
CloudFormation Command Line Interface User Guide for Extension Development

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CloudFormation Command Line Interface: User Guide for Extension Development

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What is the CloudFormation Command Line Interface (CFN-CLI)?

The *CloudFormation Command Line Interface (CFN-CLI)* is an open-source tool that enables you to develop and test Amazon and third-party extensions, such as resource types or modules, and register them for use in Amazon CloudFormation. The CloudFormation CLI provides a consistent way to model and provision both Amazon and third-party extensions through CloudFormation. The CloudFormation CLI includes commands to manage each step of creating your extensions. For more information about CloudFormation CLI commands see, [CloudFormation CLI reference \(p. 167\)](#).

An *extension* is an artifact, registered in the CloudFormation registry, which augments the functionality of CloudFormation in a native manner. Extensions are registered by Amazon, Amazon Partner Network, Amazon Web Services Marketplace sellers, and the developer community.

You can use the CloudFormation CLI to register extensions – both those you create yourself, in addition to ones shared with you – with the CloudFormation registry. Extensions enable CloudFormation capabilities to create, provision, and manage these custom types in a safe and repeatable manner, just as you would any Amazon resource. For more information about the CloudFormation registry, see [Using the CloudFormation registry](#) in the *CloudFormation User Guide*.

Setting up your environment for developing extensions

Before you can develop extensions, you'll need to set up your developer environment, including the CloudFormation CLI.

Currently, plugins are available for the following languages:

- Go
- Java
- Python
- TypeScript

Or, if you're using another language, you can install the CloudFormation CLI directly.

Setting up your environment

Prerequisites

- Python version 3.6 or above.
- [CloudFormation CLI command reference](#) for access to `aws cloudformation` commands.
- Your choice of IDE.

The [Walkthrough: Develop a resource type \(p. 42\)](#) walkthrough uses the Community Edition of the IntelliJ IDEA.

- [Amazon Serverless Application Model Command Line Interface \(Amazon SAM CLI\)](#).

Note

Installing the Amazon SAM CLI requires Docker as a prerequisite for testing your resource type locally.

Installing the CloudFormation CLI

The CloudFormation CLI can be installed using pip from the [Python Package Index \(PyPI\)](#).

- Resource – Requires at least one language plugin.
- Module – Language plugins aren't required.
- Hook – Requires at least one language plugin.

The language plugins are also available on PyPI. Use the following command to install all the language plugins at once.

```
pip install cloudformation-cli cloudformation-cli-java-plugin cloudformation-cli-go-plugin cloudformation-cli-python-plugin cloudformation-cli-typescript-plugin
```

(macOS) Installing CloudFormation CLI

Install Homebrew

1. Install [Homebrew](#), an open-source package manager for macOS. You'll use Homebrew to install additional development requirements.
2. Use Homebrew to install Python and the CloudFormation Command Line Interface (CFN-CLI).

```
$ brew update  
$ brew install cloudformation-cli
```

Installing the CloudFormation CLI and plugins

Use the Python Package Index (PyPI) to install the development plugin for the language of your choice. Installing any of the plugins listed below also installs the CloudFormation CLI. For full installation instructions, refer to the appropriate plugin repository.

Available Language Plugins

| Language | Plugin status | GitHub location | PyPI installation |
|------------|----------------------|--|--|
| Go | General availability | cloudformation-cli-go-plugin | pip install cloudformation-cli-go-plugin |
| Java | General availability | cloudformation-cli-java-plugin | pip install cloudformation-cli-java-plugin |
| Python | General availability | cloudformation-cli-python-plugin | pip install cloudformation-cli-python-plugin |
| TypeScript | General availability | cloudformation-cli-typescript-plugin | pip install cloudformation- |

| Language | Plugin status | GitHub location | PyPI installation |
|----------|---------------|-----------------|-----------------------|
| | | | cli-typescript-plugin |

Upgrading to CFN-CLI 2.0

If you have developed resource types using the CFN-CLI 1.0, we suggest you update to CFN-CLI 2.0 and rebuild those types. Upgrading involves updating the CloudFormation CLI, in addition to any language plugins you are using, but doesn't require any changes to your resource type solution itself.

Enhancements in CFN-CLI 2.0 include:

- Increased resource payload limit, from 8 KB to 6 MB.
- Increased resource stabilization time, from 12 hours to 36 hours, or 48 hours if you are using a stack role to consume the resource.
- Improved resource stability, with improved retry strategy and fail-fast.

To upgrade CFN-CLI 2.0 and the CloudFormation Provider Development Toolkit Go Plugin

1. Upgrade the Go Plugin using the following command:

```
pip3 install --upgrade cloudformation-cli-go-plugin
```

2. Update the Go plugin in the go.mod file.

```
go get -u github.com/aws-cloudformation/cloudformation-cli-go-plugin
```

3. To update a resource type to use the CFN-CLI 2.0, build and register a new version of the resource using the following command:

```
make  
cfn submit --set-default
```

To upgrade CFN-CLI 2.0 and the CloudFormation Provider Development Toolkit Java Plugin

1. Upgrade the Java Plugin using the following command:

```
pip3 install --upgrade cloudformation-cli-java-plugin
```

2. Update Java plugin in maven pom.xml to 2.0.0.

```
<dependency>  
  <groupId>software.amazon.cloudformation</groupId>  
  <artifactId>aws-cloudformation-rpdk-java-plugin</artifactId>  
  <version>2.0.0</version>  
</dependency>
```

3. To update a resource type to use the CFN-CLI 2.0, build and register a new version of the resource using the following command:

```
mvn package  
cfn submit --set-default
```

To upgrade CFN-CLI 2.0 and the CloudFormation Provider Development Toolkit Python Plugin

1. Upgrade the Python Plugin using the following command:

```
pip3 install cloudformation-cli-python-plugin
```

2. To update a resource type to use the CFN-CLI 2.0, build and register a new version of the resource using the following command:

```
cfn submit --set-default
```


Creating resource types

If you use third-party resources in your infrastructure and applications, you can now model and automate those resources by developing them as *resource types* for use within CloudFormation. A resource type includes a resource type specification and handlers that control API interactions with the underlying Amazon or third-party services. These interactions include create, read, update, delete, and list (CRUDL) operations for resources. Use resource types to model and provision resources using CloudFormation.

Resource types are treated as first-class citizens within Amazon CloudFormation you can use Amazon CloudFormation capabilities to create, provision, and manage these custom resources in a safe and repeatable manner, just as you would any Amazon resource. Using resource types for third-party resources provides you a way to reliably manage these resources using a single tool, without having to resort to time-consuming and error-prone methods like manual configuration or custom scripts.

You can create resource types and make them available for use within the Amazon account in which they're registered.

Using the CloudFormation CLI to create resource types

Use the [CloudFormation Command Line Interface \(CLI\)](#) to develop your resource types. The CloudFormation CLI is an open-source project that provides a consistent way to model and provision both Amazon and third-party resources using CloudFormation. It includes commands to enable each step of creating your resource types.

There are three major steps in developing a resource types:

- Model

Create and validate a schema that serves as the canonical definition of your resource type.

Use the [init \(p. 167\)](#) command to generate your resource project, including an example resource schema. Edit the example schema to define the actual model of your resource type. This includes resource properties and their attributes, as well specifying resource event handlers and any permissions needed for each.

As you iterate on your resource model, you can use the [validate \(p. 168\)](#) command to validate your schema against the [Resource type definition schema](#) and fix any issues.

- Develop

Add logic that controls what happens to the resource at each stage in its lifecycle, and then test the resource locally to ensure it works as expected.

Implement the resource provisioning actions that the CloudFormation CLI stubbed out when you initially generated your resource project.

If you make changes to your resource schema, use the [generate \(p. 168\)](#) command to generate the language-specific data model, contract test, and unit test stubs based on the current state of the resource schema. (If you use the Java add-in for the CloudFormation CLI, this is done for you automatically.)

When you're ready to test the resource behavior, the CloudFormation CLI provides two commands for testing:

- Use the `invoke` command to test a single handler.
- Use the `test` (p. 170) command to run the entire suite of resource contract tests locally, using the Amazon SAM Command Line Interface (SAM CLI), to make sure the handlers you've written comply with expected handler behavior at each stage of the resource lifecycle.
- Register

Register the resource type with the CloudFormation registry in order to make it available for use in CloudFormation templates.

Use the `submit` (p. 171) command to register the resource type with CloudFormation and make it available for use in CloudFormation operations. Registration includes:

- Validating the resource schema.
- Packaging up the resource project files and uploading them to CloudFormation.
- Registering the resource definition in your account, in the specified Region.

You can register multiple versions of a resource type, and specify which version you want users to use by default.

Modeling resource types for use in Amazon CloudFormation

The first step in creating a resource type is *modeling* that resource, which involves crafting a schema that defines the resource, its properties, and their attributes. When you initially create your resource type project using the CloudFormation CLI `init` (p. 167) command, one of the files created is an example resource schema. Use this schema file as a starting point for defining the shape and semantics of your resource type.

Note

When naming your extension, we recommend that you don't use the following namespaces: `aws`, `amzn`, `alexa`, `amazon`, `awsquickstart`. CloudFormation doesn't block private registration using `cfn submit` for types whose names include these namespaces, but you won't be able to publish these types.

In order to be considered valid, your resource type's schema must adhere to the [Resource type definition schema](#). This meta-schema provides a means of validating your resource specification during resource development.

The Resource Type Definition Schema is a *meta-schema* that extends [draft-07](#) of the [JSON Schema](#). To simplify authoring resource specifications, the Resource Type Definition Schema constrains the scope of the full JSON Schema standard in terms of how certain validations can be expressed, and encourages consistent modeling for all resource schemas. (For full details on how the Resource Type Definition Schema differs from the full JSON schema, see [Divergence From JSON Schema](#).)

Once you have defined your resource schema, you can use the CloudFormation CLI `validate` (p. 168) command to verify that the resource schema is valid.

In terms of testing, the resource schema also determines:

- What unit test stubs are generated in your resource package, and what contract tests are appropriate to run for the resource. When you run the CloudFormation CLI `generate` (p. 168) command, the CloudFormation CLI generates empty unit tests based on the properties of the resource and their attributes.
- Which contract tests are appropriate for CloudFormation CLI to run for your resources. When you run the `test` (p. 170) command, the CloudFormation CLI runs the appropriate contract tests, based on which handlers are included in your resource schema.

Defining property attributes

Certain properties of a resource may have special meaning when used in different contexts. For example, a given resource property may be read-only when read back for state changes, but can be specified when used as the target of a `$ref` from a related resource. Because of this semantic difference in how this property metadata should be interpreted, certain property attributes are defined at the resource level, rather than at a property level.

These attributes include:

- `primaryIdentifier`
- `additionalIdentifiers`
- `createOnlyProperties`
- `readOnlyProperties`
- `writeOnlyProperties`

For reference information on resource schema elements, see [Resource type schema \(p. 9\)](#).

How to define a minimal resource

The example below displays a minimal resource type definition. In this case, the resource consists of a single optional property, `Name`, which is also specified as its primary (and only) identifier.

Note that this resource schema would require a `handlers` section with the create, read, and update handlers specified in order for the resource to actually be provisioned within a CloudFormation account.

```
{
  "typeName": "myORG::myService::myResource",
  "properties": {
    "Name": {
      "description": "The name of the resource.",
      "type": "string",
      "pattern": "^[a-zA-Z0-9_-]{0,64}$",
      "maxLength": 64
    }
  },
  "createOnlyProperties": [
    "/properties/Name"
  ],
  "identifiers": [
    [
      "/properties/Name"
    ]
  ],
  "additionalProperties": false
}
```

Defining the account-level configuration of an extension

There might be cases where your extension includes properties that the user must specify for all instances of the extension in a given account and Region. In such cases, you can define those properties in a *configuration definition* that the user then sets at the Region level. For example, if your extension needs to access a third-party web service, you can include a configuration for the user to specify their credentials for that service.

When the user sets the configuration, CloudFormation validates it against the configuration definition, and then saves this information at the Region level. From then on, CloudFormation can access that configuration during operations involving any instances of that extension in the Region. Configurations are available to CloudFormation during all resource operations, including `read` and `list` events that don't explicitly involve a stack template.

Note

Configuration definitions aren't compatible with [module \(p. 73\)](#) extensions.

Your configuration definition must validate against the [provider configuration definition meta-schema](#).

The `CloudFormation` property name is reserved, and can't be used to define any properties in your configuration definition.

Use the `typeConfiguration` element of the [provider definition meta-schema](#) to include the configuration definition as part of your extension's schema.

