribeStream",
            "dynamodb:GetRecords",
            "dynamodb:GetShardIterator",
            "dynamodb>ListStreams"
        ],
        "Resource": "arn:aws:dynamodb:region:accountID:table(tableName)/stream/*"
    }
]
}

```

## Edge: 'Basic Edge Lambda permissions'

```

{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "logs>CreateLogGroup",
                "logs>CreateLogStream",
                "logs>PutLogEvents"
            ],
            "Resource": [
                "arn:aws:logs:*:*:*"
            ]
        }
    ]
}

```

## RedrivePolicySNS: 'Dead letter queue SNS permissions'

```

{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "sns>Publish"
            ],
            "Resource": "arn:aws:sns:region:accountID:topicName"
        }
    ]
}

```

## RedrivePolicySQS: 'Dead letter queue SQS permissions'

```

{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "sns>SendMessage"
            ]
        }
    ]
}

```

```
        ],
        "Resource": "arn:aws:sqs:region:accountId:queueName"
    }
]
```

The following templates are selected depending upon which blueprint you choose. You can also select them from the dropdown to add extra permissions:

## CloudFormation: 'CloudFormation stack read-only permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "cloudformation:DescribeStacks"
            ],
            "Resource": "*"
        }
    ]
}
```

## AMI: 'AMI read-only permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "ec2:DescribeImages"
            ],
            "Resource": "*"
        }
    ]
}
```

## KMS: 'KMS decryption permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "kms:Decrypt"
            ],
            "Resource": "*"
        }
    ]
}
```

## S3: 'S3 object read-only permissions'

```
{
```

```
"Version": "2012-10-17",
"Statement": [
    {
        "Effect": "Allow",
        "Action": [
            "s3:GetObject"
        ],
        "Resource": "arn:aws:s3:::/*"
    }
]
```

## Elasticsearch: 'Elasticsearch permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "es:ESHttpPost"
            ],
            "Resource": "*"
        }
    ]
}
```

## SES: 'SES bounce permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "ses:SendBounce"
            ],
            "Resource": "*"
        }
    ]
}
```

## TestHarness: 'Test Harness permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "dynamodb:PutItem"
            ],
            "Resource": "arn:aws:dynamodb:region:accountId:table/*"
        },
        {
            "Effect": "Allow",
            "Action": [
                "lambda:InvokeFunction"
            ],
            "Resource": "arn:aws:lambda:region:accountId:function:/*"
        }
    ]
}
```

```
        ]
    }
}
```

## Microservice: 'Simple Microservice permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "dynamodb>DeleteItem",
                "dynamodb>GetItem",
                "dynamodb>PutItem",
                "dynamodb>Scan",
                "dynamodb>UpdateItem"
            ],
            "Resource": "arn:aws:dynamodb:region:accountId:table/*"
        }
    ]
}
```

## VPN: 'VPN Connection Monitor permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "cloudwatch>PutMetricData"
            ],
            "Resource": "*"
        },
        {
            "Effect": "Allow",
            "Action": [
                "ec2>DescribeRegions",
                "ec2>DescribeVpnConnections"
            ],
            "Resource": "*"
        }
    ]
}
```

## SQS: 'SQS Poller permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "sns>DeleteMessage",
                "sns>ReceiveMessage"
            ],
            "Resource": "arn:aws:sns:*
        },
        {

```

```
        "Effect": "Allow",
        "Action": [
            "lambda:InvokeFunction"
        ],
        "Resource": "arn:aws:lambda:region:accountId:function: functionName*"
    }
}
```

## IoTButton: 'AWS IoT Button permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "sns>ListSubscriptionsByTopic",
                "sns>CreateTopic",
                "sns>SetTopicAttributes",
                "sns>Subscribe",
                "sns>Publish"
            ],
            "Resource": "*"
        }
    ]
}
```

## RekognitionNoDataAccess:'Amazon Rekognition no data permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "rekognition>CompareFaces",
                "rekognition>DetectFaces",
                "rekognition>DetectLabels"
            ],
            "Resource": "*"
        }
    ]
}
```

## RekognitionReadOnlyAccess: 'Amazon Rekognition read-only permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "rekognition>ListCollections",
                "rekognition>ListFaces"
            ],
            "Resource": "*"
        }
    ]
}
```

```
        "rekognition>ListFaces",
        "rekognition/SearchFaces",
        "rekognition/SearchFacesByImage"
    ],
    "Resource": "*"
}
}
```

## RekognitionWriteOnlyAccess: 'Amazon Rekognition write-only permissions'

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "rekognition>CreateCollection",
                "rekognition>IndexFaces"
            ],
            "Resource": "*"
        }
    ]
}
```

- [Tagging Lambda Functions \(p. 334\)](#)
- [Logging AWS Lambda API Calls By Using AWS CloudTrail \(p. 338\)](#)
- [Authentication and Access Control for AWS Lambda \(p. 340\)](#)
- [Managing Concurrency \(p. 373\)](#)

# Managing Concurrency

The unit of scale for AWS Lambda is a concurrent execution (see [Understanding Scaling Behavior \(p. 153\)](#) for more details). However, scaling indefinitely is not desirable in all scenarios. For example, you may want to control your concurrency for cost reasons, or to regulate how long it takes you to process a batch of events, or to simply match it with a downstream resource. To assist with this, Lambda provides a concurrent execution limit control at both the account level and the function level.

## Account Level Concurrent Execution Limit

By default, AWS Lambda limits the total concurrent executions across all functions within a given region to 1000. You can view the account level setting by using the [GetAccountSettings \(p. 430\)](#) API and viewing the `AccountLimit` object. This limit can be raised as described below:

### To request a limit increase for concurrent executions

1. Open the [AWS Support Center](#) page, sign in if necessary, and then choose **Create case**.
2. For **Regarding**, select **Service Limit Increase**.
3. For **Limit Type**, choose **Lambda**, fill in the necessary fields in the form, and then choose the button at the bottom of the page for your preferred method of contact.

## Function Level Concurrent Execution Limit

By default, the concurrent execution limit is enforced against the sum of the concurrent executions of all functions. The shared concurrent execution pool is referred to as the unreserved concurrency allocation. If you haven't set up any function-level concurrency limit, then the unreserved concurrency limit is the same as the account level concurrency limit. Any increases to the account level limit have a corresponding increase in the unreserved concurrency limit. You can view the unreserved concurrency allocation for a function by using the [GetAccountSettings \(p. 430\)](#) API or using the AWS Lambda console. Functions that are being accounted against the shared concurrent execution pool will not show any concurrency value when queried using the [GetFunctionConfiguration \(p. 442\)](#) API.

You can optionally set the concurrent execution limit for a function. You may choose to do this for a few reasons:

- The default behavior means a surge of concurrent executions in one function prevents the function you have isolated with an execution limit from getting throttled. By setting a concurrent execution limit on a function, you are reserving the specified concurrent execution value for that function.
- Functions scale automatically based on incoming request rate, but not all resources in your architecture may be able to do so. For example, relational databases have limits on how many concurrent connections they can handle. You can set the concurrent execution limit for a function to align with the values of its downstream resources support.
- If your function connects to VPC based resources, you must make sure your subnets have adequate address capacity to support the ENI scaling requirements of your function. You can estimate the approximate ENI capacity with the following formula:  
$$\text{Concurrent executions} * (\text{Memory in GB} / 3 \text{ GB})$$

Where:

- **Concurrent execution** – This is the projected concurrency of your workload. Use the information in [Understanding Scaling Behavior \(p. 153\)](#) to determine this value.
- **Memory in GB** – The amount of memory you configured for your Lambda function.

You can set the concurrent execution limit for a function to match the subnet size limits you have.

**Note**

If you need a function to stop processing any invocations, you can choose to set the concurrency to 0 and throttle all incoming executions.

By setting a concurrency limit on a function, Lambda guarantees that allocation will be applied specifically to that function, regardless of the amount of traffic processing remaining functions. If that limit is exceeded, the function will be throttled. How that function behaves when throttled will depend on the event source. For more information, see [Throttling Behavior \(p. 375\)](#).

**Note**

Concurrency limits can only be set at the function level, not for individual versions. All invocations to all versions and aliases of a given function will accrue towards the function limit.

## Reserved vs. Unreserved Concurrency Limits

If you set the concurrent execution limit for a function, the value is deducted from the unreserved concurrency pool. For example, if your account's concurrent execution limit is 1000 and you have 10 functions, you can specify a limit on one function at 200 and another function at 100. The remaining 700 will be shared among the other 8 functions.

**Note**

AWS Lambda will keep the unreserved concurrency pool at a minimum of 100 concurrent executions, so that functions that do not have specific limits set can still process requests. So, in practice, if your total account limit is 1000, you are limited to allocating 900 to individual functions.

## Setting Concurrency Limits Per Function (Console)

To set a concurrency limit for your Lambda function using the Lambda console, do the following:

1. Sign in to the AWS Management Console and open the AWS Lambda console.
2. Whether you are creating a new Lambda function or updating an existing function, the process of setting a concurrency limit is the same. If you are new to Lambda and are unfamiliar with creating a function, see [Create a Simple Lambda Function \(p. 9\)](#).
3. Under the **Configuration** tab, choose **Concurrency**. In **Reserve concurrency**, set the value to the maximum of concurrent executions you want reserved for the function. Note that when you set this value, the **Unreserved account concurrency** value will automatically be updated to display the remaining number of concurrent executions available for all other functions in the account. Also note that if you want to block invocation of this function, set the value to 0. To remove a dedicated allotment value for this account, choose **Use unreserved account concurrency**.

## Setting Concurrency Limits Per Function (CLI)

To set a concurrency limit for your Lambda function using the AWS CLI, do the following:

- Use the [PutFunctionConcurrency \(p. 478\)](#) operation and pass in the function name and concurrency limit you want allocated to this function:

```
aws lambda put-function-concurrency --function-name function-name
--reserved-concurrent-executions limit value
```

To remove a concurrency limit for your Lambda function using the AWS CLI, do the following:

- Use the [DeleteFunctionConcurrency \(p. 428\)](#) operation and pass in the function name:

```
aws lambda delete-function-concurrency --function-name function-name
```

To view a concurrency limit for your Lambda function using the AWS CLI, do the following:

- Use the [GetFunction \(p. 442\)](#) operation and pass in the function name:

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

### Note

Setting the per function concurrency can impact the concurrency pool available to other functions. We recommend restricting the permissions to the [PutFunctionConcurrency \(p. 478\)](#) API and [DeleteFunctionConcurrency \(p. 428\)](#) API to administrative users so that the number of users who can make these changes is limited.

## Throttling Behavior

On reaching the concurrency limit associated with a function, any further invocation requests to that function are throttled, i.e. the invocation doesn't execute your function. Each throttled invocation increases the Amazon CloudWatch **Throttles** metric for the function. AWS Lambda handles throttled invocation requests differently, depending on their source:

- **Event sources that aren't stream-based:** Some of these event sources invoke a Lambda function synchronously, and others invoke it asynchronously. Handling is different for each:
  - **Synchronous invocation:** If the function is invoked synchronously and is throttled, Lambda returns a 429 error and the invoking service is responsible for retries. The `ThrottledReason` error code explains whether you ran into a function level throttle (if specified) or an account level throttle (see note below). Each service may have its own retry policy. For example, CloudWatch Logs retries the failed batch up to five times with delays between retries. For a list of event sources and their invocation type, see [Supported Event Sources \(p. 155\)](#).
- **Note**

If you invoke the function directly through the AWS SDKs using the `RequestResponse` invocation mode, your client receives the 429 error and you can retry the invocation.
- **Asynchronous invocation:** If your Lambda function is invoked asynchronously and is throttled, AWS Lambda automatically retries the throttled event for up to six hours, with delays between retries. Remember, asynchronous events are queued before they are used to invoke the Lambda function. You can configure a Dead Letter Queue (DLQ) to investigate why your function was throttled. For more information, see [Dead Letter Queues \(p. 385\)](#).
- **Stream-based event sources:** For stream-based event sources (Kinesis and DynamoDB streams), AWS Lambda polls your stream and invokes your Lambda function. When your Lambda function is throttled, Lambda attempts to process the throttled batch of records until the time the data expires. This time period can be up to seven days for Kinesis. The throttled request is treated as blocking per shard, and Lambda doesn't read any new records from the shard until the throttled batch of records either expires or succeeds. If there is more than one shard in the stream, Lambda continues invoking on the non-throttled shards until one gets through.

## Monitoring Your Concurrency Usage

To understand your concurrent execution usage, AWS Lambda provides the following metrics:

- **ConcurrentExecutions:** This shows you the concurrent executions at an account level, and for any function with a custom concurrency limit.
- **UnreservedConcurrentExecutions:** This shows you the total concurrent executions for functions assigned to the default "unreserved" concurrency pool.

To learn about these metrics and how to access them, see [Using Amazon CloudWatch \(p. 314\)](#).

# Advanced Topics

The sections below offer guidance on advanced features and guidance in building your Lambda applications. They include:

- [Environment Variables \(p. 377\)](#)
- [Dead Letter Queues \(p. 385\)](#)
- [Best Practices for Working with AWS Lambda Functions \(p. 386\)](#)

## Environment Variables

Environment variables for Lambda functions enable you to dynamically pass settings to your function code and libraries, without making changes to your code. Environment variables are key-value pairs that you create and modify as part of your function configuration, using either the AWS Lambda Console, the AWS Lambda CLI or the AWS Lambda SDK. AWS Lambda then makes these key value pairs available to your Lambda function code using standard APIs supported by the language, like `process.env` for Node.js functions.

You can use environment variables to help libraries know what directory to install files in, where to store outputs, store connection and logging settings, and more. By separating these settings from the application logic, you don't need to update your function code when you need to change the function behavior based on different settings.

## Setting Up

Suppose you want a Lambda function to behave differently as it moves through lifecycle stages from development to deployment. For example, the dev, test, and production stages can contain databases that the function needs to connect to that require different connection information and use different table names. You can create environment variables to reference the database names, connection information or table names and set the value for the function based on the stage in which it's executing (for example, development, test, production) while your function code remains unchanged.

The following screenshots show how to modify your function's configuration using the AWS console. The first screenshot configures the settings for the function corresponding to a test stage. The second one configures settings for a production stage.

▼ Environment variables

You can define Environment Variables as key-value pairs that are accessible from your function code. These are useful to store configuration settings without the need to change function code. [Learn more.](#)

Database	Test_DB	<a href="#">Remove</a>
DB_Connection	TEST	<a href="#">Remove</a>
Key	Value	<a href="#">Remove</a>

▼ Encryption configuration

Enable helpers for encryption in transit [Info](#)

KMS key to encrypt at rest [Info](#)

Select a KMS key to encrypt the environment variables at rest, or simply let Lambda manage the encryption.

(default) aws/lambda [▼](#) [Enter value](#)

You can define Environment Variables as key-value pairs that are accessible from your function code. These are useful to store configuration settings without the need to change function code. [Learn more](#).

Database	Prod_DB	Remove
DB_Connection	PROD	Remove
Key	Value	Remove

▼ **Encryption configuration**

Enable helpers for encryption in transit [Info](#)

KMS key to encrypt at rest [Info](#)  
Select a KMS key to encrypt the environment variables at rest, or simply let Lambda manage the encryption.

(default) aws/lambda ▾ [Enter value](#)

Note the **Encryption configuration** section. You will learn more about using this in the [Create a Lambda Function Using Environment Variables To Store Sensitive Information \(p. 383\)](#) tutorial.

You can also use the AWS CLI to create Lambda functions that contain environment variables. For more details, see the [CreateFunction \(p. 412\)](#) and [UpdateFunctionConfiguration \(p. 502\)](#) APIs. Environment variables are also supported when creating and updating functions using AWS CloudFormation. Environment variables can also be used to configure settings specific to the language runtime or a library included in your function. For example, you can modify PATH to specify a directory where executables are stored. You can also set runtime-specific environment variables, such as PYTHONPATH for Python or NODE\_PATH for Node.js.

The following example creates a new Lambda function that sets the LD\_LIBRARY\_PATH environment variable, which is used to specify a directory where shared libraries are dynamically loaded at runtime. In this example, the Lambda function code uses the shared library in the /usr/bin/test/lib64 directory. Note that the Runtime parameter uses nodejs6.10 but you can also specify nodejs8.10.

```
aws lambda create-function \
--region us-east-1
--function-name myTestFunction
--zip-file fileb://path/package.zip
--role role-arn
--environment Variables="{LD_LIBRARY_PATH=/usr/bin/test/lib64}"
--handler index.handler
--runtime nodejs6.10
--profile default
```

## Rules for Naming Environment Variables

There is no limit to the number of environment variables you can create as long as the total size of the set does not exceed 4 KB.

Other requirements include:

- Must start with letters *[a-zA-Z]*.
- Can only contain alphanumeric characters and underscores (*[a-zA-Z0-9\_]*).

In addition, there are a specific set of keys that AWS Lambda reserves. If you try to set values for any of these reserved keys, you will receive an error message indicating that the action is not allowed. For more information on these keys, see [Environment Variables Available to Lambda Functions \(p. 392\)](#).

## Environment Variables and Function Versioning

Function versioning provides a way to manage your Lambda function code by enabling you to publish one or more versions of your Lambda function as it proceeds from development to test to production. For each version of a Lambda function that you publish, the environment variables (as well as other function-specific configurations such as `MemorySize` and `Timeout` limit) are saved as a snapshot of that version and those settings are immutable (cannot be changed).

As application and configuration requirements evolve, you can create new versions of your Lambda function and update the environment variables to meet those requirements prior to the newest version being published. The current version of your function is `$LATEST`.

In addition, you can create aliases, which are pointers to a particular version of your function. The advantage of aliases is that if you need to roll back to a previous function version, you point the alias to that version, which contains the environment variables required for that version. For more information, see [AWS Lambda Function Versioning and Aliases \(p. 277\)](#).

## Environment Variable Encryption

When you create or update Lambda functions that use environment variables, AWS Lambda encrypts them using the [AWS Key Management Service](#). When your Lambda function is invoked, those values are decrypted and made available to the Lambda code.

The first time you create or update Lambda functions that use environment variables in a region, a default service key is created for you automatically within AWS KMS. This key is used to encrypt environment variables. However, should you wish to use encryption helpers and use KMS to encrypt environment variables after your Lambda function is created, then you must create your own AWS KMS key and choose it instead of the default key. The default key will give errors when chosen. Creating your own key gives you more flexibility, including the ability to create, rotate, disable, and define access controls, and to audit the encryption keys used to protect your data. For more information, see the [AWS Key Management Service Developer Guide](#).

If you use your own key, you will be billed per [AWS Key Management Service Pricing](#) guidelines. You will not be billed if you use the default service key provided by AWS Lambda.

If you're using the default KMS service key for Lambda, then no additional IAM permissions are required in your function execution role – your role will just work automatically without changes. If you're supplying your own (custom) KMS key, then you'll need to add `kms:Decrypt` to your execution role. In addition, the user that will be creating and updating the Lambda function must have permissions to use the KMS key. For more information on KMS keys, see the [Using Key Policies in AWS KMS](#).

## Storing Sensitive Information

As mentioned in the previous section, when you deploy your Lambda function, all the environment variables you've specified are encrypted by default after, but not during, the deployment process. They are then decrypted automatically by AWS Lambda when the function is invoked. If you need to store sensitive information in an environment variable, we strongly suggest you encrypt that information before deploying your Lambda function.

Fortunately, the Lambda console makes that easier for you by providing encryption helpers that leverage [AWS Key Management Service](#) to store that sensitive information as [Ciphertext](#). The Lambda console also provides decryption helper code to decrypt that information for use in your Lambda function code. For more information, see [Create a Lambda Function Using Environment Variables To Store Sensitive Information \(p. 383\)](#).

## Error scenarios

If your function configuration exceeds 4KB, or you use environment variable keys reserved by AWS Lambda, then your update or create operation will fail with a configuration error. During execution time, it's possible that the encryption/decryption of environment variables can fail. If AWS Lambda is unable to decrypt the environment variables due to an AWS KMS service exception, AWS KMS will return an exception message explaining what the error conditions are and what, if any, remedies you can apply to address the issue. These will be logged to your function log stream in Amazon CloudWatch logs. For example, if the KMS key you are using to access the environment variables is disabled, you will see the following error:

```
Lambda was unable to configure access to your environment variables because the KMS key used is disabled.  
Please check your KMS key settings.
```

## Next Step

[Create a Lambda Function Using Environment Variables \(p. 381\)](#)

# Create a Lambda Function Using Environment Variables

This section will illustrate how you can modify a Lambda function's behavior through configuration changes that require no changes to the Lambda function code.