Important

It's strongly recommended that you use dynamic references to restrict sensitive configuration definitions, such as third-party credentials, as in the example below. For more details on dynamic references, see [Using dynamic references to specify template values](#) in the *Amazon CloudFormation User Guide*.

Example: Defining a configuration definition to specify third-party credentials

The following example illustrates how you might model third-party credentials in an extension. The schema below for the `MyOrg::MyService::Resource` resource type includes a `typeConfiguration` section. The configuration definition includes a required property, `ServiceCredentials`, of type `Credentials`. As defined in the `definitions` section, the `Credentials` type includes two properties for the user to specify their credentials for a third-party service: `ApiKey` and `ApplicationKey`.

In this example, both properties must be dynamic references, as represented by the regex pattern for each property. By using dynamic references here, CloudFormation never stores the actual credential values, but instead retrieves them from Amazon Secrets Manager or Systems Manager Parameter Store only when necessary. For more information about dynamic references, including how CloudFormation distinguishes which service to retrieve values from, see [Using dynamic references to specify template values](#) in the *Amazon CloudFormation User Guide*.

To see how users set configuration data for their extensions, see [Configuring extensions at the account level](#) in the *Amazon CloudFormation User Guide*.

```
{
  "typeName": "MyOrg::MyService::Resource",
  "description": "Example resource type that requires third-party credentials",
  "additionalProperties": false,
  "typeConfiguration": {
    "properties": {
      "ServiceCredentials": {
        "$ref": "#/definitions/Credentials"
      }
    },
    "additionalProperties": false,
    "required": [
      "ServiceCredentials"
    ]
  },
  "definitions": {
    "Credentials": {
      "type": "object",
      "properties": {
```

```
        "apiKey": {
          "description": "Third-party API key",
          "type": "string",
          "pattern": "{{resolve:.*:[a-zA-Z0-9_-./]+}}"
        },
        "applicationKey": {
          "description": "Third-party application key",
          "type": "string",
          "pattern": "{{resolve:.*:[a-zA-Z0-9_-./]+}}"
        }
      },
      "additionalProperties": false
    }
  },
  "properties": {
    "Id": {
      "type": "string"
    },
    "Name": {
      "type": "string"
    }
  },
  "primaryIdentifier": [
    "/properties/Id"
  ],
  "additionalIdentifiers": [
    ["/properties/Name"]
  ],
  "handlers": {
  }
}
```

Resource type schema

To be considered valid, your resource type's schema must adhere to the [Resource provider definition schema](#). This meta-schema provides a means of validating your resource specification during resource development.

Syntax

Below is the structure for a typical resource type schema. For the complete meta-schema definition, see the [Resource Provider Definition Schema](#) on [GitHub](#).

```
{
  "typeName": "string",
  "description": "string",
  "sourceUrl": "string",
  "documentationUrl": "string",
  "definitions": {
    "definitionName": {
      . . .
    }
  },
  "properties": {
    "propertyName": {
      "description": "string",
      "type": "string",
      . . .
    },
  },
  "required": [
```

```
    "propertyName"  
  ],  
  "readOnlyProperties": [  
    "/properties/propertyName"  
  ],  
  "writeOnlyProperties": [  
    "/properties/propertyName"  
  ],  
  "primaryIdentifier": [  
    "/properties/propertyName"  
  ],  
  "createOnlyProperties": [  
    "/properties/propertyName"  
  ],  
  "deprecatedProperties": [  
    "/properties/propertyName"  
  ],  
  "additionalIdentifiers": [  
    [  
      "/properties/propertyName"  
    ]  
  ],  
  "handlers": {  
    "create": {  
      "permissions": [  
        "permission"  
      ]  
    },  
    "read": {  
      "permissions": [  
        "permission"  
      ]  
    },  
    "update": {  
      "permissions": [  
        "permission"  
      ]  
    },  
    "delete": {  
      "permissions": [  
        "permission"  
      ]  
    },  
    "list": {  
      "permissions": [  
        "permission"  
      ]  
    }  
  }  
}
```

Properties

typeName

The unique name for your resource. Specifies a three-part namespace for your resource, with a recommended pattern of `Organization::Service::Resource`.

Note

The following organization namespaces are reserved and can't be used in your resource type names:

- Alexa
- AMZN

- Amazon
- ASK
- Amazon
- Custom
- Dev

Required: Yes

Pattern: `^[a-zA-Z0-9]{2,64}:[a-zA-Z0-9]{2,64}:[a-zA-Z0-9]{2,64}$`

`description`

A short description of the resource. This will be displayed in the Amazon CloudFormation console.

Required: Yes

`sourceUrl`

The URL of the source code for this resource, if public.

`documentationUrl`

The URL of a page providing detailed documentation for this resource.

Note

While the resource schema itself should include complete and accurate property descriptions, the `documentationUrl` property enables you to provide users with documentation that describes and explains the resource in more detail, including examples, use cases, and other detailed information.

`definitions`

Use the `definitions` block to provide shared resource property schemas.

It's considered a best practice is to use the `definitions` section to define schema elements that may be used at multiple points in your resource type schema. You can then use a JSON pointer to reference that element at the appropriate places in your resource type schema.

`properties`

The properties of the resource.

All properties of a resource must be expressed in the schema. Arbitrary inputs aren't allowed. A resource must contain at least one property.

Nested properties are not allowed. Instead, define any nested properties in the `definitions` element, and use a `$ref` pointer to reference them in the desired property.

Required: Yes

`propertyName`

`insertionOrder`

For properties of type `array`, set to `true` to specify that the order in which array items are specified must be honored, and that changing the order of the array will indicate a change in the property.

The default is `true`.

`readOnly`

Reserved for CloudFormation use.

`writeOnly`

Reserved for CloudFormation use.

dependencies

Any properties that are required if this property is specified.

patternProperties

Use to specify a specification for key-value pairs.

```
"type": "object",  
"propertyNames": {  
  "format": "regex"  
}
```

properties

Minimum: 1

patternProperties

Pattern: `^[A-Za-z0-9]{1,64}$`

Specifies a pattern that properties must match to be valid.

allOf

The property must contain all of the data structures define here.

Contains a single schema. A list of schemas is not allowed.

Minimum: 1

anyOf

The property can contain any number of the data structures define here.

Contains a single schema. A list of schemas is not allowed.

Minimum: 1

oneOf

The property must contain only one of the data structures define here.

Contains a single schema. A list of schemas is not allowed.

Minimum: 1

items

For properties of type array, defines the data structure of each array item.

Contains a single schema. A list of schemas is not allowed.

In addition, the following elements, defined in [draft-07](#) of the [JSON Schema](#), are allowed in the `properties` object:

- `$ref`
- `$comment`
- `title`
- `description`
- `examples`
- `default`

- `multipleOf`
- `maximum`
- `exclusiveMaximum`
- `minimum`
- `exclusiveMinimum`
- `minLength`
- `pattern`
- `maxItems`
- `minItems`
- `uniqueItems`
- `contains`
- `maxProperties`
- `required`
- `const`
- `enum`
- `type`
- `format`

`remote`

Reserved for CloudFormation use.

`readOnlyProperties`

Resource properties that can be returned by a `read` or `list` request, but can't be set by the user.

Type: List of JSON pointers

`writeOnlyProperties`

Resource properties that can be specified by the user, but can't be returned by a `read` or `list` request. Write-only properties are often used to contain passwords, secrets, or other sensitive data.

Type: List of JSON pointers

`createOnlyProperties`

Resource properties that can be specified by the user only during resource creation.

Note

Any property not explicitly listed in the `createOnlyProperties` element can be specified by the user during a resource update operation.

Type: List of JSON pointers

`deprecatedProperties`

Resource properties that have been deprecated by the underlying service provider. These properties are still accepted in create and update operations. However they may be ignored, or converted to a consistent model on application. Deprecated properties are not guaranteed to be returned by read operations.

Type: List of JSON pointers

`primaryIdentifier`

The uniquely identifier for an instance of this resource type. An identifier is a non-zero-length list of JSON pointers to properties that form a single key. An identifier can be a single or multiple properties to support composite-key identifiers.

Type: List of JSON pointers

Required: Yes

`additionalIdentifiers`

An optional list of supplementary identifiers, each of which uniquely identifies an instance of this resource type. An identifier is a non-zero-length list of JSON pointers to properties that form a single key. An identifier can be a single property, or multiple properties to construct composite-key identifiers.

Type: List of JSON pointers

Minimum: 1

`handlers`

Specifies the provisioning operations which can be performed on this resource type. The handlers specified determine what provisioning actions CloudFormation takes with respect to the resource during various stack operations.

- If the resource type doesn't contain `create`, `read`, and `delete` handlers, CloudFormation can't actually provision the resource.
- If the resource type doesn't contain an `update` handler, CloudFormation can't update the resource during stack update operations, and will instead replace it.

If your resource type calls Amazon APIs in any of its handlers, you must create an [IAM execution role](#) that includes the necessary permissions to call those Amazon APIs, and provision that execution role in your account. For more information, see [Accessing Amazon APIs from a Resource Type](#).

`create`

`permissions`

A string array that specifies the Amazon permissions needed to invoke the create handler.

You must specify at least one permission for each handler.

Required: Yes

`read`

`permissions`

A string array that specifies the Amazon permissions needed to invoke the read handler.

You must specify at least one permission for each handler.

Required: Yes

`update`

`permissions`

A string array that specifies the Amazon permissions needed to invoke the update handler.

You must specify at least one permission for each handler.

Required: Yes

`delete`

`permissions`

A string array that specifies the Amazon permissions needed to invoke the delete handler.

You must specify at least one permission for each handler.

Required: Yes

`list`

The `list` handler must at least return the resource's primary identifier.

`permissions`

A string array that specifies the Amazon permissions needed to invoke the list handler.

You must specify at least one permission for each handler.

Required: Yes

`allof`

The resource must contain all of the data structures defined here.

Minimum: 1

`anyOf`

The resource can contain any number of the data structures define here.

Minimum: 1

`oneOf`

The resource must contain only one of the data structures define here.

Minimum: 1

In addition, the following element, defined in [draft-07](#) of the [JSON Schema](#), is allowed:

- *Required: Yes*

Patterns for modeling your resource types

Use the following patterns to model the data structures of your resource types using the Resource Provider Schema.

How to specify a property as dependent on another

Use the `dependencies` element to specify if a property is required in order for another property to be specified. In the following example, if the user specifies a value for the `ResponseCode` property, they must also specify a value for `ResponsePagePath`, and vice versa. (Note that, as a best practice, this is also called out in the description of each property.)

```
"properties": {
  "CustomErrorResponse": {
    "additionalProperties": false,
    "dependencies": {
      "ResponseCode": [
        "ResponsePagePath"
      ],
      "ResponsePagePath": [
        "ResponseCode"
      ]
    }
  },
  "properties": {
```

```
    "ResponseCode": {
      "description": "The HTTP status code that you want CloudFront to return to the
viewer along with the custom error page. If you specify a value for ResponseCode, you must
also specify a value for ResponsePagePath.",
      "type": "integer"
    },
    "ResponsePagePath": {
      "description": "The path to the custom error page that you want CloudFront
to return to a viewer when your origin returns the HTTP status code specified by
ErrorCode. If you specify a value for ResponsePagePath, you must also specify a value for
ResponseCode.",
      "type": "string"
    }
    . . .
  },
  "type": "object"
},
},
. . .
```

How to define nested properties

It's considered a best practice is to use the `definitions` section to define schema elements that may be used at multiple points in your resource type schema. You can then use a JSON pointer to reference that element at the appropriate places in your resource type schema.

For example, define the reused element in the `definitions` section:

```
"definitions": {
  "AccountId": {
    "pattern": "^[0-9]{12}$",
    "type": "string"
  },
  . . .
},
. . .
```

And then reference that definition where appropriate:

```
"AwsAccountNumber": {
  "description": "An AWS account that is included in the TrustedSigners complex type for
this distribution.",
  "$ref": "#/definitions/AccountId"
},
. . .
```

Advanced: How to encapsulate complex logic

Use the `allOf`, `oneOf`, or `anyOf` elements to encapsulate complex logic in your resource type schema.