In this tutorial, you will do the following:

- Create a deployment package with sample code that returns the value of an environment variable that specifies the name of an Amazon S3 bucket.
- Invoke a Lambda function and verify that the Amazon S3 bucket name that is returned matches the value set by the environment variable.
- Update the Lambda function by changing the Amazon S3 bucket name specified by the environment variable.
- Invoke the Lambda function again and verify that the Amazon S3 bucket name that is returned matches the updated value.

## Step 1: Prepare

Make sure you have completed the following steps:

- Signed up for an AWS account and created an administrator user in the account (called **adminuser**). For instructions, see [Set Up an AWS Account \(p. 4\)](#)
- Installed and set up the AWS CLI. For instructions, see [Set Up the AWS Command Line Interface \(AWS CLI\) \(p. 6\)](#)

## Step 2: Set Up the Lambda Environment

In this section, you do the following:

- Create the Lambda function deployment package using the sample code provided.
- Create a Lambda execution role.
- Create the Lambda function by uploading the deployment package, and then test it by invoking it manually.

### Step 2.1: Create the Deployment Package

The code sample below reads the environment variable of a Lambda function that returns the name of an Amazon S3 bucket.

1. Open a text editor and copy the following code:

```
var AWS = require('aws-sdk');

exports.handler = function(event, context, callback) {

    var bucketName = process.env.S3_BUCKET;
    callback(null, bucketName);
}
```

2. Save the file as *index.js*.
3. Zip the *index.js*. file as *Test\_Environment\_Variables.zip*.

### Step 2.2: Create an Execution Role

Create an IAM role (execution role) that you can specify at the time you create your Lambda function.

1. Sign in to the AWS Management Console and open the IAM console at <https://console.aws.amazon.com/iam/>.
2. Follow the steps in [IAM Roles](#) in the *IAM User Guide* to create an IAM role (execution role). As you follow the steps to create a role, note the following:
  - In **Select Role Type**, choose **AWS Service Roles**, and then choose **AWS Lambda**.
  - In **Attach Policy**, choose the policy named **AWSLambdaBasicExecutionRole**.
3. Write down the Amazon Resource Name (ARN) of the IAM role. You need this value when you create your Lambda function in the next step.

### Step 2.3 Create the Lambda function and Test It

In this section, you create a Lambda function containing an environment variable that specifies an Amazon S3 bucket named `Test`. When invoked, the function simply returns the name of the Amazon S3 bucket. Then you update the configuration by changing the Amazon S3 bucket name to `Prod` and when invoked again, the function returns the updated name of the Amazon S3 bucket.

To create the Lambda function, open a command prompt and run the following Lambda AWS CLI `create-function` command. You need to provide the .zip file path and the execution role ARN. Note that the Runtime parameter uses `nodejs6.10` but you can also specify `nodejs8.10`.

```
aws lambda create-function \
--region us-east-1 \
--function-name ReturnBucketName \
--zip-file fileb://file-path/Test_Environment_Variables.zip \
--role role-arn \
--environment Variables={S3_BUCKET=Test} \
--handler index.handler \
--runtime nodejs6.10 \
--version version \
--profile default
```

#### Note

Optionally, you can upload the .zip file to an Amazon S3 bucket in the same AWS region, and then specify the bucket and object name in the preceding command. You need to replace the `--zip-file` parameter with the `--code` parameter. For example:

```
--code S3Bucket=bucket-name,S3Key=zip-file-object-key
```

Next, run the following Lambda CLI `invoke` command to invoke the function. Note that the command requests asynchronous execution. You can optionally invoke it synchronously by specifying `RequestResponse` as the `invocation-type` parameter value.

```
aws lambda invoke \
--invocation-type Event \
--function-name ReturnBucketName \
--region us-east-1 \
--profile default \
outputfile.txt
```

The Lambda function will return the name of the Amazon S3 bucket as "Test".

Next, run the following Lambda CLI `update-function-configuration` command to update the Amazon S3 environment variable by pointing it to the `Prod` bucket.

```
aws lambda update-function-configuration
--function-name ReturnBucketName \
--region us-east-1 \
--environment Variables={S3_BUCKET=Prod}
```

Run the `aws lambda invoke` command again using the same parameters. This time, the Lambda function will return the Amazon S3 bucket name as `Prod`.

## Create a Lambda Function Using Environment Variables To Store Sensitive Information

Along with specifying configuration settings for your Lambda function, you can also use environment variables to store sensitive information, such as a database password, using [AWS Key Management Service](#) and the Lambda console's encryption helpers. For more information, see [Environment Variable Encryption \(p. 380\)](#). The following example shows you how to do this and also how to use KMS to decrypt that information.

This tutorial will demonstrate how you can use the Lambda console to encrypt an environment variable containing sensitive information. Note that if you are updating an existing function, you can skip ahead

to the instruction step outlining how to Expand the **Environment Variables** section of [Step 2: Configure the Lambda Function \(p. 384\)](#).

## Step 1: Create the 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 a Lambda function**.
3. In **Select blueprint**, choose the **Author from scratch** button.
4. In **Basic information**, do the following:
  - In **Name\***, specify your Lambda function name.
  - In **Role\***, choose **Choose an existing role**.
  - In **Existing role\***, choose **lambda\_basic\_execution**.

**Note**

If the policy of the execution role does not have the `decrypt` permission, you will need add it.

- Choose **Create function**.

## Step 2: Configure the Lambda Function

1. Under **Configuration**, specify the **Runtime** of your choice.
2. Under the **Lambda function code** section you can take advantage of the **Edit code inline** option to replace the Lambda function handler code with your custom code.
3. Note the **Triggers** tab. Under the **Triggers** page, you can optionally choose a service that automatically triggers your Lambda function by choosing the **Add trigger** button and then choosing the gray box with ellipses (...) to display a list of available services. For this example, do not configure a trigger and choose **Configuration**.
4. Note the **Monitoring** tab. This page will provide immediate CloudWatch metrics for your Lambda function invocations, as well as links to other helpful guides, including [Using AWS X-Ray \(p. 322\)](#).
5. Expand the **Environment variables** section.
6. Enter your key-value pair. Expand the **Encryption configuration** section. Note that Lambda provides a default service key under **KMS key to encrypt at rest** which encrypts your information after it has been uploaded. If the information you provided is sensitive, you can additionally check the **Enable helpers for encryption in transit** checkbox and supply a custom key. This masks the value you entered and results in a call to AWS KMS to encrypt the value and return it as **Ciphertext**. If you haven't created a KMS key for your account, you will be provided a link to the AWS IAM console to create one. The account must have `encrypt` and `decrypt` permissions for that key. Note that the **Encrypt** button toggles to **Decrypt** after you choose it. This affords you the option to update the information. Once you have done that, choose the **Encrypt** button.

The **Code** button provides sample decrypt code specific to the runtime of your Lambda function that you can use with your application.

**Note**

You cannot use the default Lambda service key for encrypting sensitive information on the client side. For more information, see [Environment Variable Encryption \(p. 380\)](#).

# Dead Letter Queues

Any Lambda function invoked **asynchronously** is retried twice before the event is discarded. If the retries fail and you're unsure why, use Dead Letter Queues (DLQ) to direct unprocessed events to an [Amazon SQS](#) queue or an [Amazon SNS](#) topic to analyze the failure.

AWS Lambda directs events that cannot be processed to the specified [Amazon SNS topic](#) topic or [Amazon SQS queue](#). Functions that don't specify a DLQ will discard events after they have exhausted their retries. For more information about retry policies, see [Understanding Retry Behavior \(p. 152\)](#).

You configure a DLQ by specifying the Amazon Resource Name **TargetArn** value on the Lambda function's `DeadLetterConfig` parameter (whether it's an [Amazon SQS](#) queue or an [Amazon SNS](#) topic).

```
{
  "Code": {
    "ZipFile": blob,
    "S3Bucket": "string",
    "S3Key": "string",
    "S3ObjectVersion": "string"
  },
  "Description": "string",
  "FunctionName": "string",
  "Handler": "string",
  "MemorySize": number,
  "Role": "string",
  "Runtime": "string",
  "Timeout": number
  "Publish": bool,
  "DeadLetterConfig": {
    "TargetArn": "string"
  }
}
```

You need to explicitly provide receive/delete/sendMessage access to your DLQ resource as part of the [execution role](#) for your Lambda function. The payload written to the DLQ target ARN is the original event payload with no modifications to the message body. The attributes of the message, described next, contain information to help you understand why the event wasn't processed:

Name	Type	Value
RequestID	String	Unique request identifier
ErrorCode	Number	3-digit HTTP error code
ErrorMessage	String	Error message (truncated to 1 KB)

If the event payload consistently fails to reach the target ARN, AWS Lambda increments a [CloudWatch metric](#) called `DeadLetterErrors` and then deletes the event payload.



# Best Practices for Working with AWS Lambda Functions

The following are recommended best practices for using AWS Lambda:

## Topics

- [Function Code \(p. 386\)](#)
- [Function Configuration \(p. 387\)](#)
- [Alarming and Metrics \(p. 387\)](#)
- [Stream Event Invokes \(p. 387\)](#)
- [Async Invokes \(p. 388\)](#)
- [Lambda VPC \(p. 388\)](#)

## Function Code

- **Separate the Lambda handler (entry point) 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 Context reuse to improve the performance of your function.** Make sure any externalized configuration or dependencies that your code retrieves are stored and referenced locally after initial execution. Limit the re-initialization of variables/objects on every invocation. Instead use static initialization/constructor, global/static variables and singletons. Keep alive and reuse connections (HTTP, database, etc.) that were established during a previous invocation.
- **Use Environment Variables (p. 377) 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 the AWS SDK for the Node.js and Python runtimes (a full list can be found here: [Lambda Execution Environment and Available Libraries \(p. 391\)](#)). 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, we recommend packaging all 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.
- **Minimize the complexity of your dependencies.** Prefer simpler frameworks that load quickly on [Execution Context](#) 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 concurrent execution limit to 0 immediately to throttle all invocations to the function, while you update the code.

## 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 [AWS CloudWatch Logs](#). 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.

- **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 [Authentication and Access Control for AWS Lambda \(p. 340\)](#).
- **Be familiar with AWS Lambda Limits (p. 394).** 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.

## Alarming and Metrics

- **Use AWS Lambda Metrics (p. 319) 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 execution time 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.)

## Stream Event Invokes

- **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. [BatchSize](#) 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.

**Note**

When there are not enough records to process, instead of waiting, the stream processing function will be invoked with a smaller number of records.

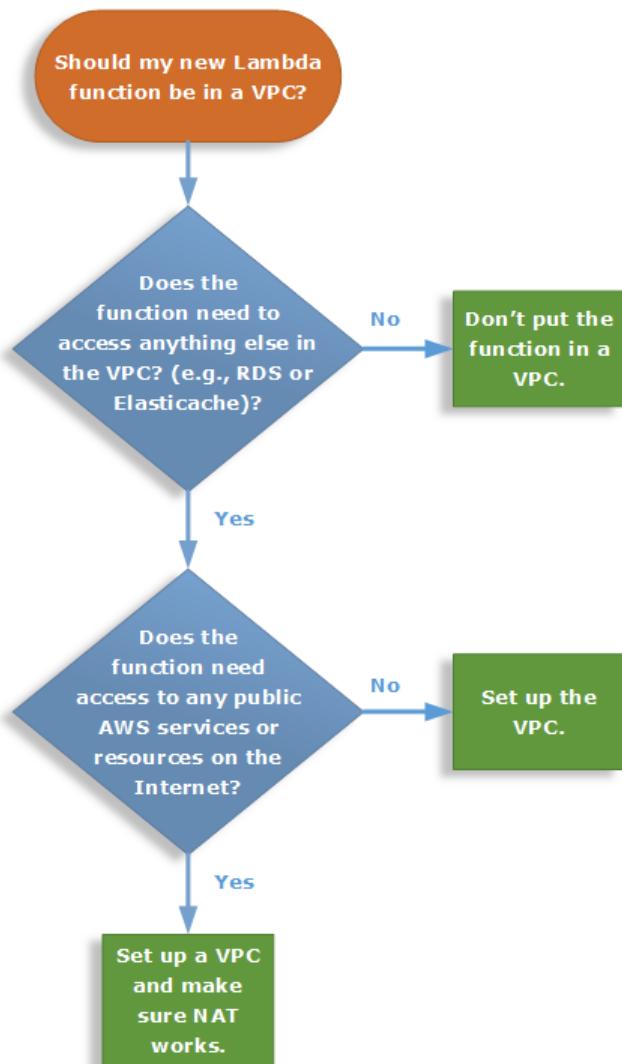
- **Increase Kinesis stream processing throughput by adding shards.** A Kinesis stream is composed of one or more shards. Lambda will poll each shard with at most one concurrent invocation. For example, if your stream has 100 active shards, there will be at most 100 Lambda function invocations running 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).

## Async Invokes

- [Create and use Dead Letter Queues \(p. 385\)](#) to address and replay async function errors.

## Lambda VPC

- The following diagram guides you through a decision tree as to whether you should use a VPC (Virtual Private Cloud):



- **Don't put your Lambda function in a VPC unless you have to.** There is no benefit outside of using this to access resources you cannot expose publicly, like a private [Amazon Relational Database](#) instance. Services like Amazon Elasticsearch Service can be secured over IAM with access policies, so exposing the endpoint publicly is safe and wouldn't require you to run your function in the VPC to secure it.
- **Lambda creates elastic network interfaces (ENIs) in your VPC to access your internal resources.** Before requesting a concurrency increase, ensure you have enough ENI capacity (the formula for this can be found here: [Configuring a Lambda Function to Access Resources in an Amazon VPC \(p. 133\)](#)) and IP address space. If you do not have enough ENI capacity, you will need to request an increase. If you do not have enough IP address space, you may need to create a larger subnet.
- **Create dedicated Lambda subnets in your VPC:**
  - This will make it easier to apply a custom route table for NAT Gateway traffic without changing your other private/public subnets. For more information, see [Configuring a Lambda Function to Access Resources in an Amazon VPC \(p. 133\)](#)
  - This also allows you to dedicate an address space to Lambda without sharing it with other resources.

# Runtime Support Policy

AWS Lambda will only deprecate runtime versions that are marked as EOL (End of Life) at the end of their maintenance window. Versions that are marked deprecated will stop supporting creation of new functions and updates of existing functions authored in the deprecated runtime (unless re-configured to use a supported runtime version). AWS Lambda will also not provide security updates, technical support or hotfixes for deprecated runtimes and reserves the right to disable invocations of functions configured to run on a deprecated runtime at any time.

You can find a list of runtime versions that are marked as deprecated below:

Runtime	Version
Node.js	0.10
Node.js	4.3

## Deprecation Status

The Node Foundation declared End-of-Life (EOL) for Node.js v4 on April 30, 2018. As a result, this version of Node.js is no longer receiving bug fixes, security updates, or performance improvements from the Node Foundation. Per the AWS Lambda runtime support policy, language runtimes that have been end-of-lifed by the supplier are deprecated in AWS Lambda.

While invocations of Lambda functions configured to use Node.js v4.3 will continue to work normally, the ability to create new Lambda functions configured to use the Node.js v4.3 runtime will be disabled on July 31, 2018. Code updates to existing functions using Node.js v4.3 will be disabled on October 31, 2018. We strongly encourage you to update all your functions to a newer version of Node.js (v6.10 or v8.10) so that you continue to benefit from important security, performance, and functionality enhancements offered by the Node Foundation via more recent releases.

# Lambda Execution Environment and Available Libraries

The underlying AWS Lambda execution environment is based on the following:

- Public Amazon Linux AMI version (AMI name: amzn-ami-hvm-2017.03.1.20170812-x86\_64-gp2) which can be accessed [here](#).  
For information about using an AMI, see [Amazon Machine Images \(AMI\)](#) in the *Amazon EC2 User Guide for Linux Instances*.
- Linux kernel version – 4.9.93-41.60.amzn1.x86\_64

If you are using any native binaries in your code, make sure they are compiled against the package and library versions from this AMI and kernel. Note that only 64-bit binaries are supported on AWS Lambda and that the specific CPU make and model is subject to continual updates.

AWS Lambda supports the following runtime versions:

- Node.js – v8.10, v6.10 or v4.3

**Note**

v4.3 has been deprecated. For more information on AWS Lambda's policy on deprecated runtimes, see [Runtime Support Policy \(p. 390\)](#).

- Java – Java 8
- Python – Python 3.6 and 2.7
- .NET Core – .NET Core 1.0.1 and .NET Core 2.0
- Go – Go 1.x

**Note**

Not all runtimes are available on the Public Amazon Linux AMI version or its yum repositories. You may need to download and install them manually from their respective public sites.

The following libraries are available in the AWS Lambda execution environment, regardless of the supported runtime you use, so you don't need to include them:

- AWS SDK – [AWS SDK for JavaScript](#) version 2.233.1
- AWS SDK for Python 2.7 (Boto 3) version 3-1.7.14 botocore-1.10.14  
AWS SDK for Python 3.6 (Boto 3) version 3-1.7.14 botocore-1.10.14
- Amazon Linux build of java-1.8.0-openjdk for Java.

For an example of using the boto libraries in your Lambda function, see [Accessing Resources from a Lambda Function \(p. 132\)](#).

# Environment Variables Available to Lambda Functions

The following is a list of environment variables that are part of the AWS Lambda execution environment and made available to Lambda functions. The table below indicates which ones are reserved by AWS Lambda and cannot be changed as well as which ones you can set when creating your Lambda function. For more information on using environment variables with your Lambda function, see [Environment Variables \(p. 377\)](#).

## Lambda Environment Variables

Key	Reserved	Value
LAMBDA_TASK_ROOT	Yes	Contains the path to your Lambda function code.
AWS_EXECUTION_ENV	Yes	The environment variable is set to one of the following options, depending on the runtime of the Lambda function: <ul style="list-style-type: none"> <li>• AWS_Lambda_java8</li> <li>• AWS_Lambda_nodejs4.3</li> <li>• AWS_Lambda_nodejs6.10</li> <li>• AWS_Lambda_nodejs8.10</li> <li>• AWS_Lambda_python2.7</li> <li>• AWS_Lambda_python3.6</li> <li>• AWS_Lambda_dotnetcore1.0</li> <li>• AWS_Lambda_dotnetcore2.0</li> </ul>
LAMBDA_RUNTIME_DIR	Yes	Restricted to Lambda runtime-related artifacts. For example the aws-sdk for Node.js and boto3 for Python can be found under this path.
AWS_REGION	Yes	The AWS region where the Lambda function is executed.
AWS_DEFAULT_REGION	Yes	The AWS region where the Lambda function is executed.
AWS_LAMBDA_LOG_GROUP_NAME	Yes	The name of Amazon CloudWatch Logs group where log streams containing your Lambda function logs are created.
AWS_LAMBDA_LOG_STREAM_NAME	Yes	The Amazon CloudWatch Logs streams containing your Lambda function logs.
AWS_LAMBDA_FUNCTION_NAME	Yes	The name of the Lambda function.
AWS_LAMBDA_FUNCTION_MEMORY_SIZE	Yes	The size of the Lambda function in MB.

Key	Reserved	Value
AWS_LAMBDA_FUNCTION_VERSION	Yes	The version of the Lambda function.
AWS_ACCESS_KEY AWS_ACCESS_KEY_ID AWS_SECRET_KEY AWS_SECRET_ACCESS_KEY AWS_SESSION_TOKEN AWS_SECURITY_TOKEN	Yes	The security credentials required to execute the Lambda function, depending on which runtime is used. Different runtimes use a subset of these keys. They are generated via an IAM execution role specified for the function.
PATH	No	Contains /usr/local/bin, /usr/bin or /bin for running executables.
LANG	No	Set to en_US.UTF-8. This is the Locale of the runtime.
LD_LIBRARY_PATH	No	Contains /lib64, /usr/lib64, LAMBDA_TASK_ROOT, LAMBDA_TASK_ROOT/lib. Used to store helper libraries and function code.
NODE_PATH	No	Set for the Node.js runtime. It contains LAMBDA_RUNTIME_DIR, LAMBDA_RUNTIME_DIR/node_modules, LAMBDA_TASK_ROOT.
PYTHONPATH	No	Set for the Python runtime. It contains LAMBDA_RUNTIME_DIR.
TZ	Yes	The current local time. Defaults to <a href="#">UTC</a> .

# AWS Lambda Limits

As explained in [Lambda Functions \(p. 15\)](#), once you've packaged up your custom code, including any dependencies, and uploaded it to AWS Lambda, you have created a *Lambda function*. But there are limits that AWS Lambda imposes that include, for example, the size of your deployment package or the amount of memory your Lambda function is allocated per invocation. In addition:

- IAM limits may impact your Lambda function. For more information, see [Limitations on IAM Entities and Objects](#).
- If you're using Lambda@Edge, additional limits apply. For more information, see [Limits on Lambda@Edge](#) in the Amazon CloudFront Developer Guide.

This section discusses those AWS Lambda limits.

## Topics

- [AWS Lambda Limits \(p. 394\)](#)
- [AWS Lambda Limit Errors \(p. 395\)](#)

# AWS Lambda Limits

## AWS Lambda Resource Limits per Invocation

Resource	Limits
Memory allocation range	Minimum = 128 MB / Maximum = 3008 MB (with 64 MB increments). If the maximum memory use is exceeded, function invocation will be terminated.
Ephemeral disk capacity ("tmp" space)	512 MB
Number of file descriptors	1,024
Number of processes and threads (combined total)	1,024
Maximum execution duration per request	300 seconds (5 minutes)
<a href="#">Invoke (p. 450)</a> request body payload size (RequestResponse/synchronous invocation) NOTE: The response body payload also must adhere to this limit.	6 MB
<a href="#">Invoke (p. 450)</a> request body payload size (Event/asynchronous invocation)	128 KB

## AWS Lambda Account Limits Per Region

Resource	Default Limit
Concurrent executions (see <a href="#">Managing Concurrency (p. 373)</a> )	1000

### To request a limit increase for concurrent execution

1. Open the [AWS Support Center](#) page, sign in, if necessary, and then click **Create case**.
2. Under **Regarding**, select **Service Limit Increase**.
3. Under **Limit Type**, select **Lambda**, fill in the necessary fields in the form, and then click the button at the bottom of the page for your preferred method of contact.

#### Note

AWS may automatically raise the concurrent execution limit on your behalf to enable your function to match the incoming event rate, as in the case of triggering the function from an Amazon S3 bucket.

The following table lists service limits for deploying a Lambda function.

#### AWS Lambda Deployment Limits

Item	Default Limit
Lambda function deployment package size (compressed .zip/.jar file)	50 MB
Total size of all the deployment packages that can be uploaded per region	75 GB
Size of code/dependencies that you can zip into a deployment package (uncompressed .zip/.jar size).	250 MB
<b>Note</b> Each Lambda function receives an additional 500MB of non-persistent disk space in its own /tmp directory. The /tmp directory can be used for loading additional resources like dependency libraries or data sets during function initialization.	
Total size of environment variables set	4 KB

#### Note

If the size of your Lambda function's zipped deployment packages exceeds 3MB, you will not be able to use the inline code editing feature in the Lambda console. You can still use the console to invoke your Lambda function.

## AWS Lambda Limit Errors

Functions that exceed any of the limits listed in the previous limits tables will fail with an `exceeded limits` exception. These limits are fixed and cannot be changed at this time. For example, if you receive the exception `CodeStorageExceededException` or an error message similar to "Code storage limit exceeded" from AWS Lambda, you need to reduce the size of your code storage.

### To reduce the size of your code storage

1. Remove the functions that you no longer use.
2. Reduce the code size of the functions that you do not want to remove. You can find the code size of a Lambda function by using the AWS Lambda console, the AWS Command Line Interface, or AWS SDKs.

# 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.

## 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](#).

### Topics

- [Actions \(p. 396\)](#)
- [Data Types \(p. 509\)](#)

## Actions

The following actions are supported:

- [AddPermission \(p. 398\)](#)
- [CreateAlias \(p. 403\)](#)
- [CreateEventSourceMapping \(p. 407\)](#)
- [CreateFunction \(p. 412\)](#)
- [DeleteAlias \(p. 420\)](#)
- [DeleteEventSourceMapping \(p. 422\)](#)
- [DeleteFunction \(p. 425\)](#)
- [DeleteFunctionConcurrency \(p. 428\)](#)
- [GetAccountSettings \(p. 430\)](#)
- [GetAlias \(p. 432\)](#)
- [GetEventSourceMapping \(p. 435\)](#)
- [GetFunction \(p. 438\)](#)
- [GetFunctionConfiguration \(p. 442\)](#)
- [GetPolicy \(p. 447\)](#)
- [Invoke \(p. 450\)](#)
- [InvokeAsync \(p. 455\)](#)
- [ListAliases \(p. 458\)](#)
- [ListEventSourceMappings \(p. 461\)](#)
- [ListFunctions \(p. 464\)](#)
- [ListTags \(p. 467\)](#)
- [ListVersionsByFunction \(p. 469\)](#)
- [PublishVersion \(p. 472\)](#)
- [PutFunctionConcurrency \(p. 478\)](#)
- [RemovePermission \(p. 480\)](#)
- [TagResource \(p. 483\)](#)
- [UntagResource \(p. 485\)](#)
- [UpdateAlias \(p. 487\)](#)
- [UpdateEventSourceMapping \(p. 491\)](#)
- [UpdateFunctionCode \(p. 495\)](#)
- [UpdateFunctionConfiguration \(p. 502\)](#)

## AddPermission

Adds a permission to the resource policy associated with the specified AWS Lambda function. You use resource policies to grant permissions to event sources that use *push* model. In a *push* model, event sources (such as Amazon S3 and custom applications) invoke your Lambda function. Each permission you add to the resource policy allows an event source, permission to invoke the Lambda function.

For information about the push model, see [Lambda Functions](#).

If you are using versioning, the permissions you add are specific to the Lambda function version or alias you specify in the AddPermission request via the Qualifier parameter. For more information about versioning, see [AWS Lambda Function Versioning and Aliases](#).

This operation requires permission for the `lambda:AddPermission` action.

## Request Syntax

```
POST /2015-03-31/functions/FunctionName/policy?Qualifier=Qualifier HTTP/1.1
Content-type: application/json

{
  "Action": "string",
  "EventSourceToken": "string",
  "Principal": "string",
  "RevisionId": "string",
  "SourceAccount": "string",
  "SourceArn": "string",
  "StatementId": "string"
}
```

## URI Request Parameters

The request requires the following URI parameters.

### [FunctionName](#) (p. 398)

Name of the Lambda function whose resource policy you are updating by adding a new permission.

You can specify a function name (for example, `Thumbnail1`) or you can specify Amazon Resource Name (ARN) of the function (for example, `arn:aws:lambda:us-west-2:account-id:function:Thumbnail1`). AWS Lambda also allows you to specify partial ARN (for example, `account-id:Thumbnail`). Note that the length constraint applies only to the 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:lambda:`)?([a-z]{2}-[a-z]+\-\d{1}:)?(\d{12}:)?(function:)?( [a-zA-Z0-9-\_]+)(:(\\$LATEST|[a-zA-Z0-9-\_]+))?

### [Qualifier](#) (p. 398)

You can use this optional query parameter to describe a qualified ARN using a function version or an alias name. The permission will then apply to the specific qualified ARN. For example, if you specify function version 2 as the qualifier, then permission applies only when request is made using qualified function ARN:

`arn:aws:lambda:aws-region:acct-id:function:function-name:2`

If you specify an alias name, for example `PROD`, then the permission is valid only for requests made using the alias ARN:

`arn:aws:lambda:aws-region:acct-id:function:function-name:PROD`

If the qualifier is not specified, the permission is valid only when requests are made using unqualified function ARN.

`arn:aws:lambda:aws-region:acct-id:function:function-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.

### Action (p. 398)

The AWS Lambda action you want to allow in this statement. Each Lambda action is a string starting with `lambda:` followed by the API name (see [Actions](#)). For example, `lambda:CreateFunction`. You can use wildcard (`lambda:*`) to grant permission for all AWS Lambda actions.

Type: String

Pattern: `(lambda:[*]|lambda:[a-zA-Z]+|[*])`

Required: Yes

### EventSourceToken (p. 398)

A unique token that must be supplied by the principal invoking the function. This is currently only used for Alexa Smart Home functions.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Pattern: `[a-zA-Z0-9._\^-]+`

Required: No

### Principal (p. 398)

The principal who is getting this permission. It can be Amazon S3 service Principal (`s3.amazonaws.com`) if you want Amazon S3 to invoke the function, an AWS account ID if you are granting cross-account permission, or any valid AWS service principal such as `sns.amazonaws.com`. For example, you might want to allow a custom application in another AWS account to push events to AWS Lambda by invoking your function.

Type: String

Pattern: `.*`

Required: Yes

### RevisionId (p. 398)

An optional value you can use to ensure you are updating the latest update of the function version or alias. If the `RevisionID` you pass doesn't match the latest `RevisionId` of the function or alias, it will fail with an error message, advising you to retrieve the latest function version or alias `RevisionID` using either [GetFunction \(p. 438\)](#) or [GetAlias \(p. 432\)](#).

Type: String

Required: No

#### [SourceAccount \(p. 398\)](#)

This parameter is used for S3 and SES. The AWS account ID (without a hyphen) of the source owner. For example, if the `SourceArn` identifies a bucket, then this is the bucket owner's account ID. You can use this additional condition to ensure the bucket you specify is owned by a specific account (it is possible the bucket owner deleted the bucket and some other AWS account created the bucket). You can also use this condition to specify all sources (that is, you don't specify the `SourceArn`) owned by a specific account.

Type: String

Pattern: \d{12}

Required: No

#### [SourceArn \(p. 398\)](#)

This is optional; however, when granting permission to invoke your function, you should specify this field with the Amazon Resource Name (ARN) as its value. This ensures that only events generated from the specified source can invoke the function.

**Important**

If you add a permission without providing the source ARN, any AWS account that creates a mapping to your function ARN can send events to invoke your Lambda function.

Type: String

Pattern: arn:aws:([a-zA-Z0-9\-\\_])+:(a-z){2}-[a-z]+\-\d{1}?:(\d{12})?:(.\*?)

Required: No

#### [StatementId \(p. 398\)](#)

A unique statement identifier.

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. 400)

The permission statement you specified in the request. The response returns the same as a string using a backslash ("\\") as an escape character in the JSON.

Type: String

## Errors

### InvalidParameterValueException

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### PolicyLengthExceededException

Lambda function access policy is limited to 20 KB.

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.

HTTP Status Code: 409

### ResourceNotFoundException

The resource (for example, a Lambda function or access policy statement) 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

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## CreateAlias

Creates an alias that points to the specified Lambda function version. For more information, see [Introduction to AWS Lambda Aliases](#).

Alias names are unique for a given function. This requires permission for the `lambda:CreateAlias` action.

### 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 requires the following URI parameters.

#### **FunctionName** (p. 403)

Name of the Lambda function for which you want to create an alias. Note that the length constraint applies only to the 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:lambda:)?([a-z]{2}-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

### Request Body

The request accepts the following data in JSON format.

#### **Description** (p. 403)

Description of the alias.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

#### **FunctionVersion** (p. 403)

Lambda function version for which you are creating the alias.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

Required: Yes

#### Name (p. 403)

Name for the alias you are creating.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(?!^[\0-9]+$)([a-zA-Z0-9-_]+)`

Required: Yes

#### RoutingConfig (p. 403)

Specifies an additional version your alias can point to, allowing you to dictate what percentage of traffic will invoke each version. For more information, see [Traffic Shifting Using Aliases \(p. 295\)](#).

Type: [AliasRoutingConfiguration \(p. 515\)](#) 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. 404)

Lambda function ARN that is qualified using the alias name as the suffix. For example, if you create an alias called `BETA` that points to a `helloworld` function version, the ARN is `arn:aws:lambda:aws-regions:acct-id:function:helloworld:BETA`.

Type: String

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:\$\$LATEST|[a-zA-Z0-9-_]+)?`

### Description (p. 404)

Alias description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

### FunctionVersion (p. 404)

Function version to which the alias points.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: (\\$LATEST | [0-9]+)

### Name (p. 404)

Alias name.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: (?![0-9]+\$)([a-zA-Z0-9-\_]+)

### RevisionId (p. 404)

Represents the latest updated revision of the function or alias.

Type: String

### RoutingConfig (p. 404)

Specifies an additional function versions the alias points to, allowing you to dictate what percentage of traffic will invoke each version. For more information, see [Traffic Shifting Using Aliases \(p. 295\)](#).

Type: [AliasRoutingConfiguration \(p. 515\)](#) object

## Errors

### InvalidParameterValueException

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### ResourceConflictException

The resource already exists.

HTTP Status Code: 409

### ResourceNotFoundException

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## CreateEventSourceMapping

Identifies a stream as an event source for a Lambda function. It can be either an Amazon Kinesis stream or an Amazon DynamoDB stream. AWS Lambda invokes the specified function when records are posted to the stream.

This association between a stream source and a Lambda function is called the event source mapping.

You provide mapping information (for example, which stream to read from and which Lambda function to invoke) in the request body.

Each event source, such as an Amazon Kinesis or a DynamoDB stream, can be associated with multiple AWS Lambda functions. A given Lambda function can be associated with multiple AWS event sources.

If you are using versioning, you can specify a specific function version or an alias via the function name parameter. For more information about versioning, see [AWS Lambda Function Versioning and Aliases](#).

This operation requires permission for the `lambda:CreateEventSourceMapping` action.

## Request Syntax

```
POST /2015-03-31/event-source-mappings/ HTTP/1.1
Content-type: application/json

{
    "BatchSize": number,
    "Enabled": boolean,
    "EventSourceArn": "string",
    "FunctionName": "string",
    "StartingPosition": "string",
    "StartingPositionTimestamp": number
}
```

## URI Request Parameters

The request does not use any URI parameters.

## Request Body

The request accepts the following data in JSON format.

### [BatchSize \(p. 407\)](#)

The largest number of records that AWS Lambda will retrieve from your event source at the time of invoking your function. Your function receives an event with all the retrieved records. The default is 100 records.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

Required: No

### [Enabled \(p. 407\)](#)

Indicates whether AWS Lambda should begin polling the event source. By default, `Enabled` is true.

Type: Boolean

Required: No

### [EventSourceArn \(p. 407\)](#)

The Amazon Resource Name (ARN) of the Amazon Kinesis or the Amazon DynamoDB stream that is the event source. Any record added to this stream could cause AWS Lambda to invoke your Lambda function, it depends on the `BatchSize`. AWS Lambda POSTs the Amazon Kinesis event, containing records, to your Lambda function as JSON.

Type: String

Pattern: `arn:aws:([a-zA-Z0-9\-\-])+:([a-z]{2}-[a-z]+\-\d{1})?:(\d{12})?:(\.* )`

Required: Yes

### [FunctionName \(p. 407\)](#)

The Lambda function to invoke when AWS Lambda detects an event on the stream.

You can specify the function name (for example, `Thumbnail`) or you can specify Amazon Resource Name (ARN) of the function (for example, `arn:aws:lambda:us-west-2:account-id:function:Thumbnail`).

If you are using versioning, you can also provide a qualified function ARN (ARN that is qualified with function version or alias name as suffix). For more information about versioning, see [AWS Lambda Function Versioning and Aliases](#)

AWS Lambda also allows you to specify only the function name with the account ID qualifier (for example, `account-id:Thumbnail`).

Note that the length constraint applies only to the 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:lambda:)?([a-z]{2}-[a-z]+\-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_+]))?`

Required: Yes

### [StartingPosition \(p. 407\)](#)

The position in the DynamoDB or Kinesis stream where AWS Lambda should start reading. For more information, see [GetShardIterator](#) in the *Amazon Kinesis API Reference Guide* or [GetShardIterator](#) in the *Amazon DynamoDB API Reference Guide*. The `AT_TIMESTAMP` value is supported only for [Kinesis streams](#).

Type: String

Valid Values: `TRIM_HORIZON` | `LATEST` | `AT_TIMESTAMP`

Required: Yes

### [StartingPositionTimestamp \(p. 407\)](#)

The timestamp of the data record from which to start reading. Used with [shard iterator type AT\\_TIMESTAMP](#). If a record with this exact timestamp does not exist, the iterator returned is for the next (later) record. If the timestamp is older than the current trim horizon, the iterator returned is for the oldest untrimmed data record (`TRIM_HORIZON`). Valid only for [Kinesis streams](#).

Type: Timestamp

Required: No

## Response Syntax

```
HTTP/1.1 202
Content-type: application/json

{
    "BatchSize": number,
    "EventSourceArn": "string",
    "FunctionArn": "string",
    "LastModified": number,
    "LastProcessingResult": "string",
    "State": "string",
    "StateTransitionReason": "string",
    "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.

### **BatchSize** (p. 409)

The largest number of records that AWS Lambda will retrieve from your event source at the time of invoking your function. Your function receives an event with all the retrieved records.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

### **EventSourceArn** (p. 409)

The Amazon Resource Name (ARN) of the Amazon Kinesis stream that is the source of events.

Type: String

Pattern: arn:aws:([a-zA-Z0-9\-])+:( [a-z]{2}-[a-z]+\-\d{1})?:(\d{12})?:(.\* )

### **FunctionArn** (p. 409)

The Lambda function to invoke when AWS Lambda detects an event on the stream.

Type: String

Pattern: arn:aws:lambda:[a-z]{2}-[a-z]+\-\d{1}:\d{12}:function:[a-zA-Z0-9-\_]+(: (\\$LATEST|[a-zA-Z0-9-\_]+))?

### **LastModified** (p. 409)

The UTC time string indicating the last time the event mapping was updated.

Type: Timestamp

### **LastProcessingResult** (p. 409)

The result of the last AWS Lambda invocation of your Lambda function.

Type: String

### **State** (p. 409)

The state of the event source mapping. It can be `Creating`, `Enabled`, `Disabled`, `Enabling`, `Disabling`, `Updating`, or `Deleting`.

Type: String

#### [StateTransitionReason \(p. 409\)](#)

The reason the event source mapping is in its current state. It is either user-requested or an AWS Lambda-initiated state transition.

Type: String

#### [UUID \(p. 409\)](#)

The AWS Lambda assigned opaque identifier for the mapping.

Type: String

## Errors

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### **ResourceConflictException**

The resource already exists.

HTTP Status Code: 409

### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)

- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## CreateFunction

Creates a new Lambda function. The function metadata is created from the request parameters, and the code for the function is provided by a .zip file in the request body. If the function name already exists, the operation will fail. Note that the function name is case-sensitive.

If you are using versioning, you can also publish a version of the Lambda function you are creating using the `Publish` parameter. For more information about versioning, see [AWS Lambda Function Versioning and Aliases](#).

This operation requires permission for the `lambda:CreateFunction` action.

## Request Syntax

```
POST /2015-03-31/functions HTTP/1.1
Content-type: application/json

{
  "Code": {
    "S3Bucket": "string",
    "S3Key": "string",
    "S3ObjectVersion": "string",
    "ZipFile": blob
  },
  "DeadLetterConfig": {
    "TargetArn": "string"
  },
  "Description": "string",
  "Environment": {
    "Variables": {
      "string" : "string"
    }
  },
  "FunctionName": "string",
  "Handler": "string",
  "KMSKeyArn": "string",
  "MemorySize": number,
  "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.

### [Code \(p. 412\)](#)

The code for the Lambda function.

Type: [FunctionCode \(p. 523\)](#) object

Required: Yes

### [DeadLetterConfig \(p. 412\)](#)

The parent object that contains the target ARN (Amazon Resource Name) of an Amazon SQS queue or Amazon SNS topic. For more information, see [Dead Letter Queues \(p. 385\)](#).

Type: [DeadLetterConfig \(p. 517\)](#) object

Required: No

### [Description \(p. 412\)](#)

A short, user-defined function description. Lambda does not use this value. Assign a meaningful description as you see fit.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

### [Environment \(p. 412\)](#)

The parent object that contains your environment's configuration settings.

Type: [Environment \(p. 518\)](#) object

Required: No

### [FunctionName \(p. 412\)](#)

The name you want to assign to the function you are uploading. The function names appear in the console and are returned in the [ListFunctions \(p. 464\)](#) API. Function names are used to specify functions to other AWS Lambda API operations, such as [Invoke \(p. 450\)](#). Note that the length constraint applies only to the 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:lambda:)?([a-z]{2}-[a-z]+\-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: Yes

### [Handler \(p. 412\)](#)

The function within your code that Lambda calls to begin execution. For Node.js, it is the `module-name.export` value in your function. For Java, it can be `package.class-name::handler` or `package.class-name`. For more information, see [Lambda Function Handler \(Java\)](#).

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

Required: Yes

### [KMSKeyArn \(p. 412\)](#)

The Amazon Resource Name (ARN) of the KMS key used to encrypt your function's environment variables. If not provided, AWS Lambda will use a default service key.