In the example below, if `whitelist` is specified for the `Forward` property in your resource, then the `WhitelistedNames` property must also be specified.

```
"properties": {
  "Cookies": {
    "oneOf": [
      {
        "additionalProperties": false,
        "properties": {
```

```
        "Forward": {
          "description": "Specifies which cookies to forward to the origin for
this cache behavior.",
          "enum": [
            "all",
            "none"
          ],
          "type": "string"
        },
        "required": [
          "Forward"
        ]
      },
    ],
    {
      "additionalProperties": false,
      "properties": {
        "Forward": {
          "description": "Specifies which cookies to forward to the origin for
this cache behavior.",
          "enum": [
            "whitelist"
          ],
          "type": "string"
        },
        "WhitelistedNames": {
          "description": "Required if you specify whitelist for the value of
Forward.",
          "items": {
            "type": "string"
          },
          "minItems": 1,
          "type": "array"
        }
      },
      "required": [
        "Forward",
        "WhitelistedNames"
      ]
    },
    "type": "object"
  }
}
. . .
```

Preventing false drift detection results for resource types

When Amazon CloudFormation performs drift detection on a resource, it looks up the value for each resource property as specified in the stack template, and compares that value with the current resource property value returned by the resource `read` handler. A resource is then considered to have drifted if one or more of its properties have been deleted, or had their value changed. In some cases, however, the resource may not be able to return the exact same value in the `read` handler as was specified in the stack template, even though the value is essentially the same and shouldn't be considered as drifted.

To prevent these cases from being incorrectly reported as drifted resources, you can specify a *property transform* in your resource schema. The property transform provides a way for CloudFormation to accurately compare the resource property value specified in the template with the value returned from the `read` handler. During drift detection, if CloudFormation finds a property where the template value differs from the value returned by the `read` handler, it determines if a property transform has

been defined for that property in the resource schema. If it has, CloudFormation applies that property transform to the value specified in the template, and then compares it to the `read` handler value again. If these two values match, the property isn't considered to have drifted, and is marked as `IN_SYNC`.

For more information about drift detection, see [Detecting unmanaged configuration changes to stacks and resources](#) in the *CloudFormation User Guide*.

Defining a property transform for drift detection operations

Use the `propertyTransform` element to define a property transform for a given resource property.

```
"propertyTransform": {  
  "property_path": "transform"  
}
```

Where:

- `property_path` is the path to the resource property in the resource schema.
- `transform` is the transform to perform on the resource property value specified in the stack template.

Property transforms are written in [JSONata](#), an open-source, lightweight query and transformation language for JSON data.

For example, consider the `AWS::Route53::HostedZone` resource. For the `Name` property, users can specify a domain name with or without a trailing `.` in their templates. However, assume the Route 53 service always returns the domain name with a trailing `.`. This means that if a user specified a domain name without the trailing `.` in their template, created the stack, and then performed drift detection on the stack, CloudFormation would erroneously report the `AWS::Route53::HostedZone` resource as drifted. To prevent this from happening, the resource developer would add a `propertyTransform` element to the resource schema to enable CloudFormation to determine if both property values were actually the same:

```
"propertyTransform": {  
  "/properties/Name": "$join([Name, \".\"])"  
}
```

Specifying multiple transforms for a property

You can specify multiple transforms for CloudFormation to attempt by using the `$OR` operator. If you specify multiple transforms, CloudFormation tries them all, in the order they're specified, until it finds one that results in the property values matching, or it has tried them all.

For example, for the following property transform, CloudFormation would attempt two transforms to determine whether the property value has actually drifted:

- Append `.` to the template property value, and determine if the updated value now matches the property value returned by the resource `read` handler. If it does, CloudFormation reports the property as `IN_SYNC`. If not, CloudFormation performs the next transform.
- Append the string `test` to the template property value, and determine if the updated value now matches the property value returned by the resource `read` handler. If it does, CloudFormation reports the property as `IN_SYNC`. If not, CloudFormation reports the property, and the resource, as `MODIFIED`.

```
"propertyTransform": {
```

```
"/properties/Name": "$join([Name, \".\"] ) $OR $join([Name, \"test\"])"  
}
```

Developing resource types for use in Amazon CloudFormation templates

Once you've modeled your resource type, and validated its schema, the next step is to develop the resource. Developing the resource consists of two main steps:

- Implementing the appropriate event handlers for your resource.
- Testing the resource locally to ensure it works as expected.

Implementing resource handlers

When you [generate](#) (p. 168) your resource package, the CloudFormation CLI stubs out empty handler functions, each of which each corresponds to a specific event in the resource lifecycle. You add logic to these handlers to control what happens to your resource type at each stage of its lifecycle.

- `create`: CloudFormation invokes this handler when the resource is initially created during stack create operations.
- `read`: CloudFormation invokes this handler as part of a stack update operation when detailed information about the resource's current state is required.
- `update`: CloudFormation invokes this handler when the resource is updated as part of a stack update operation.
- `delete`: CloudFormation invokes this handler when the resource is deleted, either when the resource is deleted from the stack as part of a stack update operation, or the stack itself is deleted.
- `list`: CloudFormation invokes this handler when summary information about multiple resources of this resource type is required.

You can only specify a single handler for each event.

Which handlers you implement for a resource determine what provisioning actions CloudFormation takes with respect to the resource during various stack operations:

- If the resource type contains both `create` and `update` handlers, CloudFormation invokes the appropriate handler during stack create and update operation.
- If the resource type doesn't contain an `update` handler, CloudFormation can't update the resource during stack update operations, and will instead replace it. CloudFormation invokes the `create` handler to create a new resource, then deletes the old resource by invoking the `delete` handler.
- If the resource type doesn't contain `create`, `read`, and `delete` handlers, CloudFormation can't actually provision the resource.

Use the resource schema to specify which handlers you have implemented. If you choose not to implement a specific handler, remove it from the `handlers` section of the resource schema.

Accessing Amazon APIs from a resource type

If your resource type calls Amazon APIs in any of its handlers, you must create an [IAM execution role](#) that includes the necessary permissions to call those Amazon APIs, and provision that execution role in

your account. CloudFormation then assumes that execution role to provide your resource type with the appropriate credentials.

When you call `generate`, the CloudFormation CLI automatically generates an execution role template, `resource-role.yaml`, as part of generating the code files for the resource type package. This template is based on the permissions specified for each handler in the [handlers](#) section of the [Resource type schema](#). When you use `submit` to register the resource type, the CloudFormation CLI attempts to create or update an execution role based on the template, and then passes this execution role to CloudFormation as part of the registration.

For more information about the permissions available per Amazon service, see [Actions, resources, and condition keys for Amazon services](#) in the *Amazon Identity and Access Management User Guide*.

Monitoring runtime logging for resource types

When you register a resource type using `cf submit`, CloudFormation creates a CloudWatch log group for the resource type in your account. This enables you to access the logs for your resource to help you diagnose any faults. The log group is named according to the following pattern:

```
/my-resource-type-stack-ResourceHandler-string
```

Where:

- *my-resource-type* is the three-part resource type name.
- *string* is a unique string generated by CloudFormation.

Now, when you initiate stack operations for stacks that contain the resource type, CloudFormation delivers log events emitted by the resource type to this log group.

Testing resource types using contract tests

As you model and develop your resource type, you should have the CloudFormation CLI perform tests to ensure that the resource type is behaving as expected during each event in the resource lifecycle. The CloudFormation CLI performs a suite of tests called contract tests to enforce CloudFormation's [handler contract](#) (p. 27). Developing and registering your resource type in CloudFormation signifies an agreement that your resource is compliant and doesn't break any framework expectations. All resources that fail contract tests are blocked from publishing into our registry.

Testing resource types locally using Amazon SAM

Once you've implemented the desired handlers for your resource, you can also test the resource locally using the Amazon SAM command line interface (CLI), to make sure your resource behaves as expected, debug what's wrong, and fix any issues.

To start testing, use the Amazon SAM CLI to start the Local Lambda service. Run the following command in a terminal separate from your resource type workspace, or as a background process.

```
$ sam local start-lambda
```

If you have functions defined in your Amazon SAM template, it will provide an endpoint to invoke these functions locally. This is especially helpful because it allows for remote debugging to step through resource type invocations in real time.

```
Starting the Local Lambda Service. You can now invoke your Lambda Functions defined in your template through the endpoint.
```



```
2020-01-15 15:27:19 * Running on http://127.0.0.1:3001/ (Press CTRL+C to quit)
```

Alternatively, you can also specify using the public Lambda service and invoke functions deployed in your account. Be aware, however, that using the local service allows for more iteration. To specify a debug port for remote debugging, use the `-d` option:

```
sam local start-lambda -d PORT
```

Once you have the Lambda service started, use the `test` command to perform contract tests:

```
cfn test
```

The CloudFormation CLI selects the appropriate contract tests to execute, based on the handlers specified in your resource type schema. If a test fails, the CloudFormation CLI outputs a detailed trace of the failure, including the related assertion failure and mismatched values.

For more information about testing using Amazon SAM CLI, see [Testing and debugging serverless applications](#) in the *Amazon Serverless Application Model Developer Guide*.

How the CloudFormation CLI constructs and executes contract tests

The CloudFormation CLI uses [PyTest](#), an open-source testing framework, to execute the contract tests.

The tests themselves are located in the `suite` folder of the CloudFormation CLI repository on GitHub. Each test is adorned with the appropriate `pytest` markers. For example, tests applicable to the `create` handler are adorned with the `@pytest.mark.create` marker. This enables the CloudFormation CLI to execute only those tests appropriate for a resource type, based on the handlers specified in the resource type's schema. For example, suppose a resource type's schema specified `create`, `read`, and `delete` handlers. In this case, the CloudFormation CLI would not perform any test marked with only the `@pytest.mark.update` or `@pytest.mark.list`, since those handlers weren't implemented.

To test `create` and `update` handlers, the CloudFormation CLI uses the resource type's schema and [Hypothesis](#), an open-source Python library used to generate testing strategies. The resource type schema is walked to generate a strategy for valid resource models, and the strategy is used to generate models for tests.

Tests `create`, `update`, and `delete` resources to test various aspects of the resource handler contract during handler operations. The CloudFormation CLI uses PyTest `fixtures` to decrease the amount of time the contract tests take to perform. Using fixtures enable the tests within a test module to share resources, rather than have to create a new resource for each test. Currently, the contract tests employ the following fixtures:

- `created_resource` in the `handler_create` test module.
- `updated_resource` in the `handler_update` test module.
- `deleted_resource` in `handler_delete` test module.

Specifying input data for use in contract tests

By default, the CloudFormation CLI performs resource contract tests using input properties generated from the patterns you define in your resource type schema. However, most resources are complex enough that the input properties for creating or updating those resources requires an understanding of

the resource being provisioned. To address this, you can specify the input the CloudFormation CLI uses when performing its contract tests.

The CloudFormation CLI offers two ways for you to specify the input data for it to use when performing contract tests:

- Overrides file

Using an `overrides` file provides a light-weight way of specifying input data for certain specific properties for the CloudFormation CLI to use during both create and update operations testing.

- Input files

You can also use multiple `input` files to specify contract test input data if:

- You want or need to specify different input data for create and update operations, or invalid data with which to test.
- You want to specify multiple different input data sets.

Specifying input data using an override file

Using an override file enables you to overwrite input values for specific resource properties. Input values specified in the override file are used in contract testing for both create and update operations. You can only specify a single override file, and only specify a single input value for each resource property. For any properties for which you don't specify values, the CloudFormation CLI uses generated input.

Because the input data specified in the `overrides.json` file is used by the CloudFormation CLI during testing of create and update operations, you can't include input values for create-only properties in the file, as this would lead to contract test failures during update operations. For more information, see [createOnlyProperties](#).

To override the input data used for specific properties during contract testing, add an `overrides.json` file to the root directory of your resource type project. The `overrides.json` file should contain only the resource properties to be used in testing. Use the following syntax:

```
{
  "CREATE": {
    "/property_name": "property_value" # optional_comment
  }
}
```

For example:

```
{
  "CREATE": {
    "/SubnetId": "subnet-0bc6136e" # This should be a real subnet that exists in the
    account you're testing against.
  }
}
```

You can also use output values from other stacks when specifying input data. For example, suppose you had a stack that contained an export value named `SubnetExport`:

```
Resources:
  VPC:
    Type: "AWS::EC2::VPC"
    Properties:
      CidrBlock: "10.0.0.0/16"
  Subnet:
```

```
Type: "AWS::EC2::Subnet"
Properties:
  CidrBlock: "10.0.0.0/24"
  VpcId: !Ref VPC
Outputs:
  SubnetId:
    Value: !Ref Subnet
  Export:
    Name: SubnetExport
```

You could then specify that export value as input data using the export value name using the following syntax:

```
{
  "CREATE": {
    "/SubnetId": "{{SubnetExport}}"
  }
}
```

For more information, see [Outputs](#).

Specifying input data using input files

Use `input` files to specify different kinds of input data for the CloudFormation CLI to use: create input, update input, and invalid input. Each kind of data is specified in a separate file. You can also specify multiple sets of input data for contract tests.

To specify `input` files for the CloudFormation CLI to use in contract testing, add an `inputs` folder to the root directory of your resource type project. Then add your input files.

Specify which kind of input data a file contains by using the following naming conventions, where `n` is an integer:

- `inputs_n_create.json`: Use files with `_create.json` for specifying inputs for creating the resource. This includes input values for create-only properties. For more information, see [createOnlyProperties](#).
- `inputs_n_update.json`: Use files with `_update.json` for specifying inputs for updating the resource.
- `inputs_n_invalid.json`: Use files with `_invalid.json` for specifying invalid inputs to test when creating or updating the resource.

To specify multiple sets of input data for contract tests, increment the integer in the file names to order your input data sets. For example, your first set of input files should be named `inputs_1_create.json`, `inputs_1_update.json`, and `inputs_1_invalid.json`. Your next set would be named `inputs_2_create.json`, `inputs_2_update.json`, and `inputs_2_invalid.json`, and so on.

Each input file is a JSON file containing only the resource properties to be used in testing. Below is an example of an input file data set.

```
{
  "AlarmName": "Name",
  "AlarmDescription": "TestAlarmDimensions Description",
  "Namespace": "CloudWatchNamespace",
  "MetricName": "Fault",
  "Dimensions": [
    {
```

```
        "Name": "MethodName",  
        "Value": "Value"  
    }  
],  
"Statistic": "Average",  
"Period": 60,  
"EvaluationPeriods": 5,  
"Threshold": 0.01,  
"ComparisonOperator": "GreaterThanOrEqualToThreshold"  
}
```

If you specify an `inputs` folder, the CloudFormation CLI uses only the input data included in that folder. Therefore, you must specify `create`, `update`, and `invalid` data files for the CloudFormation CLI to successfully complete the contract tests.

If you specify both input files and an `overrides` file, the CloudFormation CLI ignores the `overrides` file and uses the input data specified in the `inputs` folder.

You can also use output values from other stacks when specifying input data. For example, suppose you had a stack that contained an export value named `SubnetExport`:

```
Resources:  
  VPC:  
    Type: "AWS::EC2::VPC"  
    Properties:  
      CidrBlock: "10.0.0.0/16"  
  Subnet:  
    Type: "AWS::EC2::Subnet"  
    Properties:  
      CidrBlock: "10.0.0.0/24"  
      VpcId: !Ref VPC  
Outputs:  
  SubnetId:  
    Value: !Ref Subnet  
  Export:  
    Name: SubnetExport
```

You could then specify that export value as input data using the export value name using the following syntax:

```
{  
  "SubnetId": "{{SubnetExport}}",  
  . . .  
}
```

For more information, see [Outputs](#).

Viewing contract test logs

It's important to note that contract tests aren't run during private type registration (unless the resource contains one of the following namespaces: `aws`, `amzn`, `alexa`, `amazon`, `awsquickstart`), but failing contract tests does block a publisher's ability to publish their type. This is because public resources are consumed by other external customers and need to maintain a high quality bar. For this reason, it's important to debug your contract test failures early on in the resource development process.

Running contract tests generates two types of logs. Using both helps expedite the debugging process.

- `Lambda` logs show logs from your handlers and provide more details on the input and output for each handler call.

- `Test` logs show the result of running the test suite, including which tests have failed or passed, in addition to a traceback if a test has failed.

Because there are multiple ways to invoke contract tests against your resource, there are different places to find logs depending on which operation you are using.

- If you run contract tests locally, logs are divided into the following two sections:
 - Lambda logs are in the terminal tab in which you ran `sam local start-lambda`.
 - Test logs are in the terminal tab in which you ran `cf test`.
- If you run contract tests through the type registration (`cf submit`), logs are uploaded in two areas. Contract tests are only run during type registration if your type name includes one of the following namespaces: `aws`, `amzn`, `alexa`, `amazon`, `awsquickstart`.
- Lambda logs are delivered to a CloudWatch log group in your account. The log group adheres to the following naming pattern:

```
<Hyphenated TypeName>-ContractTests-<RegistrationToken>
```

For example, `aws-cloudwatch-alarm-ContractTests-ca7096d7-ccb3-4c7d-ad51-78d0a1a300ca`.

- To receive test logs in an Amazon S3 bucket, you have to modify the IAM role that's created by CloudFormation, which adheres to the following naming pattern:

```
CloudFormationManagedUplo-LogAndMetricsDeliveryRol-<RandomId>
```

Add the following inline policy:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Action": [
        "s3:PutObject"
      ],
      "Resource": [
        "*"
      ],
      "Effect": "Allow"
    },
    {
      "Action": [
        "kms:Encrypt",
        "kms:Decrypt",
        "kms:ReEncrypt*",
        "kms:GenerateDataKey*",
        "kms:DescribeKey"
      ],
      "Resource": "*",
      "Effect": "Allow"
    }
  ]
}
```

Also add the following trust policy:

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

```
"Principal": {
  "Service": [
    "cloudformation.amazonaws.com",
    "resources.cloudformation.amazonaws.com"
  ],
  "Action": "sts:AssumeRole"
}
]
```

Invoking `cfn submit --role-arn <arn for above IAM role>` uploads your test logs to an Amazon S3 bucket named `cloudformationmanageduploadinfrast-artifactbucket-
<RandomId>` under the following path:

```
CloudFormation/ContractTestResults/<TypeName>/
<ContractTestInvocationToken>.zip
```

Download the zip file to see your test logs.

- If you run contract tests against your registered type through the `TestType`, both logs are condensed and uploaded to an Amazon S3 bucket in your account. You must specify the `--log-delivery-bucket` parameter when invoking `TestType` to receive logs in your account.

Testing resource types manually

Running contract tests with the `cfn-test` command uses the Amazon SAM CLI, so it's possible to attach a debugger from your IDE by specifying a port when you start the local Lambda service. However, we don't suggest this approach because the debugger detaches after each individual handler invocation completes.

Instead, you can mimic the scenarios modeled in contract tests by invoking the handlers with the `sam local invoke` command. This allows you to step through each handler invocation without interruption. You first need to define test templates that Amazon SAM can run against the resource handlers. Create the test templates in a separate folder in the resource directory and name the folder `sam-tests`.

The test templates must adhere to the following format:

```
"action": "<Action>",
"request": {
  "clientRequestToken": "<Random UUID>",
  "desiredResourceState": <ResourceModel json>,
  "logicalResourceIdentifier": "<Logical Id>"
},
"callbackContext": <CallbackContext json>
}
```

- For **credentials**, use temporary credentials of your personal Amazon Web Services account. For best practices, see [Set default credentials and Region](#) in the Amazon SDK for Java Developer Guide.
 - You will need the `accessKeyId`, `secretAccessKey`, and `sessionToken` with their corresponding values.
- For **action**, specify the handler you want to test. Allowed values: `CREATE`, `READ`, `DELETE`, `UPDATE`, `LIST`.
- For **clientRequestToken**, specify a random UUID string. To retrieve this, use any UUID generator tool.
- For **desiredResourceState**, specify the properties of the resource required for the request that follow the resource schema.
- For **logicalResourceIdentifier**, specify a logical ID to assign to your resource instance. You can use this in subsequent handler invocations for the same resource.

- For **callbackContext**, the request begins with a null value for callback context. For handlers with stabilization logic, the subsequent requests have callback context from the previous request's response.

Once you've written the input files, do the following to debug your handlers:

1. Ensure that Docker is downloaded and installed on your machine, and that you've added the resource directory to Docker.
2. In one terminal, start the local Lambda service by running `sam local start-lambda`.
3. In your IDE, create a remote configuration and add a port number. Add a breakpoint in the appropriate handler you are invoking.
4. In another terminal, invoke the handler by running `sam local invoke TestEntrypoint --event sam-tests/<input filename> -d <PORT number>`.
5. Step through the code to debug any handler errors.

For more information about testing using the Amazon SAM CLI, see [Testing and Debugging Serverless Applications](#) in the *Amazon Serverless Application Model Developer Guide*.

Resource type handler contract

The resource type handler contract specifies the expected and required behavior to which a resource must adhere in each given event handler. It defines a set of specific, unambiguous rules with which `create`, `read`, `update`, `delete` and `list` resource handlers must comply. Following the contract will allow customers to interact with all resource types under a uniform set of behaviors and expectations, and prevents creation of unintended or duplicate resources.

A resource implementation **MUST** pass all resource contract tests to be registered.

Assuming no other concurrent interaction on the resource, the handlers must comply with the following contract.

All terminology in the handler contract requirements adheres to the [RFC 2119 specification](#).

Create handlers

Input assumptions

The `create` handler can make the following assumptions about input submitted to it:

- The input to a `create` handler **MUST** be valid against the resource schema.

Output requirements

The `create` handler must adhere to the following requirements regarding its output:

- A `create` handler **MUST** always return a `ProgressEvent` object within 60 seconds. For more information, see [ProgressEvent Object Schema](#).

In every `ProgressEvent` object, the `create` handler **MUST** return a model which conforms to the shape of the resource schema. For more information, see [Returned models must conform to the shape of the schema](#).

Every model **MUST** include the `primaryIdentifier`. The only exception is if the first progress event is `FAILED`, and the resource hasn't yet been created. In this case, a subsequent `read` call **MUST** return `NotFound`.

- A `create` handler MUST NOT return `SUCCESS` until it has applied all properties included in the `create` request. For more information, see [Update, create, and delete handlers must satisfy desired-state stabilization](#).

- A `create` handler MUST return `IN_PROGRESS` if it hasn't yet reached the desired-state.

A `create` handler SHOULD return a model containing all properties set so far and nothing more during each `IN_PROGRESS` event.

- A `create` handler MUST return `FAILED` progress event if it can't reach the desired-state within the timeout specified in the resource schema.

The progress event MUST return an error message and the most applicable error code. For more information, see [Handler error codes](#).

- A `create` handler MAY return `SUCCESS` once it reaches the desired-state.

Once the desired state has been reached, a `create` handler MAY perform runtime-state stabilization. For more information, see [Update and create handlers should satisfy runtime-state stabilization](#).

When the `create` handler returns `SUCCESS`, it MUST return a `ProgressEvent` object containing a model that satisfies the following requirements:

- All properties specified in the `create` request MUST be present in the model returned, and they MUST match exactly, with the exception of properties defined as `writeOnlyProperties` in the resource schema.
- The model MUST contain all properties that have values, including any properties that have default values, and any `readOnlyProperties` as defined in the resource schema.
- The model MUST NOT return any properties that are null or don't have values.
- After a `create` operation returns `SUCCESS`, a subsequent `read` request MUST succeed when passed in the `primaryIdentifier` or any `additionalIdentifiers` associated with the provisioned resource instance.
- After a `create` operation returns `SUCCESS`, a subsequent `list` operation MUST return the `primaryIdentifier` associated with the provisioned resource instance.

If the `list` operation is paginated, the entire `list` operation is defined as all `list` requests until the `nextToken` is `null`.

- A `create` handler MUST be idempotent. A `create` handler MUST NOT create multiple resources given the same idempotency token.
- A `create` handler MUST return `FAILED` with an `AlreadyExists` error code if the resource already existed before the `create` request.

Update handlers

Input assumptions

The update handler can make the following assumptions about input submitted to it:

- The input to an update handler MUST be valid against the resource schema.
- Any `createOnlyProperties` specified in update handler input MUST NOT be different from their previous state.
- The input to an update handler MUST contain either the `primaryIdentifier` or an `additionalIdentifier`.

Output requirements

The update handler must adhere to the following requirements:

- An update handler MUST always return a ProgressEvent object within 60 seconds. For more information, see [ProgressEvent Object Schema](#).

In every ProgressEvent object, the update handler MUST return a model which conforms to the shape of the resource schema. For more information, see [Returned models must conform to the shape of the schema](#).

Every model MUST include the primaryIdentifier.

The primaryIdentifier returned in every progress event must match the primaryIdentifier passed into the request.

- An update handler MUST NOT return SUCCESS until it has applied all properties included in the update request. For more information, see [Update, create, and delete handlers must satisfy desired-state stabilization](#).
 - An update handler MUST return IN_PROGRESS if it hasn't yet reached the desired-state.

An update handler SHOULD return a model containing all properties set so far and nothing more during each IN_PROGRESS event.

- An update handler MUST return FAILED progress event if it can't reach the desired-state within the timeout specified in the resource schema.

The progress event MUST return an error message and the most applicable error code. For more information, see [Handler error codes](#).

- An update handler MAY return SUCCESS once it reaches the desired-state.

Once the desired state has been reached, an update handler MAY perform runtime-state stabilization. For more information, see [Update and create handlers should satisfy runtime-state stabilization](#).

When the update handler returns SUCCESS, it MUST return a ProgressEvent object containing a model that satisfies the following requirements:

- All properties specified in the update request MUST be present in the model returned, and they MUST match exactly, with the exception of properties defined as writeOnlyProperties in the resource schema.
- The model MUST contain all properties that have values, including any properties that have default values, and any readOnlyProperties as defined in the resource schema.
- The model MUST NOT return any properties that are null or don't have values.

All list or collection properties MUST be applied in full. The successful outcome MUST be replacement of the previous properties, if any.

- An update handler MUST return FAILED with a NotFound error code if the resource didn't exist before the update request.
- An update handler MUST NOT create a new physical resource.

Delete handlers

Input assumptions

The delete handler can make the following assumptions about input submitted to it:

- The input to a delete handler MUST contain either the primaryIdentifier or an additionalIdentifier. Any other properties MAY NOT be included in the request.

Output requirements

The `delete` handler must adhere to the following requirements:

- A `delete` handler MUST always return a `ProgressEvent` object within 60 seconds. For more information, see [ProgressEvent Object Schema](#).
- A `delete` handler MUST NOT return `SUCCESS` until the resource has reached the desired state for deletion. For more information, see [Update, create, and delete handlers must satisfy desired-state stabilization](#).
- A `delete` handler MUST return `IN_PROGRESS` if it hasn't yet reached the desired state.
- A `delete` handler MUST return `FAILED` progress event if it can't reach the desired-state within the timeout specified in the resource schema.

The progress event MUST return an error message and the most applicable error code. For more information, see [Handler error codes](#).

- A `delete` handler MUST return `SUCCESS` once it reaches the desired state. (This is because there is no runtime-state stabilization for delete requests.)

When the `delete` handler returns `SUCCESS`, the `ProgressEvent` object MUST NOT contain a model.

- A `delete` handler MUST return `FAILED` with a `NotFound` error code if the resource didn't exist before the delete request.
- Once a `delete` operation successfully completes, any subsequent `update`, `delete`, or `read` request for the deleted resource instance MUST return `FAILED` with a `NotFound` error code.
- Once a `delete` operation successfully completes, any subsequent `list` operation MUST NOT return the `primaryIdentifier` associated with the deleted resource instance.

If the `list` operation is paginated, the 'list operation' is defined as all `list` calls until the `nextToken` is `null`.

- Once a `delete` operation successfully completes, a subsequent `create` request with the same `primaryIdentifier` or `additionalIdentifiers` MUST NOT return `FAILED` with an `AlreadyExists` error code.
- Once a `delete` operation successfully completes, the resource SHOULD NOT be billable to the client.

Read handlers

Input assumptions

The read handler can make the following assumptions about input submitted to it:

- The input to a read handler MUST contain either the `primaryIdentifier` or an `additionalIdentifier`. Any other properties MAY NOT be included in the request.

Output requirements

The read handler must adhere to the following requirements regarding its output:

- A read handler MUST always return a `ProgressEvent` object within 30 seconds. For more information, see [ProgressEvent Object Schema](#).

A read handler MUST always return a status of `SUCCESS` or `FAILED`; it MUST NOT return a status of `IN_PROGRESS`.

- A read handler MUST return a model representation that conforms to the shape of the resource schema.

- The model **MUST** contain all properties that have values, including any properties that have default values and any `readOnlyProperties` as defined in the resource schema.
- The model **MUST NOT** return any properties that are null or don't have values.
- A read handler **MUST** return `FAILED` with a `NotFound` error code if the resource doesn't exist.

List handlers

- A `list` handler **MUST** always return a `ProgressEvent` object within 30 seconds. For more information, see [ProgressEvent Object Schema](#).

A `list` handler **MUST** always return a status of `SUCCESS` or `FAILED`; it **MUST NOT** return a status of `IN_PROGRESS`.

- A `list` handler **MUST** return an array of primary identifiers.

When passed in a read request, each `primaryIdentifier` **MUST NOT** return `FAILED` with `NotFound` error code.

- A `list` request **MUST** support pagination by returning a `NextToken`.

The `NextToken` returned **MUST** be able to be used in a subsequent `list` request to retrieve the next set of results from the service.

The `NextToken` **MUST** be null when all results have been returned.

- A `list` request **MUST** return an empty array if there are no resources found.
- A `list` handler **MAY** accept a set of properties conforming to the shape of the resource schema as filter criteria.

The filter should use `AND(&)` when multiple properties are passed in.

Additional requirements

The following requirements also apply to resource handlers.

Returned models must conform to the shape of the schema

A model returned in a `ProgressEvent` object **MUST** always conform to the shape of the resource schema. This means that each property that's returned **MUST** adhere to its own individual restrictions: correct data type, regex, length, etc. However, the model returned **MAY NOT** contain all properties defined as required in the json-schema.

More specifically, contract tests validate models based on json-schema [Validation keywords](#).

- ALL Validation Keywords for the following **MUST** be observed:
 - Any Instance Type (Section 6.1)
 - Numeric Instances (Section 6.2)
 - Strings (Section 6.3)
 - Arrays (Section 6.4)
- All Validation Keywords for Objects (Section 6.5) **MUST** be observed **EXCEPT** for:
 - `required` (Section 6.5.3)
 - `dependencies` (Section 6.5.7)
 - `propertyNames` (Section 6.5.8)
- Contract tests won't validate Validation Keywords for:
 - Applying Subschemas Conditionally (Section 6.6)

- Applying Subschemas With Boolean Logic (Section 6.7)

Update, create, and delete handlers must satisfy desired-state stabilization

Stabilization is the process of waiting for a resource to be in a particular state. Note that reaching the desired-state is mandatory for all handlers before returning `SUCCESS`.

Create and update handlers

For Create and Update handlers, desired-state stabilization is satisfied when all properties specified in the request are applied as requested. This is verified by calling the Read handler.

In many cases, the desired-state is reached immediately upon completion of a Create/Update API call. However, in some cases, multiple API calls and or wait periods may be required in order to reach this state.

Eventual consistency in desired-state stabilization

Eventual consistency means that the result of an API command you run might not be immediately visible to all subsequent commands you run. Handling API eventual consistency is required as part of desired-state stabilization. This is because a subsequent Read call might fail with a `NotFound` error code.

Amazon EC2 resources are a great example of this. For more information, see [Eventual Consistency](#) in the *Amazon Elastic Compute Cloud API Reference*.

Examples of desired-state stabilization

For a simple example of desired-state stabilization, consider the implementation of the `create` handler for the `AWS::Logs::MetricFilter` resource: immediately after the handler code completes the call to the `PutMetricFilter` method, the `AWS::Logs::MetricFilter` has achieved its desired state. You can examine the code for this resource in its open-source repository at github.com/aws-cloudformation/aws-cloudformation-resource-providers-logs.

A more complex example is the implementation of the `update` handler for the `AWS::Kinesis::Stream` resource. The `update` handler must make multiple API calls during an update, including `AddTagsToStream` or `RemoveTagsFromStream`, `UpdateShardCount`, `IncreaseRetentionPeriod` or `DecreaseRetentionPeriod`, and `StartStreamEncryption` or `StopStreamEncryption`. Meanwhile, each API call will set the `StreamStatus` to `UPDATING`, during which time other API operations can't be performed or the API will throw a `ResourceInUseException`. Therefore, to reach the desired state, the handler will need to wait for the `StreamStatus` to become `ACTIVE` in between each API operation.

Delete handlers

Usually, the definition of *deleted* is obvious. A `delete` API operation will result in the resource being purged from the database, and the resource is no longer describable to the user.

However, sometimes, a deletion will result in the resource leaving an *audit trail*, in which the resource can still be described by service API operations, but can no longer be interacted with by the user. For example, when you delete a CloudFormation stack, it's assigned a status of `DELETE_COMPLETE`, but it can still be returned from a `DescribeStacks` API call. For resources like this, the desired-state for deletion is when the resource has reached a *terminal, inoperable, and irrecoverable state*. If the resource can continue to be mutated by the user through another API call, then it isn't *deleted*, it's *updated*.

There is no difference between desired-state stabilization and runtime-state stabilization for a delete handler. By definition, once a resource has reached the desired-state for deletion, a subsequent `read` call MUST return `FAILED` with a `NotFound` error code, and a subsequent `create` call with the same

`primaryIdentifier` or `additionalIdentifiers` MUST NOT return `FAILED` with an `AlreadyExists` error code. Additional restrictions are defined in the contract above.

So in the case of a CloudFormation stack, a `read` handler MUST return `FAILED` with a `NotFound` error code if the stack is `DELETE_COMPLETE`, even though its audit trail can still be accessed by the `DescribeStacks` API.

Update and create handlers should satisfy runtime-state stabilization

Runtime-state stabilization is a process of waiting for the resource to be "ready" to use. Generally, runtime-state stabilization is done by continually describing the resource until it reaches a particular state, though it can take many forms.

Runtime-state stabilization can mean different things for different resources, but the following are common requirements:

- *Additional mutating API calls can be made on the resource*

Some resources can't be modified while they're in a particular state.

- *Dependent resources can consume the resource*

There may be other resources which need to consume the resource in some way, but can't until it is in a particular state.

- *Users can interact with the resource*

Customers may not be able to use the resource until it is in a particular status. This usually overlaps with the dependent resources requirement, although there could be different qualifications, depending on the resources.

While desired-state stabilization is mandatory, runtime-state stabilization is optional but encouraged. Users have come to expect that once a resource is `COMPLETE`, they will be able to use it.

Examples of run-time stabilization

For a simple example of run-time stabilization, consider the implementation of the `create` handler for the `AWS::KinesisFirehose::DeliveryStream` resource. The `create` handler invokes only a single API, `CreateDeliveryStream`, in order for the resource to reach its desired state. Immediately after this API call is made, a `read` request will return the correct desired state. However, the resource still has not reached run-time stabilization because it can't be used by the customer or downstream resources until the `DeliveryStreamStatus` is `ACTIVE`.

For a more complex example, consider the implementation of the `update` handler for the `AWS::Kinesis::Stream` resource once again. Once the `update` handler has made its final call, to `StartStreamEncryption` or `StopStreamEncryption` as described in [Examples of desired-state stabilization](#), the resource has reached its desired state. However, like the other API calls on the Kinesis resource, the `StreamStatus` will again be set to `UPDATING`. During this period, it has reached its desired state, and customers can even continue using the stream. But it hasn't yet achieved runtime-stabilization, because additional API calls cannot be made on the resource until the `StreamStatus` gets set to `ACTIVE`.

Handlers must not leak resources

Resource leaking refers to when a handler loses track of the existence of a resource. This happens most often in the following cases:

- A `create` handler isn't idempotent. Re-invoking the handler with the same `idempotencyToken` will cause another resource to be created, and the handler is only tracking a single resource.

- A `create` handler creates the resource, but is unable to communicate an identifier for that resource back to CloudFormation. A subsequent `delete` call doesn't have enough information to delete the resource.
- A bug in the `delete` handler causes the resource to not actually be deleted, but the `delete` handler reports that the resource was successfully deleted.

Contract tests

As part of testing your resource, the CloudFormation CLI performs a suite of tests, each written to test a requirement contained in the [resource type handler contract](#) (p. 27). Each handler invocation is expected to follow the general requirements for that handler listed in the contract. This topic lists tests that explicitly test some more specific requirements.

create handler tests

The CloudFormation CLI performs the following contract tests for `create` handlers.

| Test | Description |
|-------------------------------------|---|
| <code>contract_create_create</code> | Creates a resource, waits for the resource creation to complete, and then creates the resource again with the expectation that the second create operation will fail with the <code>AlreadyExists</code> error code. This test isn't run for resources if the primary identifier or any additional identifiers are read-only. |
| <code>contract_create_read</code> | Creates a resource, waits for the resource creation to complete, and then reads the created resource to ensure that the input to the <code>create</code> handler is equal to the output from the <code>read</code> handler. The comparison ignores any read-only/generated properties in the <code>read</code> output, as <code>create</code> input can't specify these. It also ignores any write-only properties in the <code>create</code> input, as these are removed from <code>read</code> output to avoid security issues. |
| <code>contract_create_delete</code> | Creates a resource, waits for the resource creation to complete, and then deletes the created resource. It also checks if the <code>create</code> input is equal to the <code>create</code> output (which is then used for <code>delete</code> input), with the exception of <code>readOnly</code> and <code>writeOnly</code> properties. |
| <code>contract_create_list</code> | Creates a resource, waits for the resource creation to complete, and then lists out the resources with the expectation that the created resource exists in the returned list. |

update handler tests

The CloudFormation CLI performs the following contract tests for `update` handlers.

| Test | Description |
|-----------------------------------|---|
| <code>contract_update_read</code> | Creates a resource, updates the resource, and then reads the resource to check that the update was made by comparing the <code>read</code> output with the <code>update</code> input. The comparison excludes read-only and write-only properties because they can't be included in the <code>update</code> input and <code>read</code> output, respectively. |

| Test | Description |
|---|--|
| <code>contract_update_list</code> | Creates a resource, updates the resource, and then lists the resource to check that the updated resource exists in the returned list. |
| <code>contract_update_without_create</code> | Updates a resource without creating it first. The test expects the update operation to fail with the <code>NotFound</code> error code. |

delete handler tests

The CloudFormation CLI performs the following contract tests for delete handlers.

| Test | Description |
|-------------------------------------|---|
| <code>contract_delete_create</code> | Creates a resource, deletes the resource, and then creates the resource again with the expectation that the deletion was successful and a new resource can be created. The CloudFormation CLI performs this contract test for resources with create-only primary identifiers. |
| <code>contract_delete_update</code> | Creates a resource, deletes the resource, and then updates the resource with the expectation that the update operation will fail with the <code>NotFound</code> error code. |
| <code>contract_delete_read</code> | Creates a resource, deletes the resource, and then reads the resource with the expectation that the read operation will fail with the <code>NotFound</code> error code. |
| <code>contract_delete_list</code> | Creates a resource, deletes the resource, and then lists the resource with the expectation that the returned list doesn't contain the deleted resource. |
| <code>contract_delete_delete</code> | Creates a resource, deletes the resource, and then deletes the resource again with the expectation that the second delete operation will fail with the <code>NotFound</code> error code. |

Handler error codes

One of the following error codes MUST be returned from the handler whenever there is a [progress event](#) with an operation status of `FAILED`.

- `AccessDenied`

The customer has insufficient permissions to perform this request.

Type: Terminal

- `AlreadyExists`

The specified resource already existed before the execution of this handler. This error is applicable to create handlers only.

Type: Terminal

- `GeneralServiceException`

The downstream service generated an error that doesn't map to any other handler error code.

Type: Terminal

- `InternalFailure`

An unexpected error occurred within the handler.

Type: Terminal

- `InvalidCredentials`

The credentials provided by the user are invalid.

Type: Terminal

- `InvalidRequest`

Invalid input from the user has generated a generic exception.

Type: Terminal

- `NetworkFailure`

The request couldn't be completed due to networking issues, such as a failure to receive a response from the server.

Type: Retriable

- `NotFound`

The specified resource doesn't exist, or is in a terminal, inoperable, and irrecoverable state.

Type: Terminal

- `NotStabilized`

The downstream resource failed to complete all of its ready-state checks.

Type: Terminal

- `NotUpdatable`

The user has requested an update to a property defined in the resource type schema as a [create-only property](#). This error is applicable to update handlers only.

Type: Terminal

- `ResourceConflict`

The resource is temporarily unavailable to be acted upon. For example, if the resource is currently undergoing an operation and can't be acted upon until that operation is finished.

Type: Retriable

- `ServiceInternalError`

The downstream service returned an internal error, typically with a 5XX HTTP Status code.

Type: Retriable

- `ServiceLimitExceeded`

A non-transient resource limit was reached on the service side.

Type: Terminal

- `Throttling`

The request was throttled by a downstream service.

Type: Retriable

ProgressEvent object schema

A `ProgressEvent` is a JSON object which represents the current operation status of the handler, the current live state of the resource, and any additional resource information the handler wishes to communicate to the CloudFormation CLI. Each handler **MUST** communicate a progress event to the CloudFormation CLI under certain circumstances, and **SHOULD** communicate a progress event under others. For more information, see [Handler Communication Contract](#).

A handler **MAY** use progress events on a re-invocation to continue work from where it left off. For a detailed discussion of this, see [Progress chaining, stabilization and callback pattern](#).

Syntax

Below is the syntax for the `ProgressEvent` object.