Type: String

Pattern: `(arn:aws:[a-z0-9-.]+::*)|()`

Required: No

### [MemorySize \(p. 412\)](#)

The amount of memory, in MB, your Lambda function is given. Lambda uses this memory size to infer the amount of CPU and memory allocated to your function. Your function use-case determines your CPU and memory requirements. For example, a database operation might need less memory compared to an image processing function. The default value is 128 MB. The value must be a multiple of 64 MB.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 3008.

Required: No

### [Publish \(p. 412\)](#)

This boolean parameter can be used to request AWS Lambda to create the Lambda function and publish a version as an atomic operation.

Type: Boolean

Required: No

### [Role \(p. 412\)](#)

The Amazon Resource Name (ARN) of the IAM role that Lambda assumes when it executes your function to access any other Amazon Web Services (AWS) resources. For more information, see [AWS Lambda: How it Works](#).

Type: String

Pattern: `arn:aws:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@\-_/.]+`

Required: Yes

### [Runtime \(p. 412\)](#)

The runtime environment for the Lambda function you are uploading.

To use the Python runtime v3.6, set the value to "python3.6". To use the Python runtime v2.7, set the value to "python2.7". To use the Node.js runtime v8.10, set the value to "nodejs8.10". To use Node.js runtime version v6.10, set the value to "nodejs6.10". To use Node.js runtime version v4.3, set the value to "nodejs4.3". To use the .NET Core runtime v1.0, set the value to "dotnetcore1.0". To use the .NET Core runtime v2.0, set the value to "dotnetcore2.0".

#### Note

Node v0.10.42 is currently marked as deprecated. You must migrate existing functions to the newer Node.js runtime versions available on AWS Lambda (nodejs8.10, nodejs6.10 or nodejs4.3) as soon as possible. Failure to do so will result in an invalid parameter error being returned. Note that you will have to follow this procedure for each region that contains functions written in the Node v0.10.42 runtime.

Type: String

Valid Values: nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | java8 | python2.7 | python3.6 | dotnetcore1.0 | dotnetcore2.0 | go1.x

Required: Yes

#### [Tags \(p. 412\)](#)

The list of tags (key-value pairs) assigned to the new function. For more information, see [Tagging Lambda Functions](#) in the [AWS Lambda Developer Guide](#).

Type: String to string map

Required: No

#### [Timeout \(p. 412\)](#)

The function execution time at which Lambda should terminate the function. Because the execution time has cost implications, we recommend you set this value based on your expected execution time. The default is 3 seconds.

Type: Integer

Valid Range: Minimum value of 1.

Required: No

#### [TracingConfig \(p. 412\)](#)

The parent object that contains your function's tracing settings.

Type: [TracingConfig \(p. 529\)](#) object

Required: No

#### [VpcConfig \(p. 412\)](#)

If your Lambda function accesses resources in a VPC, you provide this parameter identifying the list of security group IDs and subnet IDs. These must belong to the same VPC. You must provide at least one security group and one subnet ID.

Type: [VpcConfig \(p. 531\)](#) object

Required: No

## Response Syntax

```
HTTP/1.1 201
Content-type: application/json

{
    "CodeSha256": "string",
    "CodeSize": number,
    "DeadLetterConfig": {
        "TargetArn": "string"
    },
    "Description": "string",
    "Environment": {
        "Error": {
            "ErrorCode": "string",
            "Message": "string"
        },
        "Variables": {
            "string" : "string"
        }
    }
}
```

```
        },
        "FunctionArn": "string",
        "FunctionName": "string",
        "Handler": "string",
        "KMSKeyArn": "string",
        "LastModified": "string",
        "MasterArn": "string",
        "MemorySize": number,
        "RevisionId": "string",
        "Role": "string",
        "Runtime": "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.

### [CodeSha256 \(p. 415\)](#)

It is the SHA256 hash of your function deployment package.

Type: String

### [CodeSize \(p. 415\)](#)

The size, in bytes, of the function .zip file you uploaded.

Type: Long

### [DeadLetterConfig \(p. 415\)](#)

The parent object that contains the target ARN (Amazon Resource Name) of an Amazon SQS queue or Amazon SNS topic. For more information, see [Dead Letter Queues \(p. 385\)](#).

Type: [DeadLetterConfig \(p. 517\)](#) object

### [Description \(p. 415\)](#)

The user-provided description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

### [Environment \(p. 415\)](#)

The parent object that contains your environment's configuration settings.

Type: [EnvironmentResponse \(p. 520\)](#) object

### [FunctionArn \(p. 415\)](#)

The Amazon Resource Name (ARN) assigned to the function.

Type: String

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_\.]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

#### [FunctionName \(p. 415\)](#)

The name of the function. Note that the length constraint applies only to the 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 170.

Pattern: `(arn:aws:lambda:)?([a-z]{2}-[a-z]+\d{1}:(\d{12}):)?(function:)?([a-zA-Z0-9-_\.]+(:(\$LATEST|[a-zA-Z0-9-_]+))?)`

#### [Handler \(p. 415\)](#)

The function Lambda calls to begin executing your function.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

#### [KMSKeyArn \(p. 415\)](#)

The Amazon Resource Name (ARN) of the KMS key used to encrypt your function's environment variables. If empty, it means you are using the AWS Lambda default service key.

Type: String

Pattern: `(arn:aws:[a-zA-Z0-9-_\.]+:\.*|()`

#### [LastModified \(p. 415\)](#)

The time stamp of the last time you updated the function. The time stamp is conveyed as a string complying with ISO-8601 in this way YYYY-MM-DDThh:mm:ssTZD (e.g., 1997-07-16T19:20:30+01:00). For more information, see [Date and Time Formats](#).

Type: String

#### [MasterArn \(p. 415\)](#)

Returns the ARN (Amazon Resource Name) of the master function.

Type: String

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_\.]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

#### [MemorySize \(p. 415\)](#)

The memory size, in MB, you configured for the function. Must be a multiple of 64 MB.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 3008.

#### [RevisionId \(p. 415\)](#)

Represents the latest updated revision of the function or alias.

Type: String

### [Role \(p. 415\)](#)

The Amazon Resource Name (ARN) of the IAM role that Lambda assumes when it executes your function to access any other Amazon Web Services (AWS) resources.

Type: String

Pattern: `arn:aws:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@\-_/_]+`

### [Runtime \(p. 415\)](#)

The runtime environment for the Lambda function.

Type: String

Valid Values: nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | java8 | python2.7 | python3.6 | dotnetcore1.0 | dotnetcore2.0 | go1.x

### [Timeout \(p. 415\)](#)

The function execution time at which Lambda should terminate the function. Because the execution time has cost implications, we recommend you set this value based on your expected execution time. The default is 3 seconds.

Type: Integer

Valid Range: Minimum value of 1.

### [TracingConfig \(p. 415\)](#)

The parent object that contains your function's tracing settings.

Type: [TracingConfigResponse \(p. 530\)](#) object

### [Version \(p. 415\)](#)

The version of the Lambda function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

### [VpcConfig \(p. 415\)](#)

VPC configuration associated with your Lambda function.

Type: [VpcConfigResponse \(p. 532\)](#) object

## Errors

### **CodeStorageExceededException**

You have exceeded your maximum total code size per account. [Limits](#)

HTTP Status Code: 400

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### **ResourceConflictException**

The resource already exists.

HTTP Status Code: 409

### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## DeleteAlias

Deletes the specified Lambda function alias. For more information, see [Introduction to AWS Lambda Aliases](#).

This requires permission for the `lambda:DeleteAlias` action.

### Request Syntax

```
DELETE /2015-03-31/functions/FunctionName/aliases/Name HTTP/1.1
```

### URI Request Parameters

The request requires the following URI parameters.

#### **FunctionName** (p. 420)

The Lambda function name for which the alias is created. Deleting an alias does not delete the function version to which it is pointing. Note that the length constraint applies only to the 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:lambda:[a-z]{2}-[a-z]+\d{1}:(\d{12}:)?(function:[a-zA-Z0-9-_]+)(:$LATEST|[a-zA-Z0-9-_]+))?`

#### **Name** (p. 420)

Name of the alias to delete.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(?!^[\d-]+$)[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. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### **ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

### **TooManyRequestsException**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## DeleteEventSourceMapping

Removes an event source mapping. This means AWS Lambda will no longer invoke the function for events in the associated source.

This operation requires permission for the `lambda:DeleteEventSourceMapping` action.

### Request Syntax

```
DELETE /2015-03-31/event-source-mappings/UUID HTTP/1.1
```

### URI Request Parameters

The request requires the following URI parameters.

#### **UUID** (p. 422)

The event source mapping ID.

### Request Body

The request does not have a request body.

### Response Syntax

```
HTTP/1.1 202
Content-type: application/json

{
    "BatchSize": number,
    "EventSourceArn": "string",
    "FunctionArn": "string",
    "LastModified": number,
    "LastProcessingResult": "string",
    "State": "string",
    "StateTransitionReason": "string",
    "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.

#### **BatchSize** (p. 422)

The largest number of records that AWS Lambda will retrieve from your event source at the time of invoking your function. Your function receives an event with all the retrieved records.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

#### **EventSourceArn** (p. 422)

The Amazon Resource Name (ARN) of the Amazon Kinesis stream that is the source of events.

Type: String

Pattern: arn:aws:([a-zA-Z0-9\-\-]+)([a-z]{2}-[a-z]+\-\d{1})?:(\d{12})?:(.\*)

[FunctionArn \(p. 422\)](#)

The Lambda function to invoke when AWS Lambda detects an event on the stream.

Type: String

Pattern: arn:aws:lambda:[a-z]{2}-[a-z]+\-\d{1}:\d{12}:function:[a-zA-Z0-9\\_]+\:(\\$\\_LATEST|[a-zA-Z0-9\\_]+)?

[LastModified \(p. 422\)](#)

The UTC time string indicating the last time the event mapping was updated.

Type: Timestamp

[LastProcessingResult \(p. 422\)](#)

The result of the last AWS Lambda invocation of your Lambda function.

Type: String

[State \(p. 422\)](#)

The state of the event source mapping. It can be Creating, Enabled, Disabled, Enabling, Disabling, Updating, or Deleting.

Type: String

[StateTransitionReason \(p. 422\)](#)

The reason the event source mapping is in its current state. It is either user-requested or an AWS Lambda-initiated state transition.

Type: String

[UUID \(p. 422\)](#)

The AWS Lambda assigned opaque identifier for the mapping.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## DeleteFunction

Deletes the specified Lambda function code and configuration.

If you are using the versioning feature and you don't specify a function version in your `DeleteFunction` request, AWS Lambda will delete the function, including all its versions, and any aliases pointing to the function versions. To delete a specific function version, you must provide the function version via the `Qualifier` parameter. For information about function versioning, see [AWS Lambda Function Versioning and Aliases](#).

When you delete a function the associated resource policy is also deleted. You will need to delete the event source mappings explicitly.

This operation requires permission for the `lambda:DeleteFunction` action.

## Request Syntax

```
DELETE /2015-03-31/functions/FunctionName?Qualifier=Qualifier HTTP/1.1
```

## URI Request Parameters

The request requires the following URI parameters.

### FunctionName (p. 425)

The Lambda function to delete.

You can specify the function name (for example, `Thumbnail`) or you can specify Amazon Resource Name (ARN) of the function (for example, `arn:aws:lambda:us-west-2:account-id:function:Thumbnail`). If you are using versioning, you can also provide a qualified function ARN (ARN that is qualified with function version or alias name as suffix). AWS Lambda also allows you to specify only the function name with the account ID qualifier (for example, `account-id:Thumbnail`). Note that the length constraint applies only to the 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:lambda:`)?([a-z]{2}-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-\_]+)(:(\\$LATEST|[a-zA-Z0-9-\_]+))?

### Qualifier (p. 425)

Using this optional parameter you can specify a function version (but not the `\$LATEST` version) to direct AWS Lambda to delete a specific function version. If the function version has one or more aliases pointing to it, you will get an error because you cannot have aliases pointing to it. You can delete any function version but not the `\$LATEST`, that is, you cannot specify `\$LATEST` as the value of this parameter. The `\$LATEST` version can be deleted only when you want to delete all the function versions and aliases.

You can only specify a function version, not an alias name, using this parameter. You cannot delete a function version using its alias.

If you don't specify this parameter, AWS Lambda will delete the function, including all of its versions and aliases.

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. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### **ResourceConflictException**

The resource already exists.

HTTP Status Code: 409

### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)

- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## DeleteFunctionConcurrency

Removes concurrent execution limits from this function. For more information, see [Managing Concurrency \(p. 373\)](#).

### Request Syntax

```
DELETE /2017-10-31/functions/FunctionName/concurrency HTTP/1.1
```

### URI Request Parameters

The request requires the following URI parameters.

#### **FunctionName (p. 428)**

The name of the function you are removing concurrent execution limits from. For more information, see [Managing Concurrency \(p. 373\)](#).

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: (arn:aws:lambda:)?([a-z]{2}-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-\_]+)(:(\\$\#LATEST|[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. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

#### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## GetAccountSettings

Returns a customer's account settings.

You can use this operation to retrieve Lambda limits information, such as code size and concurrency limits. For more information about limits, see [AWS Lambda Limits](#). You can also retrieve resource usage statistics, such as code storage usage and function count.

### 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 \(p. 430\)](#)

Provides limits of code size and concurrency associated with the current account and region.

Type: [AccountLimit \(p. 510\)](#) object

#### [AccountUsage \(p. 430\)](#)

Provides code size usage and function count associated with the current account and region.

Type: [AccountUsage \(p. 512\)](#) object

## Errors

### **ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

### **TooManyRequestsException**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## GetAlias

Returns the specified alias information such as the alias ARN, description, and function version it is pointing to. For more information, see [Introduction to AWS Lambda Aliases](#).

This requires permission for the `lambda:GetAlias` action.

## Request Syntax

```
GET /2015-03-31/functions/FunctionName/aliases/Name HTTP/1.1
```

## URI Request Parameters

The request requires the following URI parameters.

### **FunctionName** (p. 432)

Function name for which the alias is created. An alias is a subresource that exists only in the context of an existing Lambda function so you must specify the function name. Note that the length constraint applies only to the 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:lambda:`)?([a-z]{2}-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?( [a-zA-Z0-9-\_]+)(:(\\$\#LATEST|[a-zA-Z0-9-\_]+))?

### **Name** (p. 432)

Name of the alias for which you want to retrieve information.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: (? !^ [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

{
    "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 \(p. 432\)](#)

Lambda function ARN that is qualified using the alias name as the suffix. For example, if you create an alias called `BETA` that points to a helloworld function version, the ARN is `arn:aws:lambda:aws-regions:acct-id:function:helloworld:BETA`.

Type: String

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

### [Description \(p. 432\)](#)

Alias description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

### [FunctionVersion \(p. 432\)](#)

Function version to which the alias points.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

### [Name \(p. 432\)](#)

Alias name.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(?!^[\0-9]+$)([a-zA-Z0-9-_]+)`

### [RevisionId \(p. 432\)](#)

Represents the latest updated revision of the function or alias.

Type: String

### [RoutingConfig \(p. 432\)](#)

Specifies an additional function versions the alias points to, allowing you to dictate what percentage of traffic will invoke each version. For more information, see [Traffic Shifting Using Aliases \(p. 295\)](#).

Type: [AliasRoutingConfiguration \(p. 515\)](#) object

## Errors

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## GetEventSourceMapping

Returns configuration information for the specified event source mapping (see [CreateEventSourceMapping \(p. 407\)](#)).

This operation requires permission for the `lambda:GetEventSourceMapping` action.

### Request Syntax

```
GET /2015-03-31/event-source-mappings/UUID HTTP/1.1
```

### URI Request Parameters

The request requires the following URI parameters.

#### **UUID (p. 435)**

The AWS Lambda assigned ID of the event source mapping.

### Request Body

The request does not have a request body.

### Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
    "BatchSize": number,
    "EventSourceArn": "string",
    "FunctionArn": "string",
    "LastModified": number,
    "LastProcessingResult": "string",
    "State": "string",
    "StateTransitionReason": "string",
    "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.

#### **BatchSize (p. 435)**

The largest number of records that AWS Lambda will retrieve from your event source at the time of invoking your function. Your function receives an event with all the retrieved records.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

#### **EventSourceArn (p. 435)**

The Amazon Resource Name (ARN) of the Amazon Kinesis stream that is the source of events.

Type: String

Pattern: arn:aws:([a-zA-Z0-9\-\-]+)([a-z]{2}-[a-z]+\-\d{1})?:(\d{12})?:(.\*)

[FunctionArn \(p. 435\)](#)

The Lambda function to invoke when AWS Lambda detects an event on the stream.

Type: String

Pattern: arn:aws:lambda:[a-z]{2}-[a-z]+\-\d{1}:\d{12}:function:[a-zA-Z0-9\\_]+(:(\\$\\_LATEST|[a-zA-Z0-9\\_]+))?

[LastModified \(p. 435\)](#)

The UTC time string indicating the last time the event mapping was updated.

Type: Timestamp

[LastProcessingResult \(p. 435\)](#)

The result of the last AWS Lambda invocation of your Lambda function.

Type: String

[State \(p. 435\)](#)

The state of the event source mapping. It can be Creating, Enabled, Disabled, Enabling, Disabling, Updating, or Deleting.

Type: String

[StateTransitionReason \(p. 435\)](#)

The reason the event source mapping is in its current state. It is either user-requested or an AWS Lambda-initiated state transition.

Type: String

[UUID \(p. 435\)](#)

The AWS Lambda assigned opaque identifier for the mapping.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## GetFunction

Returns the configuration information of the Lambda function and a presigned URL link to the .zip file you uploaded with [CreateFunction \(p. 412\)](#) so you can download the .zip file. Note that the URL is valid for up to 10 minutes. The configuration information is the same information you provided as parameters when uploading the function.

Using the optional `Qualifier` parameter, you can specify a specific function version for which you want this information. If you don't specify this parameter, the API uses unqualified function ARN which return information about the `$LATEST` version of the Lambda function. For more information, see [AWS Lambda Function Versioning and Aliases](#).

This operation requires permission for the `lambda:GetFunction` action.

## Request Syntax

```
GET /2015-03-31/functions/FunctionName?Qualifier=Qualifier HTTP/1.1
```

## URI Request Parameters

The request requires the following URI parameters.

### FunctionName (p. 438)

The Lambda function name.

You can specify a function name (for example, `Thumbnail`) or you can specify Amazon Resource Name (ARN) of the function (for example, `arn:aws:lambda:us-west-2:account-id:function:Thumbnail`). AWS Lambda also allows you to specify a partial ARN (for example, `account-id:Thumbnail`). Note that the length constraint applies only to the 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:lambda:[a-z]{2}-[a-z]+\d{1}:[\d{12}]:)(function:[a-zA-Z0-9-_\.]+)(:$LATEST|[a-zA-Z0-9-_+])?`

### Qualifier (p. 438)

Use this optional parameter to specify a function version or an alias name. If you specify function version, the API uses qualified function ARN for the request and returns information about the specific Lambda function version. If you specify an alias name, the API uses the alias ARN and returns information about the function version to which the alias points. If you don't provide this parameter, the API uses unqualified function ARN and returns information about the `$LATEST` version of the Lambda 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": {
    "Location": "string",
    "RepositoryType": "string"
  },
  "Concurrency": {
    "ReservedConcurrentExecutions": number
  },
  "Configuration": {
    "CodeSha256": "string",
    "CodeSize": number,
    "DeadLetterConfig": {
      "TargetArn": "string"
    },
    "Description": "string",
    "Environment": {
      "Error": {
        "ErrorCode": "string",
        "Message": "string"
      },
      "Variables": {
        "string" : "string"
      }
    },
    "FunctionArn": "string",
    "FunctionName": "string",
    "Handler": "string",
    "KMSKeyArn": "string",
    "LastModified": "string",
    "MasterArn": "string",
    "MemorySize": number,
    "RevisionId": "string",
    "Role": "string",
    "Runtime": "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. 438)

The object for the Lambda function location.

Type: [FunctionCodeLocation \(p. 524\)](#) object

### [Concurrency \(p. 438\)](#)

The concurrent execution limit set for this function. For more information, see [Managing Concurrency \(p. 373\)](#).

Type: [Concurrency \(p. 516\)](#) object

### [Configuration \(p. 438\)](#)

A complex type that describes function metadata.

Type: [FunctionConfiguration \(p. 525\)](#) object

### [Tags \(p. 438\)](#)

Returns the list of tags associated with the function. For more information, see [Tagging Lambda Functions](#) in the [AWS Lambda Developer Guide](#).

Type: String to string map

## Errors

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)

- [AWS SDK for Ruby V2](#)

## GetFunctionConfiguration

Returns the configuration information of the Lambda function. This is the same information you provided as parameters when uploading the function by using [CreateFunction \(p. 412\)](#).