```
{
  "OperationStatus": "string",
  "HandlerErrorCode": "string",
  "Message": "string",
  "CallbackContext": "string",
  "CallbackDelaySeconds": "string",
  "ResourceModel": "string",
  "ResourceModels": [
    "string"
  ],
  "NextToken": "string",
}
```

Properties

OperationStatus

Indicates whether the handler has reached a terminal state or is still computing and requires more time to complete.

Values: `PENDING` | `IN_PROGRESS` | `SUCCESS` | `FAILED`

Required: No

HandlerErrorCode

A handler error code should be provided when the event operation status is `FAILED` or `IN_PROGRESS`.

For a list of handler error codes, see [Handler Error Codes](#).

Required: Conditional. A handler error codes **MUST** be returned from the handler whenever there is a progress event with an operation status of `FAILED`.

Message

Information which can be shown to users to indicate the nature of a progress transition or callback delay.

Required: No

CallbackContext

Arbitrary information which the handler can return in an event with operation status of `IN_PROGRESS`, to allow the passing through of additional state or metadata between subsequent retries. For example, to pass through a resource identifier which can be used to continue polling for stabilization.

For more detailed examples, see [Progress chaining, stabilization and callback pattern](#).

Required: No

CallbackDelaySeconds

A callback will be scheduled with an initial delay of no less than the number of seconds specified.

Set this value to less than 0 to indicate no callback should be made.

Required: No

ResourceModel

Resource model returned by a `read` or `list` operation response for synchronous results, or for final response validation/confirmation by `create`, `update`, and `delete` operations.

Required: No

ResourceModels

List of resource models returned by a `list` operation response for synchronous results.

Required: Conditional. Required for List handlers.

NextToken

Token used to request additional pages of resources from a `list` operation response.

Required: Conditional. Required for List handlers.

Progress chaining, stabilization, and callback pattern

Often when you develop CloudFormation resource types, when interacting with web service APIs you need to chain them in sequence to apply the desired state. CloudFormation provides a framework to write these chain patterns. The framework does a lot of the heavy lifting needed to handle error conditions, throttle when calling downstream API, and more. The framework provides callbacks that the handler can use to inspect and change the behavior when making these service calls.

Most web service API calls follows a typical pattern:

1. Initiate the call context for the API.
2. Transform the incoming resource model properties to the underlying service API request.
3. Make the service call.
4. (Optional) Handle errors.
5. (Optional) Handle stabilization (if you need resource to be in a specific state before you apply the next state).
6. Finalize progress to the next part of the call chain, or indicate successful completion.

In writing the handler, you don't need to do anything special with replay/continuation semantics. The framework ensures that the call chain is effectively resumed from where it was halted. This is essentially useful when the wait time for resource stabilization runs into minutes or even hours.

Sample: Amazon Kinesis Data Streams integration

The following resource model is an example integration for a Kinesis Data Streams operation.

```
{
  "typeName": "AWS::Kinesis::Stream",
  "description": "Resource Type definition for AWS::Kinesis::Stream",
  "definitions": {
    ...
  },
  "properties": {
    "Arn": {
      "type": "string"
    },
    "Name": {
      "type": "string",
      "pattern": "[a-zA-Z0-9_.-]+"
    },
    "RetentionPeriodHours": {
      "type": "integer",
      "minimum": 24,
      "maximum": 168
    },
    "ShardCount": {
      "type": "integer",
      "minimum": 1,
      "maximum": 100000
    },
    "StreamEncryption": {
      "$ref": "#/definitions/AWSKinesisStreamStreamEncryption"
    },
    "Tags": {
      "type": "array",
      "uniqueItems": true,
      "items": {
        "$ref": "#/definitions/Tag"
      },
      "maximum": 50
    }
  }
}
...
}
```

And a sample CloudFormation template for creating this resource in a stack:

```
---
AWSTemplateFormatVersion: '2010-09-09'
Description: AWS MetricFilter
Resources:
  KinesisStream:
    Type: AWS::Kinesis::Stream
    Properties:
      ShardCount: 100
      RetentionPeriodHours: 36
      Tags:
        - Key: '1'
          Value: one
        - Key: '2'
          Value: two
      StreamEncryption:
        EncryptionType: KMS
        KeyId: alias/KinesisEncryption
```

For Kinesis, the stream must first be created with a name and shard count, then tags can be applied, followed by encryption. After creating a stream, but before any other configuration can be applied, the stream must be in an ACTIVE state.

Here is the example of the using the progress-chaining and callback pattern to apply state consistently. Note that much of the error handling is delegated to the framework. The CloudFormation CLI provides some error handling on interpreting errors that can be retried after a delay. The framework provides a fluent API that guides the developer with the right set of calls with strong typing and code completion capabilities in IDEs.

```
public class CreateHandler extends BaseKinesisHandler {
    //
    // The handler is provide with a AmazonWebServicesClientProxy that provides
    // the framework for making calls that returns a ProgressEvent,
    // which can then be chained to perform the next task.
    //
    protected ProgressEvent<ResourceModel, CallbackContext>
        handleRequest(final AmazonWebServicesClientProxy proxy,
                    final ResourceHandlerRequest<ResourceModel> request,
                    final CallbackContext callbackContext,
                    final ProxyClient<KinesisClient> client,
                    final Logger logger) {

        ResourceModel model = request.getDesiredResourceState();
        if (model.getName() == null || model.getName().isEmpty()) {
            model.setName(
                IdentifierUtils.generateResourceIdentifier(
                    "stream-", request.getClientRequestToken(), 128));
        }
        //
        // 1) initiate the call context, we are making createStream API call
        //
        return proxy.initiate(
            "kinesis:CreateStream", client, model, callbackContext)

            //
            // 2) transform Resource model properties to CreateStreamRequest API
            //
            .request((m) ->
                CreateStreamRequest.builder()
                    .streamName(m.getName()).shardCount(m.getShardCount()).build())

            //
            // 3) Make a service call. Handler does not worry about credentials, they
            // are auto injected
            //
            .call((r, c) ->
                c.injectCredentialsAndInvokeV2(r, c.client()::createStream))

            //
            // provide stabilization callback. The callback is provided with
            // the following parameters
            // a. CreateStreamRequest the we transformed in request()
            // b. CreateStreamResponse that the service returned with successful call
            // c. ProxyClient<Kinesis>, we provided in initiate call
            // d. ResourceModel we provided in initiate call
            // f. CallbackContext callback context.
            //
            //
            .stabilize((_request, _response, _client, _model, _context) ->
                isStreamActive(client1, _model, context))

            //
            // Once ACTIVE return progress
    }
}
```

```
//  
.progress()  
  
//  
// we then chain to next state, setting tags on the resource.  
// we receive ProgressEvent object from .progress().  
//  
.then(r -> {  
    Set<Tag> tags = model.getTags();  
    if (tags != null && !tags.isEmpty()) {  
        return setTags(proxy, client, model, callbackContext, false, logger);  
    }  
    return r;  
})  
  
//  
// we then setRetention...  
//  
.then(r -> {  
    Integer retention = model.getRetentionPeriodHours();  
    if (retention != null) {  
        return handleRetention(proxy, client, model, DEFAULT_RETENTION,  
retention, callbackContext, logger);  
    }  
    return r;  
})  
  
... // other steps  
  
//  
// finally we wait for Kinesis stream to be ACTIVE  
//  
.then((r) -> waitForActive(proxy, client, model, callbackContext))  
  
//  
// we then delete to ReadHandler to read the live state and send  
// back successful response.  
//  
.then((r) -> new ReadHandler()  
    .handleRequest(proxy, request, callbackContext, client, logger));  
}  
}
```

How to make other calls

The same pattern shown here for `CreateStreamRequest` is followed with others as well. The following is `handleRetention` code:

```
protected ProgressEvent<ResourceModel, CallbackContext>  
    handleRetention(final AmazonWebServicesClientProxy proxy,  
                    final ProxyClient<KinesisClient> client,  
                    final ResourceModel model,  
                    final int previous,  
                    final int current,  
                    final CallbackContext callbackContext,  
                    final Logger logger) {  
  
    if (current > previous) {  
        //  
        // 1) initiate the call context, we are making IncreaseRetentionPeriod API  
call  
        //  
        return proxy.initiate(  
            "kinesis:IncreaseRetentionPeriod:" + getClass().getSimpleName(),
```

```
        client, model, callbackContext)
        //
        // 2) transform Resource model properties to
IncreaseStreamRetentionPeriodRequest API
        //
        .request(m ->
            IncreaseStreamRetentionPeriodRequest.builder()
                .retentionPeriodHours(current)
                .streamName(m.getName()).build())
        //
        // 3) Make a service call. Handler does not worry about credentials, they
        //     are auto injected

        // Add important comments like shown below
        // https://docs.aws.amazon.com/kinesis/latest/APIReference/
API_IncreaseStreamRetentionPeriod.html
        // When applying change if stream is not ACTIVE, we get ResourceInUse.
        // We filter this expectation back off and then re-try to set this.

        //
        // set new retention period
        //
        .call((r, c) -> c.injectCredentialsAndInvokeV2(r,
c.client()::increaseStreamRetentionPeriod))

        //
        // Filter ResourceInUse or LimitExceeded.
        // Currently LimitExceeded is issued even for throttles
        //
        .exceptFilter(this::filterException).progress();
    } else {
        return proxy.initiate("kinesis:DecreaseRetentionPeriod:" +
getClass().getSimpleName(), client, model, callbackContext)
        //
        // convert to API model
        //
        .request(m ->
DecreaseStreamRetentionPeriodRequest.builder().retentionPeriodHours(current).streamName(m.getName())
            .build())
        ... // snipped for brevity
        .exceptFilter(this::filterException).progress();
    }
}

protected boolean filterException(AwsRequest request,
Exception e,
ProxyClient<KinesisClient> client,
ResourceModel model,
CallbackContext context) {
    return e instanceof ResourceInUseException ||
        e instanceof LimitExceededException;
}
```

Walkthrough: Develop a resource type

In this walkthrough, we'll use the CloudFormation CLI to create a sample resource type, `Example::Testing::WordPress`. This includes modeling the schema, developing the handlers to test those handlers, all the way to performing a dry run to get the resource type ready to submit to the CloudFormation registry. We'll be coding our new resource type in Java, and using the `us-west-2` Region.

Note

This walkthrough may reference sample resources that have been deleted. For a resource creation workflow, including a walkthrough of an example resource type in Python, see the [Resource Types walkthrough](#) in the [Amazon CloudFormation Workshop](#).

Prerequisites

For purposes of this walkthrough, it's assumed you have already set up the CloudFormation CLI and associated tooling for your Java development environment:

[Setting up your environment for developing extensions \(p. 1\)](#)

Create the resource type development project

Before we can actually design and implement our resource type, we'll need to generate a new resource type project, and then import it into our IDE.

Note

This walkthrough uses the Community Edition of the [IntelliJ IDEA](#).

Initiate the project

1. Use the `init` command to create your resource type project and generate the files it requires.

```
$ cfn init
Initializing new project
```

2. The `init` command launches a wizard that walks you through setting up the project, including specifying the resource name. For this walkthrough, specify `Example::Testing::WordPress`.

```
Enter resource type identifier (Organization::Service::Resource):
Example::Testing::WordPress
```

The wizard then enables you to select the appropriate language plugin. Currently, the only language plugin available is for Java:

```
One language plugin found, defaulting to java
```

3. Specify the package name. For this walkthrough, use `com.example.testing.wordpress`

```
Enter a package name (empty for default 'com.example.testing.wordpress'):
com.example.testing.wordpress
Initialized a new project in /workplace/tobflem/example-testing-wordpress
```

Initiating the project includes generating the files needed to develop the resource type. For example:

```
$ ls -l
README.md
example-testing-wordpress.json
lombok.config
pom.xml
rpdk.log
src
target
template.yml
```

Import the project into your IDE

In order to guarantee that any project dependencies are correctly resolved, you must import the generated project into your IDE with Maven support.

For example, if you are using IntelliJ IDEA, you would need to do the following:

1. From the **File** menu, choose **New**, then choose **Project From Existing Sources**.
2. Navigate to the project directory.
3. In the **Import Project** dialog box, choose **Import project from external model** and then choose **Maven**.
4. Choose **Next** and accept any defaults to complete importing the project.

Model the resource type

When you initiate the resource type project, an example resource type schema file is included to help start you modeling your resource type. This is a JSON file named for your resource, and contains an example of a typical resource type schema. In the case of our example resource, the schema file is named `example-testing-wordpress.json`.

1. In your IDE, open `example-testing-wordpress.json`.
2. Paste the following schema in place of the default example schema currently in the file.

This schema defines a resource, `Example::Testing::WordPress`, that provisions a WordPress site. The resource itself contains four properties, only two of which can be set by users: `Name`, and `SubnetId`. The other two properties, `InstanceId` and `PublicIp`, are read-only, meaning they can't be set by users, but will be assigned during resource creation. Both of these properties also serve as identifiers for the resource when it's provisioned.

As we'll see later in the walkthrough, creating a WordPress site actually requires more information than represented in our resource model. However, we'll be handling that information on behalf of the user in the code for the resource `create` handler.

```
{
  "typeName": "Example::Testing::WordPress",
  "description": "An example resource that creates a website based on WordPress 5.2.2.",
  "sourceUrl": "https://docs.aws.amazon.com/cloudformation-cli/latest/userguide/resource-type-walkthrough.html",
  "properties": {
    "Name": {
      "description": "A name associated with the website.",
      "type": "string",
      "pattern": "^[a-zA-Z0-9]{1,219}\\Z",
      "minLength": 1,
      "maxLength": 219
    },
    "SubnetId": {
      "description": "A subnet in which to host the website.",
      "pattern": "^(subnet-[a-f0-9]{13})|(subnet-[a-f0-9]{8})\\Z",
      "type": "string"
    },
    "InstanceId": {
      "description": "The ID of the instance that backs the WordPress site.",
      "type": "string"
    },
    "PublicIp": {
      "description": "The public IP for the WordPress site.",
      "type": "string"
    }
  }
}
```



```
    }
  },
  "required": [
    "Name",
    "SubnetId"
  ],
  "handlers": {
    "create": {
      "permissions": [
        "ec2:AuthorizeSecurityGroupIngress",
        "ec2:CreateSecurityGroup",
        "ec2>DeleteSecurityGroup",
        "ec2:DescribeInstances",
        "ec2:DescribeSubnets",
        "ec2:CreateTags",
        "ec2:RunInstances"
      ]
    },
    "read": {
      "permissions": [
        "ec2:DescribeInstances"
      ]
    },
    "delete": {
      "permissions": [
        "ec2>DeleteSecurityGroup",
        "ec2:DescribeInstances",
        "ec2:TerminateInstances"
      ]
    }
  },
  "additionalProperties": false,
  "primaryIdentifier": [
    "/properties/PublicIp",
    "/properties/InstanceId"
  ],
  "readOnlyProperties": [
    "/properties/PublicIp",
    "/properties/InstanceId"
  ]
}
```

3. Update the auto-generated files in the resource type package so that they reflect the changes we've made to the resource type schema.

When we first initiated the resource type project, the CloudFormation CLI generated supporting files and code for our resource type. Since we've made changes to the resource type schema, we'll need to regenerate that code to ensure that it reflects the updated schema. To do this, we use the generate command:

```
$ cfn generate
Generated files for Example::Testing::WordPress
```

Note

When using Maven, as part of the build process the `generate` command is automatically run before the code is compiled. So your changes will never get out of sync with the generated code.

Be aware the CloudFormation CLI must be in a location Maven/the system can find. For more information, see [Setting up your environment for developing extensions \(p. 1\)](#).

Implement the Resource handler

Now that we have our resource type schema specified, we can start implementing the behavior we want the resource type to exhibit during each resource operation. To do this, we'll have to implement the various event handlers, including:

- Adding any necessary dependencies
- Writing code to implement the various resource operation handlers.

Add dependencies

To actually make WordPress handlers that call the associated Amazon EC2 API operations, we need to declare the Amazon EC2 SDK as a dependency in Maven's pom.xml file. To enable this, we need to add a dependency on the [Amazon SDK for Java](#) to the project.

1. In your IDE, open the project's pom.xml file.
2. Add the following dependency in the dependencies section.

```
<dependency>
  <groupId>com.amazonaws</groupId>
  <artifactId>aws-java-sdk-ec2</artifactId>
  <version>1.11.606</version>
</dependency>
```

This artifact will be added by Maven from the [Maven Repository](#).

For more information on how to add dependencies, see the [Maven documentation](#).

Note

Depending on your IDE, you may have to take additional steps for your IDE to include the new dependency. In IntelliJ IDEA, a dialog should appear to enable you to import these changes. We recommend allowing automatic importing.

Implement the Create handler

With the necessary dependency specified, we can now start writing the handlers that actually implement the resource's functionality. For our example resource, we'll implement just the `create` and `delete` operation handlers.

To create a WordPress site, our resource `create` handler will have to accomplish the following:

- Gather and define inputs that we'll need to create the underlying Amazon resources on behalf of the user. These are details we're managing for them, since this is a very high-level resource type.
- Create an Amazon EC2 instance using a special AMI vended by Bitnami from the AMI Marketplace that bootstraps WordPress.
- Create a security group that the instance will belong to so you can access the WordPress site from your browser.
- Change the security group rules to dictate what the networking rules are for web access to the WordPress site.
- If something goes wrong with creating the resource, attempt to delete the security group.

Define the CallbackContext

Because our create handler is more complex than simply calling a single API, it takes some time to complete. However, each handler times out after one minute. To work around this issue, we'll write our handlers as state machines. A handler can exit with one of three states: `SUCCESS`, `IN_PROGRESS`, and `FAILED`. To wait on stabilization of underlying resources, we can return an `IN_PROGRESS` state with a `CallbackContext`. The `CallbackContext` will hold details about the current state of the execution. When we return an `IN_PROGRESS` state and a `CallbackContext`, CloudFormation will re-invoke the handler and pass the `CallbackContext` in with the request. You can then make decisions based on what is included in the context.

The `CallbackContext` is modeled as a POJO so you can define what information you want to pass between state transitions explicitly.

1. In your IDE, open the `CallbackContext.java` file, located in the `src/main/java/com/example/testing/wordpress` folder.
2. Replace the entire contents of the `CallbackContext.java` file with the following code.

```
package com.example.testing.wordpress;

import com.amazonaws.services.ec2.model.Instance;

import java.util.List;

import lombok.AllArgsConstructor;
import lombok.Builder;
import lombok.Data;
import lombok.NoArgsConstructor;

@Builder(toBuilder = true)
@Data
@NoArgsConstructor
@AllArgsConstructor
public class CallbackContext {
    private Instance instance;
    private Integer stabilizationRetriesRemaining;
    private List<String> instanceSecurityGroups;
}
```

Code the Create handler

1. In your IDE, open the `CreateHandler.java` file, located in the `src/main/java/com/example/testing/wordpress/CreateHandler.java` folder.
2. Replace the entire contents of the `CreateHandler.java` file with the following code.