If you are using the versioning feature, you can retrieve this information for a specific function version by using the optional `Qualifier` parameter and specifying the function version or alias that points to it. If you don't provide it, the API returns information about the `$LATEST` version of the function. For more information about versioning, see [AWS Lambda Function Versioning and Aliases](#).

This operation requires permission for the `lambda:GetFunctionConfiguration` operation.

### Request Syntax

```
GET /2015-03-31/functions/FunctionName/configuration?Qualifier=Qualifier HTTP/1.1
```

### URI Request Parameters

The request requires the following URI parameters.

#### **FunctionName (p. 442)**

The name of the Lambda function for which you want to retrieve the configuration information.

You can specify a function name (for example, `Thumbnail1`) or you can specify Amazon Resource Name (ARN) of the function (for example, `arn:aws:lambda:us-west-2:account-id:function:Thumbnail1`). AWS Lambda also allows you to specify a partial ARN (for example, `account-id:Thumbnail`). Note that the length constraint applies only to the 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:lambda:)?([a-z]{2}-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$\text{LATEST}|[a-zA-Z0-9-_]+))?`

#### **Qualifier (p. 442)**

Using this optional parameter you can specify a function version or an alias name. If you specify function version, the API uses qualified function ARN and returns information about the specific function version. If you specify an alias name, the API uses the alias ARN and returns information about the function version to which the alias points.

If you don't specify this parameter, the API uses unqualified function ARN, and returns information about the `$LATEST` function version.

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

{
    "CodeSha256": "string",
    "CodeSize": number,
    "DeadLetterConfig": {
        "TargetArn": "string"
    },
    "Description": "string",
    "Environment": {
        "Error": {
            "ErrorCode": "string",
            "Message": "string"
        },
        "Variables": {
            "string" : "string"
        }
    },
    "FunctionArn": "string",
    "FunctionName": "string",
    "Handler": "string",
    "KMSKeyArn": "string",
    "LastModified": "string",
    "MasterArn": "string",
    "MemorySize": number,
    "RevisionId": "string",
    "Role": "string",
    "Runtime": "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.

### **CodeSha256 (p. 442)**

It is the SHA256 hash of your function deployment package.

Type: String

### **CodeSize (p. 442)**

The size, in bytes, of the function .zip file you uploaded.

Type: Long

### **DeadLetterConfig (p. 442)**

The parent object that contains the target ARN (Amazon Resource Name) of an Amazon SQS queue or Amazon SNS topic. For more information, see [Dead Letter Queues \(p. 385\)](#).

Type: [DeadLetterConfig \(p. 517\)](#) object

## Description (p. 442)

The user-provided description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

## Environment (p. 442)

The parent object that contains your environment's configuration settings.

Type: [EnvironmentResponse \(p. 520\)](#) object

## FunctionArn (p. 442)

The Amazon Resource Name (ARN) assigned to the function.

Type: String

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_\.]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

## FunctionName (p. 442)

The name of the function. Note that the length constraint applies only to the 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 170.

Pattern: `(arn:aws:lambda:)?([a-z]{2}-[a-z]+\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

## Handler (p. 442)

The function Lambda calls to begin executing your function.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

## KMSKeyArn (p. 442)

The Amazon Resource Name (ARN) of the KMS key used to encrypt your function's environment variables. If empty, it means you are using the AWS Lambda default service key.

Type: String

Pattern: `(arn:aws:[a-zA-Z0-9-_\.]+:\.*|())`

## LastModified (p. 442)

The time stamp of the last time you updated the function. The time stamp is conveyed as a string complying with ISO-8601 in this way YYYY-MM-DDThh:mm:ssTZD (e.g., 1997-07-16T19:20:30+01:00). For more information, see [Date and Time Formats](#).

Type: String

## MasterArn (p. 442)

Returns the ARN (Amazon Resource Name) of the master function.

Type: String

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

#### [MemorySize \(p. 442\)](#)

The memory size, in MB, you configured for the function. Must be a multiple of 64 MB.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 3008.

#### [RevisionId \(p. 442\)](#)

Represents the latest updated revision of the function or alias.

Type: String

#### [Role \(p. 442\)](#)

The Amazon Resource Name (ARN) of the IAM role that Lambda assumes when it executes your function to access any other Amazon Web Services (AWS) resources.

Type: String

Pattern: `arn:aws:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@-_/+]`

#### [Runtime \(p. 442\)](#)

The runtime environment for the Lambda function.

Type: String

Valid Values: nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | java8 | python2.7 | python3.6 | dotnetcore1.0 | dotnetcore2.0 | go1.x

#### [Timeout \(p. 442\)](#)

The function execution time at which Lambda should terminate the function. Because the execution time has cost implications, we recommend you set this value based on your expected execution time. The default is 3 seconds.

Type: Integer

Valid Range: Minimum value of 1.

#### [TracingConfig \(p. 442\)](#)

The parent object that contains your function's tracing settings.

Type: [TracingConfigResponse \(p. 530\)](#) object

#### [Version \(p. 442\)](#)

The version of the Lambda function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

#### [VpcConfig \(p. 442\)](#)

VPC configuration associated with your Lambda function.

Type: [VpcConfigResponse \(p. 532\)](#) object

## Errors

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## GetPolicy

Returns the resource policy associated with the specified Lambda function.

If you are using the versioning feature, you can get the resource policy associated with the specific Lambda function version or alias by specifying the version or alias name using the `Qualifier` parameter. For more information about versioning, see [AWS Lambda Function Versioning and Aliases](#).

You need permission for the `lambda:GetPolicy` action.

## Request Syntax

```
GET /2015-03-31/functions/FunctionName/policy?Qualifier=Qualifier HTTP/1.1
```

## URI Request Parameters

The request requires the following URI parameters.

### **FunctionName** (p. 447)

Function name whose resource policy you want to retrieve.

You can specify the function name (for example, `Thumbnail`) or you can specify Amazon Resource Name (ARN) of the function (for example, `arn:aws:lambda:us-west-2:account-id:function:Thumbnail`). If you are using versioning, you can also provide a qualified function ARN (ARN that is qualified with function version or alias name as suffix). AWS Lambda also allows you to specify only the function name with the account ID qualifier (for example, `account-id:Thumbnail`). Note that the length constraint applies only to the 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:lambda:`)?([`a-zA-Z0-9-_.`]+)(:(`\$LATEST`|[`a-zA-Z0-9-_`+]))?

### **Qualifier** (p. 447)

You can specify this optional query parameter to specify a function version or an alias name in which case this API will return all permissions associated with the specific qualified ARN. If you don't provide this parameter, the API will return permissions that apply to the unqualified function ARN.

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 \(p. 447\)](#)

The resource policy associated with the specified function. The response returns the same as a string using a backslash ("\\") as an escape character in the JSON.

Type: String

### [RevisionId \(p. 447\)](#)

Represents the latest updated revision of the function or alias.

Type: String

## Errors

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)

- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## Invoke

Invokes a specific Lambda function. For an example, see [Create the Lambda Function and Test It Manually](#).

If you are using the versioning feature, you can invoke the specific function version by providing function version or alias name that is pointing to the function version using the `Qualifier` parameter in the request. If you don't provide the `Qualifier` parameter, the `$LATEST` version of the Lambda function is invoked. Invocations occur at least once in response to an event and functions must be idempotent to handle this. For information about the versioning feature, see [AWS Lambda Function Versioning and Aliases](#).

This operation requires permission for the `lambda:InvokeFunction` action.

### Note

The `TooManyRequestsException` noted below will return the following:  
`ConcurrentInvocationLimitExceeded` will be returned if you have no functions with reserved concurrency and have exceeded your account concurrent limit or if a function without reserved concurrency exceeds the account's unreserved concurrency limit.  
`ReservedFunctionConcurrentInvocationLimitExceeded` will be returned when a function with reserved concurrency exceeds its configured concurrency limit.

## 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 requires the following URI parameters.

### **ClientContext** (p. 450)

Using the `ClientContext` you can pass client-specific information to the Lambda function you are invoking. You can then process the client information in your Lambda function as you choose through the `context` variable. For an example of a `ClientContext` JSON, see [PutEvents](#) in the [Amazon Mobile Analytics API Reference and User Guide](#).

The `ClientContext` JSON must be base64-encoded and has a maximum size of 3583 bytes.

### **FunctionName** (p. 450)

The Lambda function name.

You can specify a function name (for example, `Thumbnail`) or you can specify Amazon Resource Name (ARN) of the function (for example, `arn:aws:lambda:us-west-2:account-id:function:Thumbnail`). AWS Lambda also allows you to specify a partial ARN (for example, `account-id:Thumbnail`). Note that the length constraint applies only to the 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:lambda:`)?([`a-z`]{2}-[`a-z`]+\-\d{1}:)?)?(\d{12}:)?(function:)?)?([`a-zA-Z0-9-_`.]+)(:(\\$\text{LATEST}|[`a-zA-Z0-9-_`.]+))?

### InvocationType (p. 450)

By default, this operation assumes a synchronous (`RequestResponse`) invocation type. If the Lambda function you invoke is expected to have a long-running execution time, your client may time out before execution completes. To avoid this, update the client timeout. If you are invoking the Lambda function via an SDK, please refer to the SDK documentation at the end of this section to learn more about configuring the timeout for your specific runtime.

You can optionally request asynchronous execution by specifying `Event` as the `InvocationType`. You can also use this parameter to request AWS Lambda to not execute the function but do some verification, such as if the caller is authorized to invoke the function and if the inputs are valid. You request this by specifying `DryRun` as the `InvocationType`. This is useful in a cross-account scenario when you want to verify access to a function without running it.

Valid Values: `Event` | `RequestResponse` | `DryRun`

### LogType (p. 450)

You can set this optional parameter to `Tail` in the request only if you specify the `InvocationType` parameter with value `RequestResponse`. In this case, AWS Lambda returns the base64-encoded last 4 KB of log data produced by your Lambda function in the `x-amz-log-result` header.

Valid Values: `None` | `Tail`

### Qualifier (p. 450)

You can use this optional parameter to specify a Lambda function version or alias name. If you specify a function version, the API uses the qualified function ARN to invoke a specific Lambda function. If you specify an alias name, the API uses the alias ARN to invoke the Lambda function version to which the alias points.

If you don't provide this parameter, then the API uses unqualified function ARN which results in invocation of the `$LATEST` version.

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. 450)

JSON that you want to provide to your Lambda function as input.

## 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. 451)**

The HTTP status code will be in the 200 range for successful request. For the RequestResponse invocation type this status code will be 200. For the Event invocation type this status code will be 202. For the DryRun invocation type the status code will be 204.

The response returns the following HTTP headers.

### **ExecutedVersion (p. 451)**

The function version that has been executed. This value is returned only if the invocation type is RequestResponse. For more information, see [Traffic Shifting Using Aliases \(p. 295\)](#).

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: (\\$LATEST | [0-9]+)

### **FunctionError (p. 451)**

Indicates whether an error occurred while executing the Lambda function. If an error occurred this field will have one of two values; Handled or Unhandled. Handled errors are errors that are reported by the function while the Unhandled errors are those detected and reported by AWS Lambda. Unhandled errors include out of memory errors and function timeouts. For information about how to report an Handled error, see [Programming Model](#).

### **LogResult (p. 451)**

It is the base64-encoded logs for the Lambda function invocation. This is present only if the invocation type is RequestResponse and the logs were requested.

The response returns the following as the HTTP body.

### **Payload (p. 451)**

It is the JSON representation of the object returned by the Lambda function. This is present only if the invocation type is RequestResponse.

In the event of a function error this field contains a message describing the error. For the Handled errors the Lambda function will report this message. For unhandled errors AWS Lambda reports the message.

## **Errors**

### **EC2AccessDeniedException**

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

### **ENILimitReachedException**

AWS Lambda was not able to create an Elastic Network Interface (ENI) 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. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

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 function zip file.

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

**ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) specified in the request does not exist.

HTTP Status Code: 404

**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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## InvokeAsync

### Important

This API is deprecated. We recommend you use [Invoke API](#) (see [Invoke \(p. 450\)](#)).

Submits an invocation request to AWS Lambda. Upon receiving the request, Lambda executes the specified function asynchronously. To see the logs generated by the Lambda function execution, see the CloudWatch Logs console.

This operation requires permission for the `lambda:InvokeFunction` action.

## Request Syntax

```
POST /2014-11-13/functions/FunctionName/invoke-async/ HTTP/1.1
```

```
InvokeArgs
```

## URI Request Parameters

The request requires the following URI parameters.

### FunctionName (p. 455)

The Lambda function name. Note that the length constraint applies only to the 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:lambda:`)?([a-z]{2}-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-\_\.]+)(:(\\$LATEST|[a-zA-Z0-9-\_]+))?

## Request Body

The request accepts the following binary data.

### InvokeArgs (p. 455)

JSON that you want to provide to your Lambda function as input.

## Response Syntax

```
HTTP/1.1 Status
```

## Response Elements

If the action is successful, the service sends back the following HTTP response.

### Status (p. 455)

It will be 202 upon success.

## 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

### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) specified in the request does not exist.

HTTP Status Code: 404

### **ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

## Example

### Invoke a Lambda function

The following example uses a POST request to invoke a Lambda function.

#### Sample Request

```
POST /2014-11-13/functions/helloworld/invoke-async/ HTTP/1.1
[ input json ]
```

#### Sample Response

```
HTTP/1.1 202 Accepted

x-amzn-requestid: f037bc5c-5a08-11e4-b02e-af446c3f9d0d
content-length: 0
connection: keep-alive
date: Wed, 22 Oct 2014 16:31:55 GMT
content-type: application/json
```

## 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](#)

- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## ListAliases

Returns list of aliases created for a Lambda function. For each alias, the response includes information such as the alias ARN, description, alias name, and the function version to which it points. For more information, see [Introduction to AWS Lambda Aliases](#).

This requires permission for the `lambda>ListAliases` action.

## Request Syntax

```
GET /2015-03-31/functions/FunctionName/aliases?  
FunctionVersion=FunctionVersion&Marker=Marker&MaxItems=MaxItems HTTP/1.1
```

## URI Request Parameters

The request requires the following URI parameters.

### **FunctionName** (p. 458)

Lambda function name for which the alias is created. Note that the length constraint applies only to the 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:lambda:`)?([`a-z`]{2}-[`a-z`]+-\d{1}:)?(\d{12}:)?(function:)?(`[a-zA-Z0-9-_]+`):(:(\\$\text{LATEST}|[`a-zA-Z0-9-_`+]))?

### **FunctionVersion** (p. 458)

If you specify this optional parameter, the API returns only the aliases that are pointing to the specific Lambda function version, otherwise the API returns all of the aliases created for the Lambda function.

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: (\\$\text{LATEST}|[0-9]+)

### **Marker** (p. 458)

Optional string. An opaque pagination token returned from a previous `ListAliases` operation. If present, indicates where to continue the listing.

### **MaxItems** (p. 458)

Optional integer. Specifies the maximum number of aliases to return in response. This parameter value must be greater than 0.

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 \(p. 458\)](#)

A list of aliases.

Type: Array of [AliasConfiguration \(p. 513\)](#) objects

### [NextMarker \(p. 458\)](#)

A string, present if there are more aliases.

Type: String

## Errors

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## ListEventSourceMappings

Returns a list of event source mappings you created using the [CreateEventSourceMapping](#) (see [CreateEventSourceMapping \(p. 407\)](#)).

For each mapping, the API returns configuration information. You can optionally specify filters to retrieve specific event source mappings.

If you are using the versioning feature, you can get list of event source mappings for a specific Lambda function version or an alias as described in the `FunctionName` parameter. For information about the versioning feature, see [AWS Lambda Function Versioning and Aliases](#).

This operation requires permission for the `lambda:ListEventSourceMappings` action.

## 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 requires the following URI parameters.

### [EventSourceArn \(p. 461\)](#)

The Amazon Resource Name (ARN) of the Amazon Kinesis stream. (This parameter is optional.)

Pattern: `arn:aws:([a-zA-Z0-9\-\_])+:(a-z{2}-[a-z]+\-\d{1})?:(\d{12})?:(.*)`

### [FunctionName \(p. 461\)](#)

The name of the Lambda function.

You can specify the function name (for example, `Thumbnail`) or you can specify Amazon Resource Name (ARN) of the function (for example, `arn:aws:lambda:us-west-2:account-id:function:Thumbnail`). If you are using versioning, you can also provide a qualified function ARN (ARN that is qualified with function version or alias name as suffix). AWS Lambda also allows you to specify only the function name with the account ID qualifier (for example, `account-id:Thumbnail`). Note that the length constraint applies only to the 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:lambda:)?(a-z{2}-[a-z]+\-\d{1}:(\d{12}):)?(function:)?(a-zA-Z0-9\-\_+)(:\($LATEST|[a-zA-Z0-9\-\_+]\))?`

### [Marker \(p. 461\)](#)

Optional string. An opaque pagination token returned from a previous `ListEventSourceMappings` operation. If present, specifies to continue the list from where the returning call left off.

### [MaxItems \(p. 461\)](#)

Optional integer. Specifies the maximum number of event sources to return in response. This value must be greater than 0.

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": [
    {
      "BatchSize": number,
      "EventSourceArn": "string",
      "FunctionArn": "string",
      "LastModified": number,
      "LastProcessingResult": "string",
      "State": "string",
      "StateTransitionReason": "string",
      "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. 462)**

An array of `EventSourceMappingConfiguration` objects.

Type: Array of [EventSourceMappingConfiguration \(p. 521\)](#) objects

### **NextMarker (p. 462)**

A string, present if there are more event source mappings.

Type: String

## Errors

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## ListFunctions

Returns a list of your Lambda functions. For each function, the response includes the function configuration information. You must use [GetFunction \(p. 438\)](#) to retrieve the code for your function.

This operation requires permission for the `lambda:ListFunctions` action.

If you are using the versioning feature, you can list all of your functions or only `$LATEST` versions. For information about the versioning feature, see [AWS Lambda Function Versioning and Aliases](#).

### Request Syntax

```
GET /2015-03-31/functions/?  
FunctionVersion=FunctionVersion&Marker=Marker&MasterRegion=MasterRegion&MaxItems=MaxItems  
HTTP/1.1
```

## URI Request Parameters

The request requires the following URI parameters.

#### [FunctionVersion \(p. 464\)](#)

Optional string. If not specified, only the unqualified functions ARNs (Amazon Resource Names) will be returned.

Valid value:

`ALL`: Will return all versions, including `$LATEST` which will have fully qualified ARNs (Amazon Resource Names).

Valid Values: `ALL`

#### [Marker \(p. 464\)](#)

Optional string. An opaque pagination token returned from a previous `ListFunctions` operation. If present, indicates where to continue the listing.

#### [MasterRegion \(p. 464\)](#)

Optional string. If not specified, will return only regular function versions (i.e., non-replicated versions).

Valid values are:

The region from which the functions are replicated. For example, if you specify `us-east-1`, only functions replicated from that region will be returned.

`ALL`: Will return all functions from any region. If specified, you also must specify a valid `FunctionVersion` parameter.

Pattern: `ALL | [a-z]{2}(-gov)?-[a-z]+-\d{1}`

#### [MaxItems \(p. 464\)](#)

Optional integer. Specifies the maximum number of AWS Lambda functions to return in response. This parameter value must be greater than 0.

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": [
        {
            "CodeSha256": "string",
            "CodeSize": number,
            "DeadLetterConfig": {
                "TargetArn": "string"
            },
            "Description": "string",
            "Environment": {
                "Error": {
                    "ErrorCode": "string",
                    "Message": "string"
                },
                "Variables": {
                    "string" : "string"
                }
            },
            "FunctionArn": "string",
            "FunctionName": "string",
            "Handler": "string",
            "KMSKeyArn": "string",
            "LastModified": "string",
            "MasterArn": "string",
            "MemorySize": number,
            "RevisionId": "string",
            "Role": "string",
            "Runtime": "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. 465)

A list of Lambda functions.

Type: Array of [FunctionConfiguration \(p. 525\)](#) objects

**NextMarker (p. 465)**

A string, present if there are more functions.

Type: String

## Errors

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### **ServiceException**

The AWS Lambda service encountered an internal error.

HTTP Status Code: 500

### **TooManyRequestsException**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## ListTags

Returns a list of tags assigned to a function when supplied the function ARN (Amazon Resource Name). For more information on Tagging, see [Tagging Lambda Functions](#) in the [AWS Lambda Developer Guide](#).

### Request Syntax

```
GET /2017-03-31/tags/ARN HTTP/1.1
```

### URI Request Parameters

The request requires the following URI parameters.

#### [Resource \(p. 467\)](#)

The ARN (Amazon Resource Name) of the function. For more information, see [Tagging Lambda Functions](#) in the [AWS Lambda Developer Guide](#).

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+-\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

### 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 \(p. 467\)](#)

The list of tags assigned to the function. For more information, see [Tagging Lambda Functions](#) in the [AWS Lambda Developer Guide](#).

Type: String to string map

## Errors

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

**ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## ListVersionsByFunction

List all versions of a function. For information about the versioning feature, see [AWS Lambda Function Versioning and Aliases](#).

### Request Syntax

```
GET /2015-03-31/functions/FunctionName/versions?Marker=Marker&MaxItems=MaxItems HTTP/1.1
```

### URI Request Parameters

The request requires the following URI parameters.

#### **FunctionName** (p. 469)

Function name whose versions to list. You can specify a function name (for example, Thumbnail) or you can specify Amazon Resource Name (ARN) of the function (for example, arn:aws:lambda:us-west-2:account-id:function:Thumbnail). AWS Lambda also allows you to specify a partial ARN (for example, account-id:Thumbnail). Note that the length constraint applies only to the 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:lambda:)(([a-z]{2}-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?)(([a-zA-Z0-9-\_\.]+)(:(\\$LATEST|[a-zA-Z0-9-\_]+))?

#### **Marker** (p. 469)

Optional string. An opaque pagination token returned from a previous `ListVersionsByFunction` operation. If present, indicates where to continue the listing.

#### **MaxItems** (p. 469)

Optional integer. Specifies the maximum number of AWS Lambda function versions to return in response. This parameter value must be greater than 0.

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": [
        {
            "CodeSha256": "string",
            "CodeSize": number,
            "DeadLetterConfig": {
                "TargetArn": "string"
            },
            "Description": "string",
            "Environment": {
                "Error": {

```

```

        "ErrorCode": "string",
        "Message": "string"
    },
    "Variables": {
        "string" : "string"
    }
},
"FunctionArn": "string",
"FunctionName": "string",
"Handler": "string",
"KMSKeyArn": "string",
"LastModified": "string",
"MasterArn": "string",
"MemorySize": number,
"RevisionId": "string",
"Role": "string",
"Runtime": "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 \(p. 469\)](#)

A string, present if there are more function versions.

Type: String

### [Versions \(p. 469\)](#)

A list of Lambda function versions.

Type: Array of [FunctionConfiguration \(p. 525\)](#) objects

## Errors

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## PublishVersion

Publishes a version of your function from the current snapshot of \$LATEST. That is, AWS Lambda takes a snapshot of the function code and configuration information from \$LATEST and publishes a new version. The code and configuration cannot be modified after publication. For information about the versioning feature, see [AWS Lambda Function Versioning and Aliases](#).

### 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 requires the following URI parameters.

#### [FunctionName \(p. 472\)](#)

The Lambda function name. You can specify a function name (for example, Thumbnail) or you can specify Amazon Resource Name (ARN) of the function (for example, arn:aws:lambda:us-west-2:account-id:function:ThumbNail). AWS Lambda also allows you to specify a partial ARN (for example, account-id:Thumbnail). Note that the length constraint applies only to the 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:lambda:)?([a-z]{2}-[a-z]+\-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-\_]+)(:(\\$LATEST|[a-zA-Z0-9-\_]+))?

### Request Body

The request accepts the following data in JSON format.

#### [CodeSha256 \(p. 472\)](#)

The SHA256 hash of the deployment package you want to publish. This provides validation on the code you are publishing. If you provide this parameter, the value must match the SHA256 of the \$LATEST version for the publication to succeed. You can use the **DryRun** parameter of [UpdateFunctionCode \(p. 495\)](#) to verify the hash value that will be returned before publishing your new version.

Type: String

Required: No

#### [Description \(p. 472\)](#)

The description for the version you are publishing. If not provided, AWS Lambda copies the description from the \$LATEST version.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

#### [RevisionId \(p. 472\)](#)

An optional value you can use to ensure you are updating the latest update of the function version or alias. If the RevisionID you pass doesn't match the latest RevisionId of the function or alias, it will fail with an error message, advising you to retrieve the latest function version or alias RevisionID using either [GetFunction \(p. 438\)](#) or [GetAlias \(p. 432\)](#).

Type: String

Required: No

## Response Syntax

```
HTTP/1.1 201
Content-type: application/json

{
    "CodeSha256": "string",
    "CodeSize": number,
    "DeadLetterConfig": {
        "TargetArn": "string"
    },
    "Description": "string",
    "Environment": {
        "Error": {
            "ErrorCode": "string",
            "Message": "string"
        },
        "Variables": {
            "string" : "string"
        }
    },
    "FunctionArn": "string",
    "FunctionName": "string",
    "Handler": "string",
    "KMSKeyArn": "string",
    "LastModified": "string",
    "MasterArn": "string",
    "MemorySize": number,
    "RevisionId": "string",
    "Role": "string",
    "Runtime": "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.

**CodeSha256 (p. 473)**

It is the SHA256 hash of your function deployment package.

Type: String

**CodeSize (p. 473)**

The size, in bytes, of the function .zip file you uploaded.

Type: Long

**DeadLetterConfig (p. 473)**

The parent object that contains the target ARN (Amazon Resource Name) of an Amazon SQS queue or Amazon SNS topic. For more information, see [Dead Letter Queues \(p. 385\)](#).

Type: [DeadLetterConfig \(p. 517\)](#) object

**Description (p. 473)**

The user-provided description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

**Environment (p. 473)**

The parent object that contains your environment's configuration settings.

Type: [EnvironmentResponse \(p. 520\)](#) object

**FunctionArn (p. 473)**

The Amazon Resource Name (ARN) assigned to the function.

Type: String

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_\.]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**FunctionName (p. 473)**

The name of the function. Note that the length constraint applies only to the 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 170.

Pattern: `(arn:aws:lambda:)?([a-z]{2}-[a-z]+\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

**Handler (p. 473)**

The function Lambda calls to begin executing your function.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

### [KMSKeyArn \(p. 473\)](#)

The Amazon Resource Name (ARN) of the KMS key used to encrypt your function's environment variables. If empty, it means you are using the AWS Lambda default service key.

Type: String

Pattern: `(arn:aws:[a-z0-9-.]+:.*)|()`

### [LastModified \(p. 473\)](#)

The time stamp of the last time you updated the function. The time stamp is conveyed as a string complying with ISO-8601 in this way YYYY-MM-DDThh:mm:ssTZD (e.g., 1997-07-16T19:20:30+01:00). For more information, see [Date and Time Formats](#).

Type: String

### [MasterArn \(p. 473\)](#)

Returns the ARN (Amazon Resource Name) of the master function.

Type: String

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

### [MemorySize \(p. 473\)](#)

The memory size, in MB, you configured for the function. Must be a multiple of 64 MB.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 3008.

### [RevisionId \(p. 473\)](#)

Represents the latest updated revision of the function or alias.

Type: String

### [Role \(p. 473\)](#)

The Amazon Resource Name (ARN) of the IAM role that Lambda assumes when it executes your function to access any other Amazon Web Services (AWS) resources.

Type: String

Pattern: `arn:aws:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@\-/]+`

### [Runtime \(p. 473\)](#)

The runtime environment for the Lambda function.

Type: String

Valid Values: nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | java8 | python2.7 | python3.6 | dotnetcore1.0 | dotnetcore2.0 | go1.x

### [Timeout \(p. 473\)](#)

The function execution time at which Lambda should terminate the function. Because the execution time has cost implications, we recommend you set this value based on your expected execution time. The default is 3 seconds.

Type: Integer

Valid Range: Minimum value of 1.

### [TracingConfig \(p. 473\)](#)

The parent object that contains your function's tracing settings.

Type: [TracingConfigResponse \(p. 530\)](#) object

### [Version \(p. 473\)](#)

The version of the Lambda function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: (\\$LATEST | [0-9]+)

### [VpcConfig \(p. 473\)](#)

VPC configuration associated with your Lambda function.

Type: [VpcConfigResponse \(p. 532\)](#) object

## Errors

### **CodeStorageExceededException**

You have exceeded your maximum total code size per account. [Limits](#)

HTTP Status Code: 400

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

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 (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## PutFunctionConcurrency

Sets a limit on the number of concurrent executions available to this function. It is a subset of your account's total concurrent execution limit per region. Note that Lambda automatically reserves a buffer of 100 concurrent executions for functions without any reserved concurrency limit. This means if your account limit is 1000, you have a total of 900 available to allocate to individual functions. For more information, see [Managing Concurrency \(p. 373\)](#).

### Request Syntax

```
PUT /2017-10-31/functions/FunctionName/concurrency HTTP/1.1
Content-type: application/json

{
    "ReservedConcurrentExecutions": number
}
```

### URI Request Parameters

The request requires the following URI parameters.

#### **FunctionName** (p. 478)

The name of the function you are setting concurrent execution limits on. For more information, see [Managing Concurrency \(p. 373\)](#).

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: (arn:aws:lambda:)?([a-z]{2}-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-\_+]):(:(\$LATEST|[a-zA-Z0-9-\_+]))?

### Request Body

The request accepts the following data in JSON format.

#### **ReservedConcurrentExecutions** (p. 478)

The concurrent execution limit reserved for this function. For more information, see [Managing Concurrency \(p. 373\)](#).

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. 478)**

The number of concurrent executions reserved for this function. For more information, see [Managing Concurrency \(p. 373\)](#).

Type: Integer

Valid Range: Minimum value of 0.

## Errors

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## RemovePermission

You can remove individual permissions from an resource policy associated with a Lambda function by providing a statement ID that you provided when you added the permission.

If you are using versioning, the permissions you remove are specific to the Lambda function version or alias you specify in the `AddPermission` request via the `Qualifier` parameter. For more information about versioning, see [AWS Lambda Function Versioning and Aliases](#).

Note that removal of a permission will cause an active event source to lose permission to the function.

You need permission for the `lambda:RemovePermission` action.

## Request Syntax

```
DELETE /2015-03-31/functions/FunctionName/policy/StatementId?  
Qualifier=Qualifier&RevisionId=RevisionId HTTP/1.1
```

## URI Request Parameters

The request requires the following URI parameters.

### **FunctionName** (p. 480)

Lambda function whose resource policy you want to remove a permission from.

You can specify a function name (for example, `Thumbnail`) or you can specify Amazon Resource Name (ARN) of the function (for example, `arn:aws:lambda:us-west-2:account-id:function:Thumbnail`). AWS Lambda also allows you to specify a partial ARN (for example, `account-id:Thumbnail`). Note that the length constraint applies only to the 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:lambda:`)?([a-z]{2}-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?( [a-zA-Z0-9-\_+]):(:(\\$LATEST|[a-zA-Z0-9-\_+]))?

### **Qualifier** (p. 480)

You can specify this optional parameter to remove permission associated with a specific function version or function alias. If you don't specify this parameter, the API removes permission associated with the unqualified function ARN.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: ([a-zA-Z0-9\$-\_+])

### **RevisionId** (p. 480)

An optional value you can use to ensure you are updating the latest update of the function version or alias. If the `RevisionID` you pass doesn't match the latest `RevisionId` of the function or alias, it will fail with an error message, advising you to retrieve the latest function version or alias `RevisionID` using either [GetFunction](#) (p. 438) or [GetAlias](#) (p. 432).

### **StatementId** (p. 480)

Statement ID of the permission to remove.

Length Constraints: Minimum length of 1. Maximum length of 100.

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

### **InvalidArgumentException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

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 (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## TagResource

Creates a list of tags (key-value pairs) on the Lambda function. Requires the Lambda function ARN (Amazon Resource Name). If a key is specified without a value, Lambda creates a tag with the specified key and a value of null. For more information, see [Tagging Lambda Functions](#) in the **AWS Lambda Developer Guide**.

### Request Syntax

```
POST /2017-03-31/tags/ARN HTTP/1.1
Content-type: application/json

{
  "Tags": {
    "string": "string"
  }
}
```

### URI Request Parameters

The request requires the following URI parameters.

#### [Resource \(p. 483\)](#)

The ARN (Amazon Resource Name) of the Lambda function. For more information, see [Tagging Lambda Functions](#) in the **AWS Lambda Developer Guide**.

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$\#LATEST|[a-zA-Z0-9-_]+))?`

### Request Body

The request accepts the following data in JSON format.

#### [Tags \(p. 483\)](#)

The list of tags (key-value pairs) you are assigning to the Lambda function. For more information, see [Tagging Lambda Functions](#) in the **AWS Lambda Developer Guide**.

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. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## UntagResource

Removes tags from a Lambda function. Requires the function ARN (Amazon Resource Name). For more information, see [Tagging Lambda Functions](#) in the [AWS Lambda Developer Guide](#).

### Request Syntax

```
DELETE /2017-03-31/tags/ARN?tagKeys=TagKeys HTTP/1.1
```

### URI Request Parameters

The request requires the following URI parameters.

#### Resource (p. 485)

The ARN (Amazon Resource Name) of the function. For more information, see [Tagging Lambda Functions](#) in the [AWS Lambda Developer Guide](#).

Pattern: arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-\_]+(:(\\$LATEST|[a-zA-Z0-9-\_]+))?

#### TagKeys (p. 485)

The list of tag keys to be deleted from the function. For more information, see [Tagging Lambda Functions](#) in the [AWS Lambda Developer Guide](#).

### 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. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

#### ResourceNotFoundException

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## UpdateAlias

Using this API you can update the function version to which the alias points and the alias description. For more information, see [Introduction to AWS Lambda Aliases](#).

This requires permission for the lambda:UpdateAlias action.

## 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 requires the following URI parameters.

### **FunctionName** (p. 487)

The function name for which the alias is created. Note that the length constraint applies only to the 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:lambda:)?([a-z]{2}-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-\_]+)(:(\\$LATEST|[a-zA-Z0-9-\_]+))?

### **Name** (p. 487)

The alias name.

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: (?![0-9]+\\$)([a-zA-Z0-9-\_]+)

## Request Body

The request accepts the following data in JSON format.

### **Description** (p. 487)

You can change the description of the alias using this parameter.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

### [FunctionVersion \(p. 487\)](#)

Using this parameter you can change the Lambda function version to which the alias points.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: (\\$LATEST | [0-9]+)

Required: No

### [RevisionId \(p. 487\)](#)

An optional value you can use to ensure you are updating the latest update of the function version or alias. If the RevisionID you pass doesn't match the latest RevisionId of the function or alias, it will fail with an error message, advising you to retrieve the latest function version or alias RevisionID using either [GetFunction \(p. 438\)](#) or [GetAlias \(p. 432\)](#).

Type: String

Required: No

### [RoutingConfig \(p. 487\)](#)

Specifies an additional version your alias can point to, allowing you to dictate what percentage of traffic will invoke each version. For more information, see [Traffic Shifting Using Aliases \(p. 295\)](#).

Type: [AliasRoutingConfiguration \(p. 515\)](#) 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 \(p. 488\)](#)

Lambda function ARN that is qualified using the alias name as the suffix. For example, if you create an alias called BETA that points to a helloworld function version, the ARN is arn:aws:lambda:aws-regions:acct-id:function:helloworld:BETA.

Type: String

Pattern: arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-\_]+(:(\\$LATEST|[a-zA-Z0-9-\_]+))?

#### [Description \(p. 488\)](#)

Alias description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

#### [FunctionVersion \(p. 488\)](#)

Function version to which the alias points.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: (\\$LATEST|[0-9]+)

#### [Name \(p. 488\)](#)

Alias name.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: (?![0-9]+\$)([a-zA-Z0-9-\_]+)

#### [RevisionId \(p. 488\)](#)

Represents the latest updated revision of the function or alias.

Type: String

#### [RoutingConfig \(p. 488\)](#)

Specifies an additional function versions the alias points to, allowing you to dictate what percentage of traffic will invoke each version. For more information, see [Traffic Shifting Using Aliases \(p. 295\)](#).

Type: [AliasRoutingConfiguration \(p. 515\)](#) object

## Errors

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

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 (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## UpdateEventSourceMapping

You can update an event source mapping. This is useful if you want to change the parameters of the existing mapping without losing your position in the stream. You can change which function will receive the stream records, but to change the stream itself, you must create a new mapping.

If you are using the versioning feature, you can update the event source mapping to map to a specific Lambda function version or alias as described in the `FunctionName` parameter. For information about the versioning feature, see [AWS Lambda Function Versioning and Aliases](#).

If you disable the event source mapping, AWS Lambda stops polling. If you enable again, it will resume polling from the time it had stopped polling, so you don't lose processing of any records. However, if you delete event source mapping and create it again, it will reset.

This operation requires permission for the `lambda:UpdateEventSourceMapping` action.

### Request Syntax

```
PUT /2015-03-31/event-source-mappings/UUID HTTP/1.1
Content-type: application/json

{
    "BatchSize": number,
    "Enabled": boolean,
    "FunctionName": "string"
}
```

### URI Request Parameters

The request requires the following URI parameters.

#### **UUID** (p. 491)

The event source mapping identifier.

### Request Body

The request accepts the following data in JSON format.

#### **BatchSize** (p. 491)

The maximum number of stream records that can be sent to your Lambda function for a single invocation.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

Required: No

#### **Enabled** (p. 491)

Specifies whether AWS Lambda should actively poll the stream or not. If disabled, AWS Lambda will not poll the stream.

Type: Boolean

Required: No

### FunctionName (p. 491)

The Lambda function to which you want the stream records sent.

You can specify a function name (for example, `Thumbnail`) or you can specify Amazon Resource Name (ARN) of the function (for example, `arn:aws:lambda:us-west-2:account-id:function:Thumbnail`). AWS Lambda also allows you to specify a partial ARN (for example, `account-id:Thumbnail`). Note that the length constraint applies only to the ARN. If you specify only the function name, it is limited to 64 characters in length.

If you are using versioning, you can also provide a qualified function ARN (ARN that is qualified with function version or alias name as suffix). For more information about versioning, see [AWS Lambda Function Versioning and Aliases](#)

Note that the length constraint applies only to the ARN. If you specify only the function name, it is limited to 64 character in length.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: `(arn:aws:lambda:)?([a-z]{2}-[a-z]+-\d{1}:)?(\d{12}:)?(function:)?([a-zA-Z0-9-_+])(:(\$LATEST|[a-zA-Z0-9-_+]))?`

Required: No

## Response Syntax

```
HTTP/1.1 202
Content-type: application/json

{
    "BatchSize": number,
    "EventSourceArn": "string",
    "FunctionArn": "string",
    "LastModified": number,
    "LastProcessingResult": "string",
    "State": "string",
    "StateTransitionReason": "string",
    "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.

### BatchSize (p. 492)

The largest number of records that AWS Lambda will retrieve from your event source at the time of invoking your function. Your function receives an event with all the retrieved records.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

### EventSourceArn (p. 492)

The Amazon Resource Name (ARN) of the Amazon Kinesis stream that is the source of events.

Type: String

Pattern: arn:aws:([a-zA-Z0-9\-\-]+)([a-z]{2}-[a-z]+\-\d{1})?:(\d{12})?:(.\*)

**FunctionArn (p. 492)**

The Lambda function to invoke when AWS Lambda detects an event on the stream.

Type: String

Pattern: arn:aws:lambda:[a-z]{2}-[a-z]+\-\d{1}:\d{12}:function:[a-zA-Z0-9-\_]+(:(\\$LATEST|[a-zA-Z0-9-\_]+))?

**LastModified (p. 492)**

The UTC time string indicating the last time the event mapping was updated.

Type: Timestamp

**LastProcessingResult (p. 492)**

The result of the last AWS Lambda invocation of your Lambda function.

Type: String

**State (p. 492)**

The state of the event source mapping. It can be Creating, Enabled, Disabled, Enabling, Disabling, Updating, or Deleting.

Type: String

**StateTransitionReason (p. 492)**

The reason the event source mapping is in its current state. It is either user-requested or an AWS Lambda-initiated state transition.

Type: String

**UUID (p. 492)**

The AWS Lambda assigned opaque identifier for the mapping.

Type: String

## Errors

**InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the CreateFunction or the UpdateFunctionConfiguration API, that AWS Lambda is unable to assume you will get this exception.

HTTP Status Code: 400

**ResourceConflictException**

The resource already exists.

HTTP Status Code: 409

**ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## UpdateFunctionCode

Updates the code for the specified Lambda function. This operation must only be used on an existing Lambda function and cannot be used to update the function configuration.

If you are using the versioning feature, note this API will always update the \$LATEST version of your Lambda function. For information about the versioning feature, see [AWS Lambda Function Versioning and Aliases](#).

This operation requires permission for the `lambda:UpdateFunctionCode` action.

### Request Syntax

```
PUT /2015-03-31/functions/FunctionName/code HTTP/1.1
Content-type: application/json

{
  "DryRun": boolean,
  "Publish": boolean,
  "RevisionId": string,
  "S3Bucket": string,
  "S3Key": string,
  "S3ObjectVersion": string,
  "ZipFile": blob
}
```

### URI Request Parameters

The request requires the following URI parameters.

#### **FunctionName** (p. 495)

The existing Lambda function name whose code you want to replace.

You can specify a function name (for example, `Thumbnail`) or you can specify Amazon Resource Name (ARN) of the function (for example, `arn:aws:lambda:us-west-2:account-id:function:Thumbnail`). AWS Lambda also allows you to specify a partial ARN (for example, `account-id:Thumbnail`). Note that the length constraint applies only to the 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:lambda:`)?([a-z]{2}-[a-z]+-\d{1}):(?:(\d{12}):(?:function:)?)?([a-zA-Z0-9-\_]+)(:(?:\\$LATEST|[a-zA-Z0-9-\_]+))?

### Request Body

The request accepts the following data in JSON format.

#### **DryRun** (p. 495)

This boolean parameter can be used to test your request to AWS Lambda to update the Lambda function and publish a version as an atomic operation. It will do all necessary computation and validation of your code but will not upload it or publish a version. Each time this operation is invoked, the `CodeSha256` hash value of the provided code will also be computed and returned in the response.

Type: Boolean

Required: No

[Publish \(p. 495\)](#)

This boolean parameter can be used to request AWS Lambda to update the Lambda function and publish a version as an atomic operation.

Type: Boolean

Required: No

[RevisionId \(p. 495\)](#)

An optional value you can use to ensure you are updating the latest update of the function version or alias. If the `RevisionID` you pass doesn't match the latest `RevisionId` of the function or alias, it will fail with an error message, advising you to retrieve the latest function version or alias `RevisionID` using either [GetFunction \(p. 438\)](#) or [GetAlias \(p. 432\)](#).

Type: String

Required: No

[S3Bucket \(p. 495\)](#)

Amazon S3 bucket name where the .zip file containing your deployment package is stored. This bucket must reside in the same AWS Region where you are creating the Lambda function.

Type: String

Length Constraints: Minimum length of 3. Maximum length of 63.

Pattern: ^[0-9A-Za-z\.\-\\_]\*(\?<!\.\.)\$

Required: No

[S3Key \(p. 495\)](#)

The Amazon S3 object (the deployment package) key name you want to upload.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Required: No

[S3ObjectVersion \(p. 495\)](#)

The Amazon S3 object (the deployment package) version you want to upload.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Required: No

[ZipFile \(p. 495\)](#)

The contents of your zip file containing your deployment package. If you are using the web API directly, the contents of the zip file must be base64-encoded. If you are using the AWS SDKs or the AWS CLI, the SDKs or CLI will do the encoding for you. For more information about creating a .zip file, see [Execution Permissions](#).

Type: Base64-encoded binary data object

Required: No

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
    "CodeSha256": "string",
    "CodeSize": number,
    "DeadLetterConfig": {
        "TargetArn": "string"
    },
    "Description": "string",
    "Environment": {
        "Error": {
            "ErrorCode": "string",
            "Message": "string"
        },
        "Variables": {
            "string" : "string"
        }
    },
    "FunctionArn": "string",
    "FunctionName": "string",
    "Handler": "string",
    "KMSKeyArn": "string",
    "LastModified": "string",
    "MasterArn": "string",
    "MemorySize": number,
    "RevisionId": "string",
    "Role": "string",
    "Runtime": "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.

### **CodeSha256** (p. 497)

It is the SHA256 hash of your function deployment package.

Type: String

### **CodeSize** (p. 497)

The size, in bytes, of the function .zip file you uploaded.

Type: Long

### [DeadLetterConfig \(p. 497\)](#)

The parent object that contains the target ARN (Amazon Resource Name) of an Amazon SQS queue or Amazon SNS topic. For more information, see [Dead Letter Queues \(p. 385\)](#).

Type: [DeadLetterConfig \(p. 517\)](#) object

### [Description \(p. 497\)](#)

The user-provided description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

### [Environment \(p. 497\)](#)

The parent object that contains your environment's configuration settings.

Type: [EnvironmentResponse \(p. 520\)](#) object

### [FunctionArn \(p. 497\)](#)

The Amazon Resource Name (ARN) assigned to the function.

Type: String

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_\.]+(:($LATEST|[a-zA-Z0-9-_]+))?`

### [FunctionName \(p. 497\)](#)

The name of the function. Note that the length constraint applies only to the 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 170.

Pattern: `(arn:aws:lambda:)?([a-z]{2}-[a-z]+\d{1}:(\d{12}):)?(function:)?([a-zA-Z0-9-_\.]+(:($LATEST|[a-zA-Z0-9-_]+))?)`

### [Handler \(p. 497\)](#)

The function Lambda calls to begin executing your function.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

### [KMSKeyArn \(p. 497\)](#)

The Amazon Resource Name (ARN) of the KMS key used to encrypt your function's environment variables. If empty, it means you are using the AWS Lambda default service key.

Type: String

Pattern: `(arn:aws:[a-z0-9-.]+:.*|()`

### [LastModified \(p. 497\)](#)

The time stamp of the last time you updated the function. The time stamp is conveyed as a string complying with ISO-8601 in this way YYYY-MM-DDThh:mm:ssTZD (e.g., 1997-07-16T19:20:30+01:00). For more information, see [Date and Time Formats](#).

Type: String

#### [MasterArn \(p. 497\)](#)

Returns the ARN (Amazon Resource Name) of the master function.

Type: String

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$\$LATEST|[a-zA-Z0-9-_]+))?`

#### [MemorySize \(p. 497\)](#)

The memory size, in MB, you configured for the function. Must be a multiple of 64 MB.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 3008.

#### [RevisionId \(p. 497\)](#)

Represents the latest updated revision of the function or alias.

Type: String

#### [Role \(p. 497\)](#)

The Amazon Resource Name (ARN) of the IAM role that Lambda assumes when it executes your function to access any other Amazon Web Services (AWS) resources.

Type: String

Pattern: `arn:aws:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@/-/_]+`

#### [Runtime \(p. 497\)](#)

The runtime environment for the Lambda function.

Type: String

Valid Values: nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | java8 | python2.7 | python3.6 | dotnetcore1.0 | dotnetcore2.0 | go1.x

#### [Timeout \(p. 497\)](#)

The function execution time at which Lambda should terminate the function. Because the execution time has cost implications, we recommend you set this value based on your expected execution time. The default is 3 seconds.

Type: Integer

Valid Range: Minimum value of 1.

#### [TracingConfig \(p. 497\)](#)

The parent object that contains your function's tracing settings.

Type: [TracingConfigResponse \(p. 530\)](#) object

#### [Version \(p. 497\)](#)

The version of the Lambda function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$\$LATEST|[0-9]+)`

## [VpcConfig \(p. 497\)](#)

VPC configuration associated with your Lambda function.

Type: [VpcConfigResponse \(p. 532\)](#) object

## Errors

### **CodeStorageExceededException**

You have exceeded your maximum total code size per account. [Limits](#)

HTTP Status Code: 400

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

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 (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)

- [AWS SDK for Ruby V2](#)

# UpdateFunctionConfiguration

Updates the configuration parameters for the specified Lambda function by using the values provided in the request. You provide only the parameters you want to change. This operation must only be used on an existing Lambda function and cannot be used to update the function's code.

If you are using the versioning feature, note this API will always update the \$LATEST version of your Lambda function. For information about the versioning feature, see [AWS Lambda Function Versioning and Aliases](#).

This operation requires permission for the `lambda:UpdateFunctionConfiguration` action.

## 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"
        }
    },
    "Handler": "string",
    "KMSKeyArn": "string",
    "MemorySize": number,
    "RevisionId": "string",
    "Role": "string",
    "Runtime": "string",
    "Timeout": number,
    "TracingConfig": {
        "Mode": "string"
    },
    "VpcConfig": {
        "SecurityGroupIds": [ "string" ],
        "SubnetIds": [ "string" ]
    }
}
```

## URI Request Parameters

The request requires the following URI parameters.

### FunctionName ([p. 502](#))

The name of the Lambda function.

You can specify a function name (for example, `Thumbnail1`) or you can specify Amazon Resource Name (ARN) of the function (for example, `arn:aws:lambda:us-west-2:account-id:function:Thumbnail1`). AWS Lambda also allows you to specify a partial ARN (for example, `account-id:Thumbnail`). Note that the length constraint applies only to the ARN. If you specify only the function name, it is limited to 64 character in length.

Length Constraints: Minimum length of 1. Maximum length of 140.

Pattern: (`arn:aws:lambda:`)?([*a-z*]{2}-[*a-z*]+\-\d{1}:)?(\d{12}:)?(function:)?( [*a-zA-Z0-9-\_*]+)(:(\\$\text{LATEST}|[*a-zA-Z0-9-\_*+]))?

## Request Body

The request accepts the following data in JSON format.

### [DeadLetterConfig \(p. 502\)](#)

The parent object that contains the target ARN (Amazon Resource Name) of an Amazon SQS queue or Amazon SNS topic. For more information, see [Dead Letter Queues \(p. 385\)](#).

Type: [DeadLetterConfig \(p. 517\)](#) object

Required: No

### [Description \(p. 502\)](#)

A short user-defined function description. AWS Lambda does not use this value. Assign a meaningful description as you see fit.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

### [Environment \(p. 502\)](#)

The parent object that contains your environment's configuration settings.

Type: [Environment \(p. 518\)](#) object

Required: No

### [Handler \(p. 502\)](#)

The function that Lambda calls to begin executing your function. For Node.js, it is the `module-name.export` value in your function.

Type: String

Length Constraints: Maximum length of 128.

Pattern: [ ^\s ]+

Required: No

### [KMSKeyArn \(p. 502\)](#)

The Amazon Resource Name (ARN) of the KMS key used to encrypt your function's environment variables. If you elect to use the AWS Lambda default service key, pass in an empty string ("") for this parameter.

Type: String

Pattern: (arn:aws:[a-z0-9-.]+:[.\*])|()

Required: No

### [MemorySize \(p. 502\)](#)

The amount of memory, in MB, your Lambda function is given. AWS Lambda uses this memory size to infer the amount of CPU allocated to your function. Your function use-case determines your CPU and memory requirements. For example, a database operation might need less memory compared to an image processing function. The default value is 128 MB. The value must be a multiple of 64 MB.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 3008.

Required: No

#### [RevisionId \(p. 502\)](#)

An optional value you can use to ensure you are updating the latest update of the function version or alias. If the RevisionID you pass doesn't match the latest RevisionId of the function or alias, it will fail with an error message, advising you to retrieve the latest function version or alias RevisionID using either [GetFunction \(p. 438\)](#) or [GetAlias \(p. 432\)](#).

Type: String

Required: No

#### [Role \(p. 502\)](#)

The Amazon Resource Name (ARN) of the IAM role that Lambda will assume when it executes your function.

Type: String

Pattern: `arn:aws:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@\-_/_]+`

Required: No

#### [Runtime \(p. 502\)](#)

The runtime environment for the Lambda function.

To use the Python runtime v3.6, set the value to "python3.6". To use the Python runtime v2.7, set the value to "python2.7". To use the Node.js runtime v8.10, set the value to "nodejs8.10". To use the Node.js runtime v6.10, set the value to "nodejs6.10". To use the Node.js runtime v4.3, set the value to "nodejs4.3". To use the .NET Core runtime v1.0, set the value to "dotnetcore1.0". To use the .NET Core runtime v2.0, set the value to "dotnetcore2.0".

##### **Note**

Node v0.10.42 is currently marked as deprecated. You must migrate existing functions to the newer Node.js runtime versions available on AWS Lambda (nodejs4.3, nodejs6.10 or nodejs8.10) as soon as possible. Failure to do so will result in an invalid parameter error being returned. Note that you will have to follow this procedure for each region that contains functions written in the Node v0.10.42 runtime.

Type: String

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | java8 | python2.7 | python3.6 | dotnetcore1.0 | dotnetcore2.0 | go1.x`

Required: No

#### [Timeout \(p. 502\)](#)

The function execution time at which AWS Lambda should terminate the function. Because the execution time has cost implications, we recommend you set this value based on your expected execution time. The default is 3 seconds.

Type: Integer

Valid Range: Minimum value of 1.

Required: No

#### [TracingConfig \(p. 502\)](#)

The parent object that contains your function's tracing settings.

Type: [TracingConfig \(p. 529\)](#) object

Required: No

#### [VpcConfig \(p. 502\)](#)

If your Lambda function accesses resources in a VPC, you provide this parameter identifying the list of security group IDs and subnet IDs. These must belong to the same VPC. You must provide at least one security group and one subnet ID.

Type: [VpcConfig \(p. 531\)](#) object

Required: No

## Response Syntax

```
HTTP/1.1 200
Content-type: application/json

{
    "CodeSha256": "string",
    "CodeSize": number,
    "DeadLetterConfig": {
        "TargetArn": "string"
    },
    "Description": "string",
    "Environment": {
        "Error": {
            "ErrorCode": "string",
            "Message": "string"
        },
        "Variables": {
            "string" : "string"
        }
    },
    "FunctionArn": "string",
    "FunctionName": "string",
    "Handler": "string",
    "KMSKeyArn": "string",
    "LastModified": "string",
    "MasterArn": "string",
    "MemorySize": number,
    "RevisionId": "string",
    "Role": "string",
    "Runtime": "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.

### [CodeSha256 \(p. 505\)](#)

It is the SHA256 hash of your function deployment package.

Type: String

### [CodeSize \(p. 505\)](#)

The size, in bytes, of the function .zip file you uploaded.

Type: Long

### [DeadLetterConfig \(p. 505\)](#)

The parent object that contains the target ARN (Amazon Resource Name) of an Amazon SQS queue or Amazon SNS topic. For more information, see [Dead Letter Queues \(p. 385\)](#).

Type: [DeadLetterConfig \(p. 517\)](#) object

### [Description \(p. 505\)](#)

The user-provided description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

### [Environment \(p. 505\)](#)

The parent object that contains your environment's configuration settings.

Type: [EnvironmentResponse \(p. 520\)](#) object

### [FunctionArn \(p. 505\)](#)

The Amazon Resource Name (ARN) assigned to the function.

Type: String

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_\.]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

### [FunctionName \(p. 505\)](#)

The name of the function. Note that the length constraint applies only to the 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 170.

Pattern: `(arn:aws:lambda:)?([a-z]{2}-[a-z]+\d{1}:)?(d{12}):(function:)?([a-zA-Z0-9-_\.]+)(:(\$LATEST|[a-zA-Z0-9-_]+))?`

### [Handler \(p. 505\)](#)

The function Lambda calls to begin executing your function.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

### [KMSKeyArn \(p. 505\)](#)

The Amazon Resource Name (ARN) of the KMS key used to encrypt your function's environment variables. If empty, it means you are using the AWS Lambda default service key.

Type: String

Pattern: `(arn:aws:[a-z0-9-.]+:\.*|()|`

#### [LastModified \(p. 505\)](#)

The time stamp of the last time you updated the function. The time stamp is conveyed as a string complying with ISO-8601 in this way YYYY-MM-DDThh:mm:ssTZD (e.g., 1997-07-16T19:20:30+01:00). For more information, see [Date and Time Formats](#).

Type: String

#### [MasterArn \(p. 505\)](#)

Returns the ARN (Amazon Resource Name) of the master function.

Type: String

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

#### [MemorySize \(p. 505\)](#)

The memory size, in MB, you configured for the function. Must be a multiple of 64 MB.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 3008.

#### [RevisionId \(p. 505\)](#)

Represents the latest updated revision of the function or alias.

Type: String

#### [Role \(p. 505\)](#)

The Amazon Resource Name (ARN) of the IAM role that Lambda assumes when it executes your function to access any other Amazon Web Services (AWS) resources.

Type: String

Pattern: `arn:aws:iam::\d{12}:role/?[a-zA-Z_0-9+=,.@\-/]+`

#### [Runtime \(p. 505\)](#)

The runtime environment for the Lambda function.

Type: String

Valid Values: `nodejs | nodejs4.3 | nodejs6.10 | nodejs8.10 | java8 | python2.7 | python3.6 | dotnetcore1.0 | dotnetcore2.0 | go1.x`

#### [Timeout \(p. 505\)](#)

The function execution time at which Lambda should terminate the function. Because the execution time has cost implications, we recommend you set this value based on your expected execution time. The default is 3 seconds.

Type: Integer

Valid Range: Minimum value of 1.

#### [TracingConfig \(p. 505\)](#)

The parent object that contains your function's tracing settings.

Type: [TracingConfigResponse \(p. 530\)](#) object

#### [Version \(p. 505\)](#)

The version of the Lambda function.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: (`\$LATEST` | [0-9]+)

#### [VpcConfig \(p. 505\)](#)

VPC configuration associated with your Lambda function.

Type: [VpcConfigResponse \(p. 532\)](#) object

## Errors

### **InvalidParameterValueException**

One of the parameters in the request is invalid. For example, if you provided an IAM role for AWS Lambda to assume in the `CreateFunction` or the `UpdateFunctionConfiguration` API, that AWS Lambda is unable to assume you will get this exception.

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.

HTTP Status Code: 409

### **ResourceNotFoundException**

The resource (for example, a Lambda function or access policy statement) 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**

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](#)
- [AWS SDK for JavaScript](#)
- [AWS SDK for PHP V3](#)
- [AWS SDK for Python](#)
- [AWS SDK for Ruby V2](#)

## Data Types

The following data types are supported:

- [AccountLimit \(p. 510\)](#)
- [AccountUsage \(p. 512\)](#)
- [AliasConfiguration \(p. 513\)](#)
- [AliasRoutingConfiguration \(p. 515\)](#)
- [Concurrency \(p. 516\)](#)
- [DeadLetterConfig \(p. 517\)](#)
- [Environment \(p. 518\)](#)
- [EnvironmentError \(p. 519\)](#)
- [EnvironmentResponse \(p. 520\)](#)
- [EventSourceMappingConfiguration \(p. 521\)](#)
- [FunctionCode \(p. 523\)](#)
- [FunctionCodeLocation \(p. 524\)](#)
- [FunctionConfiguration \(p. 525\)](#)
- [TracingConfig \(p. 529\)](#)
- [TracingConfigResponse \(p. 530\)](#)
- [VpcConfig \(p. 531\)](#)
- [VpcConfigResponse \(p. 532\)](#)

## AccountLimit

Provides limits of code size and concurrency associated with the current account and region.

### Contents

#### **CodeSizeUnzipped**

Size, in bytes, of code/dependencies that you can zip into a deployment package (uncompressed zip/jar size) for uploading. The default limit is 250 MB.

Type: Long

Required: No

#### **CodeSizeZipped**

Size, in bytes, of a single zipped code/dependencies package you can upload for your Lambda function(.zip/.jar file). Try using Amazon S3 for uploading larger files. Default limit is 50 MB.

Type: Long

Required: No

#### **ConcurrentExecutions**

Number of simultaneous executions of your function per region. For more information or to request a limit increase for concurrent executions, see [Lambda Function Concurrent Executions](#). The default limit is 1000.

Type: Integer

Required: No

#### **TotalCodeSize**

Maximum size, in bytes, of a code package you can upload per region. The default size is 75 GB.

Type: Long

Required: No

#### **UnreservedConcurrentExecutions**

The number of concurrent executions available to functions that do not have concurrency limits set. For more information, see [Managing Concurrency \(p. 373\)](#).

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](#)

- [AWS SDK for Ruby V2](#)

## AccountUsage

Provides code size usage and function count associated with the current account and region.

### Contents

#### FunctionCount

The number of your account's existing functions per region.

Type: Long

Required: No

#### TotalCodeSize

Total size, in bytes, of the account's deployment packages per region.

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](#)
- [AWS SDK for Ruby V2](#)

# AliasConfiguration

Provides configuration information about a Lambda function version alias.

## Contents

### AliasArn

Lambda function ARN that is qualified using the alias name as the suffix. For example, if you create an alias called `BETA` that points to a `helloworld` function version, the ARN is `arn:aws:lambda:aws-regions:acct-id:function:helloworld:BETA`.

Type: String

Pattern: `arn:aws:lambda:[a-z]{2}-[a-z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:(\$LATEST|[a-zA-Z0-9-_]+))?`

Required: No

### Description

Alias description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

### FunctionVersion

Function version to which the alias points.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Pattern: `(\$LATEST|[0-9]+)`

Required: No

### Name

Alias name.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 128.

Pattern: `(?!^[\0-9]+$)([a-zA-Z0-9-_]+)`

Required: No

### RevisionId

Represents the latest updated revision of the function or alias.

Type: String

Required: No

### RoutingConfig

Specifies an additional function versions the alias points to, allowing you to dictate what percentage of traffic will invoke each version. For more information, see [Traffic Shifting Using Aliases \(p. 295\)](#).

Type: [AliasRoutingConfiguration \(p. 515\)](#) 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](#)
- [AWS SDK for Ruby V2](#)

# AliasRoutingConfiguration

The parent object that implements what percentage of traffic will invoke each function version. For more information, see [Traffic Shifting Using Aliases \(p. 295\)](#).

## Contents

### AdditionalVersionWeights

Set this value to dictate what percentage of traffic will invoke the updated function version. If set to an empty string, 100 percent of traffic will invoke `function-version`. For more information, see [Traffic Shifting Using Aliases \(p. 295\)](#).

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](#)
- [AWS SDK for Ruby V2](#)

# Concurrency

## Contents

### ReservedConcurrentExecutions

The number of concurrent executions reserved for this function. For more information, see [Managing Concurrency \(p. 373\)](#).

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](#)
- [AWS SDK for Ruby V2](#)

## DeadLetterConfig

The Amazon Resource Name (ARN) of an Amazon SQS queue or Amazon SNS topic you specify as your Dead Letter Queue (DLQ). For more information, see [Dead Letter Queues \(p. 385\)](#).

### Contents

#### TargetArn

The Amazon Resource Name (ARN) of an Amazon SQS queue or Amazon SNS topic you specify as your Dead Letter Queue (DLQ). [Dead Letter Queues \(p. 385\)](#). For more information, see [Dead Letter Queues \(p. 385\)](#).

Type: String

Pattern: `(arn:aws:[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](#)
- [AWS SDK for Ruby V2](#)

## Environment

The parent object that contains your environment's configuration settings.

### Contents

#### Variables

The key-value pairs that represent your environment's configuration settings.

Type: String to string map

Key Pattern: [a-zA-Z]([a-zA-Z0-9\_])<sup>+</sup>

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](#)
- [AWS SDK for Ruby V2](#)

## EnvironmentError

The parent object that contains error information associated with your configuration settings.

### Contents

#### **ErrorCode**

The error code returned by the environment error object.

Type: String

Required: No

#### **Message**

The message returned by the environment error object.

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](#)
- [AWS SDK for Ruby V2](#)

## EnvironmentResponse

The parent object returned that contains your environment's configuration settings or any error information associated with your configuration settings.

### Contents

#### Error

The parent object that contains error information associated with your configuration settings.

Type: [EnvironmentError \(p. 519\)](#) object

Required: No

#### Variables

The key-value pairs returned that represent your environment's configuration settings or error information.

Type: String to string map

Key Pattern: [a-zA-Z]([a-zA-Z0-9\_])<sup>+</sup>

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](#)
- [AWS SDK for Ruby V2](#)

# EventSourceMappingConfiguration

Describes mapping between an Amazon Kinesis stream and a Lambda function.

## Contents

### BatchSize

The largest number of records that AWS Lambda will retrieve from your event source at the time of invoking your function. Your function receives an event with all the retrieved records.

Type: Integer

Valid Range: Minimum value of 1. Maximum value of 10000.

Required: No

### EventSourceArn

The Amazon Resource Name (ARN) of the Amazon Kinesis stream that is the source of events.

Type: String

Pattern: arn:aws:([a-zA-Z0-9\-])+:(a-z){2}-[a-z]+\-\d{1})?:(\d{12})?:(.\* )

Required: No

### FunctionArn

The Lambda function to invoke when AWS Lambda detects an event on the stream.

Type: String

Pattern: arn:aws:lambda:[a-z]{2}-[a-z]+\-\d{1}:\d{12}:function:[a-zA-Z0-9-\_]+(: (\\$LATEST|[a-zA-Z0-9-\_]+))?

Required: No

### LastModified

The UTC time string indicating the last time the event mapping was updated.

Type: Timestamp

Required: No

### LastProcessingResult

The result of the last AWS Lambda invocation of your Lambda function.

Type: String

Required: No

### State

The state of the event source mapping. It can be `Creating`, `Enabled`, `Disabled`, `Enabling`, `Disabling`, `Updating`, or `Deleting`.

Type: String

Required: No

### **StateTransitionReason**

The reason the event source mapping is in its current state. It is either user-requested or an AWS Lambda-initiated state transition.

Type: String

Required: No

### **UUID**

The AWS Lambda assigned opaque identifier for the 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](#)
- [AWS SDK for Ruby V2](#)

## FunctionCode

The code for the Lambda function.

### Contents

#### S3Bucket

Amazon S3 bucket name where the .zip file containing your deployment package is stored. This bucket must reside in the same AWS region where you are creating the Lambda function.

Type: String

Length Constraints: Minimum length of 3. Maximum length of 63.

Pattern: ^[0-9A-Za-z\.\-\\_]\*(\?!\.)\$

Required: No

#### S3Key

The Amazon S3 object (the deployment package) key name you want to upload.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Required: No

#### S3ObjectVersion

The Amazon S3 object (the deployment package) version you want to upload.

Type: String

Length Constraints: Minimum length of 1. Maximum length of 1024.

Required: No

#### ZipFile

The contents of your zip file containing your deployment package. If you are using the web API directly, the contents of the zip file must be base64-encoded. If you are using the AWS SDKs or the AWS CLI, the SDKs or CLI will do the encoding for you. For more information about creating a .zip file, see [Execution Permissions](#) in the [AWS Lambda Developer Guide](#).

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](#)
- [AWS SDK for Ruby V2](#)

## FunctionCodeLocation

The object for the Lambda function location.

### Contents

#### Location

The presigned URL you can use to download the function's .zip file that you previously uploaded. The URL is valid for up to 10 minutes.

Type: String

Required: No

#### RepositoryType

The repository from which you can download the function.

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](#)
- [AWS SDK for Ruby V2](#)

# FunctionConfiguration

A complex type that describes function metadata.

## Contents

### **CodeSha256**

It is the SHA256 hash of your function deployment package.

Type: String

Required: No

### **CodeSize**

The size, in bytes, of the function .zip file you uploaded.

Type: Long

Required: No

### **DeadLetterConfig**

The parent object that contains the target ARN (Amazon Resource Name) of an Amazon SQS queue or Amazon SNS topic. For more information, see [Dead Letter Queues \(p. 385\)](#).

Type: [DeadLetterConfig \(p. 517\)](#) object

Required: No

### **Description**

The user-provided description.

Type: String

Length Constraints: Minimum length of 0. Maximum length of 256.

Required: No

### **Environment**

The parent object that contains your environment's configuration settings.

Type: [EnvironmentResponse \(p. 520\)](#) object

Required: No

### **FunctionArn**

The Amazon Resource Name (ARN) assigned to the function.

Type: String

Pattern: `arn:aws:lambda:[a-zA-Z]{2}-[a-zA-Z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_]+\.(?:$LATEST|[a-zA-Z0-9-_]+)`

Required: No

### **FunctionName**

The name of the function. Note that the length constraint applies only to the 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 170.

Pattern: `(arn:aws:lambda:[a-zA-Z]{2}-[a-zA-Z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_\.]+)(:$LATEST|[a-zA-Z0-9-_]+)`?

Required: No

#### **Handler**

The function Lambda calls to begin executing your function.

Type: String

Length Constraints: Maximum length of 128.

Pattern: `[^\s]+`

Required: No

#### **KMSKeyArn**

The Amazon Resource Name (ARN) of the KMS key used to encrypt your function's environment variables. If empty, it means you are using the AWS Lambda default service key.

Type: String

Pattern: `(arn:aws:[a-zA-Z0-9-_\.]+:\.*|())`

Required: No

#### **LastModified**

The time stamp of the last time you updated the function. The time stamp is conveyed as a string complying with ISO-8601 in this way YYYY-MM-DDThh:mm:ssTZD (e.g., 1997-07-16T19:20:30+01:00). For more information, see [Date and Time Formats](#).

Type: String

Required: No

#### **MasterArn**

Returns the ARN (Amazon Resource Name) of the master function.

Type: String

Pattern: `arn:aws:lambda:[a-zA-Z]{2}-[a-zA-Z]+\d{1}:\d{12}:function:[a-zA-Z0-9-_]+(:|$LATEST|[a-zA-Z0-9-_]+)?`

Required: No

#### **MemorySize**

The memory size, in MB, you configured for the function. Must be a multiple of 64 MB.

Type: Integer

Valid Range: Minimum value of 128. Maximum value of 3008.

Required: No

#### **RevisionId**

Represents the latest updated revision of the function or alias.

Type: String

Required: No

**Role**

The Amazon Resource Name (ARN) of the IAM role that Lambda assumes when it executes your function to access any other Amazon Web Services (AWS) resources.

Type: String

Pattern: `arn:aws: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` | `java8` | `python2.7` | `python3.6` | `dotnetcore1.0` | `dotnetcore2.0` | `go1.x`

Required: No

**Timeout**

The function execution time at which Lambda should terminate the function. Because the execution time has cost implications, we recommend you set this value based on your expected execution time. The default is 3 seconds.

Type: Integer

Valid Range: Minimum value of 1.

Required: No

**TracingConfig**

The parent object that contains your function's tracing settings.

Type: [TracingConfigResponse \(p. 530\)](#) 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**

VPC configuration associated with your Lambda function.

Type: [VpcConfigResponse \(p. 532\)](#) 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](#)
- [AWS SDK for Ruby V2](#)

# TracingConfig

The parent object that contains your function's tracing settings.

## Contents

### Mode

Can be either PassThrough or Active. If PassThrough, Lambda will only trace the request from an upstream service if it contains a tracing header with "sampled=1". If Active, Lambda will respect any tracing header it receives from an upstream service. If no tracing header is received, Lambda will call X-Ray for a tracing decision.

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](#)
- [AWS SDK for Ruby V2](#)

# TracingConfigResponse

Parent object of the tracing information associated with your Lambda function.

## Contents

### Mode

The tracing mode associated with your Lambda function.

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](#)
- [AWS SDK for Ruby V2](#)

## VpcConfig

If your Lambda function accesses resources in a VPC, you provide this parameter identifying the list of security group IDs and subnet IDs. These must belong to the same VPC. You must provide at least one security group and one subnet ID.

### Contents

#### SecurityGroupIds

A list of one or more security groups IDs in your VPC.

Type: Array of strings

Array Members: Maximum number of 5 items.

Required: No

#### SubnetIds

A list of one or more subnet IDs in your VPC.

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](#)
- [AWS SDK for Ruby V2](#)

# VpcConfigResponse

VPC configuration associated with your Lambda function.

## Contents

### SecurityGroupIds

A list of security group IDs associated with the Lambda function.

Type: Array of strings

Array Members: Maximum number of 5 items.

Required: No

### SubnetIds

A list of subnet IDs associated with the Lambda function.

Type: Array of strings

Array Members: Maximum number of 16 items.

Required: No

### VpcId

The VPC ID associated with you Lambda function.

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](#)
- [AWS SDK for Ruby V2](#)

# Document History

The following table describes the important changes to the *AWS Lambda Developer Guide*.

## Relevant Dates to this History:

- **Current product version:** 2015-03-31
- **Last documentation update:** April 2, 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 <a href="#">Programming Model(Node.js) (p. 19)</a> .	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 <a href="#">Programming Model for Authoring Lambda Functions in Go (p. 58)</a> and <a href="#">Programming Model for Authoring Lambda Functions in C# (p. 67)</a> .	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 <a href="#">Creating Functions Using the AWS Lambda Console Editor (p. 106)</a> .	November 30, 2017
Setting Concurrency Limits on Individual Functions	AWS Lambda now supports setting concurrency limits on individual functions. For more information, see <a href="#">Managing Concurrency (p. 373)</a> .	November 30, 2017
Shifting Traffic with Aliases	AWS Lambda now supports shifting traffic with aliases. For more information, see <a href="#">Traffic Shifting Using Aliases (p. 295)</a> .	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 <a href="#">Gradual Code Deployment (p. 311)</a> .	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 <a href="#">Regions and Endpoints</a> in the <i>AWS General Reference</i> .	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 <a href="#">Test Your Serverless Applications Locally Using SAM CLI (Public Beta) (p. 99)</a> .	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 <a href="#">Regions and Endpoints</a> in the <i>AWS General Reference</i> .	June 22, 2017

Change	Description	Date
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 <a href="#">Regions and Endpoints</a> in the <i>AWS General Reference</i> .	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 <a href="#">Using AWS X-Ray (p. 322)</a> .	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 <a href="#">Regions and Endpoints</a> in the <i>AWS General Reference</i> .	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 <a href="#">Programming Model(Node.js) (p. 19)</a> .	March 22, 2017
EU (London) Region	AWS Lambda is now available in the EU (London) Region. For more information about Lambda regions and endpoints, see <a href="#">Regions and Endpoints</a> in the <i>AWS General Reference</i> .	February 1, 2017
AWS Lambda support for the .NET runtime, Lambda@Edge (Preview), Dead Letter Queues and automated deployment of serverless applications.	<p>AWS Lambda introduces the following features:</p> <ul style="list-style-type: none"> <li>• AWS Lambda added support for C#. For more information, see <a href="#">Programming Model for Authoring Lambda Functions in C# (p. 67)</a>.</li> <li>• Lambda@Edge (Preview) allows you to run Lambda functions at the AWS Edge locations in response to CloudFront events. For more information, see <a href="#">Lambda@Edge (p. 275)</a>.</li> <li>• Added a tutorial for automating deployment of serverless applications using AWS CodePipeline, AWS CodeBuild and AWS CloudFormation. For more information, see <a href="#">Automating Deployment of Lambda-based Applications (p. 306)</a>.</li> <li>• Updated <a href="#">Using Amazon CloudWatch (p. 314)</a> to include a section on <a href="#">Dead Letter Queues (p. 385)</a>, which you can configure to retrieve information on failed asynchronous invocations of Lambda functions.</li> </ul>	December 3, 2016
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 <a href="#">Amazon Lex (p. 160)</a> .	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 <a href="#">Regions and Endpoints</a> in the <i>AWS General Reference</i> .	November 21, 2016

Change	Description	Date
Introduced the AWS Serverless Application Model for creating and deploying Lambda-based applications and using environment variables for Lambda function configuration settings.	<p>AWS Lambda introduces the following features in this release.</p> <ul style="list-style-type: none"> <li>• <b>AWS Serverless Application Model:</b> 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 <a href="#">Deploying Lambda-based Applications (p. 277)</a>.</li> <li>• <b>Environment variables:</b> You can use environment variables to specify configuration settings for your Lambda function outside of your function code. For more information, see <a href="#">Environment Variables (p. 377)</a>.</li> </ul>	November 18, 2016
Added a tutorial under <a href="#">Getting Started (p. 3)</a> for creating an Amazon API Gateway endpoint using the Lambda console	The tutorial instructs how to seamlessly integrate a Lambda function with an API via new features introduced in <a href="#">Configure Proxy Integration for a Proxy Resource</a> . For more information, see <a href="#">Create a Simple Microservice using Lambda and API Gateway (p. 248)</a> .	August 29, 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 <a href="#">Regions and Endpoints</a> in the <a href="#">AWS General Reference</a> .	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 <a href="#">Regions and Endpoints</a> in the <a href="#">AWS General Reference</a> .	June 23, 2016
Updates to the Lambda console	The Lambda console has been updated to simplify the role-creation process. For more information, see <a href="#">Create a Simple Lambda Function (p. 9)</a> .	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 <a href="#">Programming Model(Node.js) (p. 19)</a> .	April 07, 2016
EU (Frankfurt) region	Lambda is now available in the EU (Frankfurt) region. For more information about Lambda regions and endpoints, see <a href="#">Regions and Endpoints</a> in the <a href="#">AWS General Reference</a> .	March 14, 2016
VPC support	You can now configure a Lambda function to access resources in your VPC. For more information, see <a href="#">Configuring a Lambda Function to Access Resources in an Amazon VPC (p. 133)</a> . For example walkthroughs, see <a href="#">Tutorials: Configuring a Lambda Function to Access Resources in an Amazon VPC (p. 135)</a> .	February 11, 2016

Change	Description	Date
Content reorganization	<p>The reorganized content now provides the following:</p> <ul style="list-style-type: none"> <li>• <a href="#">Getting Started (p. 3)</a> – Contains a console-based exercise in which you create a Hello World Lambda function. You explore the AWS Lambda console features, including blueprints that enable you to create Lambda functions with just a few clicks.</li> <li>• <a href="#">Use Cases (p. 173)</a> – Provides examples of how to use AWS Lambda with other AWS services or your custom applications as event sources, invoke over HTTPS, and set up AWS Lambda to invoke your Lambda function at scheduled interval.</li> <li>• <a href="#">Programming Model (p. 18)</a> – Explains programming model core concepts and describes language-specific details. Regardless of the language you choose, there is a common pattern to writing code for a Lambda function.</li> <li>• <a href="#">Creating a Deployment Package (p. 77)</a> – Explains how to create deployment packages for Lambda function code that is authored in languages supported by AWS Lambda (Python, Java, and Node.js).</li> </ul>	December 9, 2015
AWS Lambda runtime has been updated.	<p>AWS Lambda runtime has been updated with the following SDK and Linux kernel versions in this release:</p> <ul style="list-style-type: none"> <li>• AWS SDK for JavaScript: 2.2.12</li> <li>• Boto SDK: 1.2.1</li> <li>• Linux kernel version: 4.9.62-21.56.amzn1.x86_64</li> </ul> <p>For more information, see <a href="#">Lambda Execution Environment and Available Libraries (p. 391)</a>.</p>	November 4, 2015
Versioning support, Python for developing code for Lambda functions, scheduled events, and increase in execution time	<p>AWS Lambda introduces the following features in this release.</p> <ul style="list-style-type: none"> <li>• Python: You can now develop your Lambda function code using Python. For more information, see <a href="#">Programming Model (p. 18)</a>.</li> <li>• 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 <a href="#">AWS Lambda Function Versioning and Aliases (p. 277)</a>.</li> <li>• Scheduled events: You can also set up AWS Lambda to invoke your code on a regular, scheduled basis using the AWS 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 <a href="#">Using AWS Lambda with Scheduled Events (p. 262)</a>.</li> <li>• 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.</li> </ul>	October 08, 2015

Change	Description	Date
Two new walkthroughs	<p>The following new walkthroughs are added. They both use Java Lambda function.</p> <p><a href="#">Tutorial: Using AWS Lambda with Amazon DynamoDB (p. 202)</a></p> <p><a href="#">Using AWS Lambda as Mobile Application Backend (Custom Event Source: Android) (p. 249)</a></p>	August 27, 2015
Support for DynamoDB Streams	<p>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 <a href="#">Tutorial: Using AWS Lambda with Amazon DynamoDB (p. 202)</a>.</p>	July 14, 2015
AWS Lambda now supports invoking Lambda functions with REST-compatible clients.	<p>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, AWS 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.</p> <p>For an example Getting Started exercise, see <a href="#">Using AWS Lambda with Amazon API Gateway (On-Demand Over HTTPS) (p. 234)</a>.</p> <p>For more information about the Amazon API Gateway, see <a href="https://aws.amazon.com/api-gateway/">https://aws.amazon.com/api-gateway/</a>.</p>	July 09, 2015
The AWS Lambda console now provides blueprints to easily create Lambda functions and test them.	<p>AWS Lambda console provides a set of <i>blueprints</i>. 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 AWS Lambda Getting Started exercises now use the blueprints. For more information, see <a href="#">Getting Started (p. 3)</a>.</p>	In this release
AWS Lambda now supports Java to author your Lambda functions.	<p>You can now author Lambda code in Java. For more information, see <a href="#">Programming Model (p. 18)</a>.</p>	June 15, 2015
AWS Lambda now supports specifying an Amazon S3 object as the function .zip when creating or updating a Lambda function.	<p>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.</p>	May 28, 2015

Change	Description	Date
AWS Lambda now generally available with added support for mobile backends	<p>AWS 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 AWS Lambda that scale automatically without provisioning or managing infrastructure. AWS 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.</p> <p>The documentation has been updated accordingly. For information, see the following topics:</p> <p><a href="#">Getting Started (p. 3)</a></p> <p><a href="#">AWS Lambda</a></p>	April 9, 2015
Preview release	Preview release of the <i>AWS Lambda Developer Guide</i> .	November 13, 2014

# AWS Glossary

For the latest AWS terminology, see the [AWS Glossary](#) in the *AWS General Reference*.