```
package com.example.testing.wordpress;

import software.amazon.cloudformation.proxy.AmazonWebServicesClientProxy;
import software.amazon.cloudformation.proxy.Logger;
import software.amazon.cloudformation.proxy.OperationStatus;
import software.amazon.cloudformation.proxy.ProgressEvent;
import software.amazon.cloudformation.proxy.ResourceHandlerRequest;
import com.amazonaws.services.ec2.AmazonEC2;
import com.amazonaws.services.ec2.AmazonEC2ClientBuilder;
import com.amazonaws.services.ec2.model.AuthorizeSecurityGroupIngressRequest;
import com.amazonaws.services.ec2.model.CreateSecurityGroupRequest;
import com.amazonaws.services.ec2.model.DeleteSecurityGroupRequest;
import com.amazonaws.services.ec2.model.DescribeInstancesRequest;
import com.amazonaws.services.ec2.model.DescribeInstancesResult;
```

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```
import com.amazonaws.services.ec2.model.DescribeSubnetsRequest;
import com.amazonaws.services.ec2.model.DescribeSubnetsResult;
import com.amazonaws.services.ec2.model.Instance;
import com.amazonaws.services.ec2.model.InstanceNetworkInterfaceSpecification;
import com.amazonaws.services.ec2.model.IpPermission;
import com.amazonaws.services.ec2.model.IpRange;
import com.amazonaws.services.ec2.model.Reservation;
import com.amazonaws.services.ec2.model.RunInstancesRequest;
import com.amazonaws.services.ec2.model.Subnet;
import com.amazonaws.services.ec2.model.Tag;
import com.amazonaws.services.ec2.model.TagSpecification;

import java.util.List;
import java.util.UUID;

public class CreateHandler extends BaseHandler<CallbackContext> {
    private static final String SUPPORTED_REGION = "us-west-2";
    private static final String WORDPRESS_AMI_ID = "ami-04fb0368671b6f138";
    private static final String INSTANCE_TYPE = "m4.large";
    private static final String SITE_NAME_TAG_KEY = "Name";
    private static final String AVAILABLE_INSTANCE_STATE = "running";
    private static final int NUMBER_OF_STATE_POLL_RETRIES = 60;
    private static final int POLL_RETRY_DELAY_IN_MS = 5000;
    private static final String TIMED_OUT_MESSAGE = "Timed out waiting for instance to
become available.";

    private AmazonWebServicesClientProxy clientProxy;
    private AmazonEC2 ec2Client;

    @Override
    public ProgressEvent<ResourceModel, CallbackContext> handleRequest(
        final AmazonWebServicesClientProxy proxy,
        final ResourceHandlerRequest<ResourceModel> request,
        final CallbackContext callbackContext,
        final Logger logger) {

        final ResourceModel model = request.getDesiredResourceState();

        clientProxy = proxy;
        ec2Client =
AmazonEC2ClientBuilder.standard().withRegion(SUPPORTED_REGION).build();
        final CallbackContext currentContext = callbackContext == null ?

CallbackContext.builder().stabilizationRetriesRemaining(NUMBER_OF_STATE_POLL_RETRIES).build() :
            callbackContext;

        // This Lambda will continually be re-invoked with the current state of the
instance, finally succeeding when state stabilizes.
        return createInstanceAndUpdateProgress(model, currentContext);
    }

    private ProgressEvent<ResourceModel, CallbackContext>
createInstanceAndUpdateProgress(ResourceModel model, CallbackContext callbackContext) {
        // This Lambda will continually be re-invoked with the current state of the
instance, finally succeeding when state stabilizes.
        final Instance instanceStateSoFar = callbackContext.getInstance();

        if (callbackContext.getStabilizationRetriesRemaining() == 0) {
            throw new RuntimeException(TIMED_OUT_MESSAGE);
        }

        if (instanceStateSoFar == null) {
            return ProgressEvent.<ResourceModel, CallbackContext>builder()
                .resourceModel(model)
                .status(OperationStatus.IN_PROGRESS)
                .callbackContext(CallbackContext.builder()
```

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```
                .instance(createEC2Instance(model))
        .stabilizationRetriesRemaining(NUMBER_OF_STATE_POLL_RETRIES)
            .build()
        .build();
    } else if
(instanceStateSoFar.getState().getName().equals(AVAILABLE_INSTANCE_STATE)) {
        model.setInstanceId(instanceStateSoFar.getInstanceId());
        model.setPublicIp(instanceStateSoFar.getPublicIpAddress());
        return ProgressEvent.<ResourceModel, CallbackContext>builder()
            .resourceModel(model)
            .status(OperationStatus.SUCCESS)
            .build();
    } else {
        try {
            Thread.sleep(POLL_RETRY_DELAY_IN_MS);
        } catch (InterruptedException e) {
            throw new RuntimeException(e);
        }
        return ProgressEvent.<ResourceModel, CallbackContext>builder()
            .resourceModel(model)
            .status(OperationStatus.IN_PROGRESS)
            .callbackContext(CallbackContext.builder())
            .instance(updatedInstanceProgress(instanceStateSoFar.getInstanceId()))
            .stabilizationRetriesRemaining(callbackContext.getStabilizationRetriesRemaining() - 1)
                .build()
            .build();
    }
}

private Instance createEC2Instance(ResourceModel model) {
    final String securityGroupId = createSecurityGroupForInstance(model);
    final RunInstancesRequest runInstancesRequest = new RunInstancesRequest()
        .withInstanceType(INSTANCE_TYPE)
        .withImageId(WORDPRESS_AMI_ID)
        .withNetworkInterfaces(new InstanceNetworkInterfaceSpecification()
            .withAssociatePublicIpAddress(true)
            .withDeviceIndex(0)
            .withGroups(securityGroupId)
            .withSubnetId(model.getSubnetId()))
        .withMaxCount(1)
        .withMinCount(1)
        .withTagSpecifications(buildTagFromSiteName(model.getName()));

    try {
        return clientProxy.injectCredentialsAndInvoke(runInstancesRequest,
ec2Client::runInstances)
            .getReservation()
            .getInstances()
            .stream()
            .findFirst()
            .orElse(new Instance());
    } catch (Throwable e) {
        attemptToCleanUpSecurityGroup(securityGroupId);
        throw new RuntimeException(e);
    }
}

private String createSecurityGroupForInstance(ResourceModel model) {
    String vpcId;
    try {
        vpcId = getVpcIdFromSubnetId(model.getSubnetId());
    } catch (Throwable e) {
```

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```
        throw new RuntimeException(e);
    }

    final String securityGroupName = model.getName() + "-" +
UUID.randomUUID().toString();

    final CreateSecurityGroupRequest createSecurityGroupRequest = new
CreateSecurityGroupRequest()
        .withGroupName(securityGroupName)
        .withDescription("Created for the test WordPress blog: " + model.getName())
        .withVpcId(vpcId);

    final String securityGroupId =
        clientProxy.injectCredentialsAndInvoke(createSecurityGroupRequest,
ec2Client::createSecurityGroup)
            .getGroupId();

    final AuthorizeSecurityGroupIngressRequest authorizeSecurityGroupIngressRequest =
new AuthorizeSecurityGroupIngressRequest()
        .withGroupId(securityGroupId)
        .withIpPermissions(openHTTP(), openHTTPS());

    clientProxy.injectCredentialsAndInvoke(authorizeSecurityGroupIngressRequest,
ec2Client::authorizeSecurityGroupIngress);

    return securityGroupId;
}

private String getVpcIdFromSubnetId(String subnetId) throws Throwable {
    final DescribeSubnetsRequest describeSubnetsRequest = new
DescribeSubnetsRequest()
        .withSubnetIds(subnetId);

    final DescribeSubnetsResult describeSubnetsResult =
        clientProxy.injectCredentialsAndInvoke(describeSubnetsRequest,
ec2Client::describeSubnets);

    return describeSubnetsResult.getSubnets()
        .stream()
        .map(Subnet::getVpcId)
        .findFirst()
        .orElseThrow(() -> {
            throw new RuntimeException("Subnet " + subnetId +
" not found");
        });
}

private IpPermission openHTTP() {
    return new IpPermission().withIpProtocol("tcp")
        .withFromPort(80)
        .withToPort(80)
        .withIpv4Ranges(new IpRange().withCidrIp("0.0.0.0/0"));
}

private IpPermission openHTTPS() {
    return new IpPermission().withIpProtocol("tcp")
        .withFromPort(443)
        .withToPort(443)
        .withIpv4Ranges(new IpRange().withCidrIp("0.0.0.0/0"));
}

private TagSpecification buildTagFromSiteName(String siteName) {
    return new TagSpecification()
        .withResourceType("instance")
        .withTags(new Tag().withKey(SITE_NAME_TAG_KEY).withValue(siteName));
}
}
```

```
private Instance updatedInstanceProgress(String instanceId) {
    DescribeInstancesRequest describeInstancesRequest;
    DescribeInstancesResult describeInstancesResult;

    describeInstancesRequest = new
DescribeInstancesRequest().withInstanceIds(instanceId);
    describeInstancesResult =
clientProxy.injectCredentialsAndInvoke(describeInstancesRequest,
ec2Client::describeInstances);
    return describeInstancesResult.getReservations()
        .stream()
        .map(Reservation::getInstances)
        .flatMap(List::stream)
        .findFirst()
        .orElse(new Instance());
}

private void attemptToCleanUpSecurityGroup(String securityGroupId) {
    final DeleteSecurityGroupRequest deleteSecurityGroupRequest = new
DeleteSecurityGroupRequest().withGroupId(securityGroupId);
    clientProxy.injectCredentialsAndInvoke(deleteSecurityGroupRequest,
ec2Client::deleteSecurityGroup);
}
}
```

Update the Create handler unit test

Because our resource type is a high-level abstraction, a lot of implementation behavior isn't apparent by the name alone. As such, we'll need to make some additions to our unit tests so that we're not calling the live API operations that are necessary to create the WordPress site.

1. In your IDE, open the `CreateHandlerTest.java` file, located in the `src/test/java/com/example/testing/wordpress` folder.
2. Replace the entire contents of the `CreateHandlerTest.java` file with the following code.

```
package com.example.testing.wordpress;

import software.amazon.cloudformation.proxy.AmazonWebServicesClientProxy;
import software.amazon.cloudformation.proxy.Logger;
import software.amazon.cloudformation.proxy.OperationStatus;
import software.amazon.cloudformation.proxy.ProgressEvent;
import software.amazon.cloudformation.proxy.ResourceHandlerRequest;
import com.amazonaws.services.ec2.model.AuthorizeSecurityGroupIngressRequest;
import com.amazonaws.services.ec2.model.AuthorizeSecurityGroupIngressResult;
import com.amazonaws.services.ec2.model.CreateSecurityGroupRequest;
import com.amazonaws.services.ec2.model.CreateSecurityGroupResult;
import com.amazonaws.services.ec2.model.DescribeInstancesRequest;
import com.amazonaws.services.ec2.model.DescribeInstancesResult;
import com.amazonaws.services.ec2.model.DescribeSubnetsRequest;
import com.amazonaws.services.ec2.model.DescribeSubnetsResult;
import com.amazonaws.services.ec2.model.GroupIdentifier;
import com.amazonaws.services.ec2.model.Instance;
import com.amazonaws.services.ec2.model.InstanceState;
import com.amazonaws.services.ec2.model.Reservation;
import com.amazonaws.services.ec2.model.RunInstancesRequest;
import com.amazonaws.services.ec2.model.RunInstancesResult;
import com.amazonaws.services.ec2.model.Subnet;

import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
```

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```
import org.mockito.Mock;
import org.mockito.junit.jupiter.MockitoExtension;

import static org.assertj.core.api.Assertions.assertThat;
import static org.mockito.ArgumentMatchers.any;
import static org.mockito.Mockito.doReturn;
import static org.mockito.Mockito.mock;

@ExtendWith(MockitoExtension.class)
public class CreateHandlerTest {
    private static String EXPECTED_TIMEOUT_MESSAGE = "Timed out waiting for instance to
    become available.";

    @Mock
    private AmazonWebServicesClientProxy proxy;

    @Mock
    private Logger logger;

    @BeforeEach
    public void setup() {
        proxy = mock(AmazonWebServicesClientProxy.class);
        logger = mock(Logger.class);
    }

    @Test
    public void testSuccessState() {
        final InstanceState inProgressState = new InstanceState().withName("running");
        final GroupIdentifier group = new GroupIdentifier().withGroupId("sg-1234");
        final Instance instance = new
Instance().withInstanceId("i-1234").withState(inProgressState).withPublicIpAddress("54.0.0.0").with

        final CreateHandler handler = new CreateHandler();

        final ResourceModel model = ResourceModel.builder()
            .name("MyWordPressSite")
            .subnetId("subnet-1234")
            .build();

        final ResourceModel desiredOutputModel = ResourceModel.builder()
            .instanceId("i-1234")
            .publicIp("54.0.0.0")
            .name("MyWordPressSite")
            .subnetId("subnet-1234")
            .build();

        final ResourceHandlerRequest<ResourceModel> request =
ResourceHandlerRequest.<ResourceModel>builder()
            .desiredResourceState(model)
            .build();

        final CallbackContext context = CallbackContext.builder()
            .stabilizationRetriesRemaining(1)
            .instance(instance)
            .build();

        final ProgressEvent<ResourceModel, CallbackContext> response
            = handler.handleRequest(proxy, request, context, logger);

        assertThat(response).isNotNull();
        assertThat(response.getStatus()).isEqualTo(OperationStatus.SUCCESS);
        assertThat(response.getCallbackContext()).isNull();
        assertThat(response.getCallbackDelaySeconds()).isEqualTo(0);
        assertThat(response.getResourceModel()).isEqualTo(desiredOutputModel);
        assertThat(response.getResourceModels()).isNull();
    }
}
```


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```
        assertThat(response.getMessage()).isNull();
        assertThat(response.getErrorCode()).isNull();
    }

    @Test
    public void testInProgressStateInstanceCreationNotInvoked() {
        final InstanceState inProgressState = new InstanceState().withName("in-
progress");
        final GroupIdentifier group = new GroupIdentifier().withGroupId("sg-1234");
        final Instance instance = new
Instance().withState(inProgressState).withPublicIpAddress("54.0.0.0").withSecurityGroups(group);
        doReturn(new DescribeSubnetsResult().withSubnets(new
Subnet().withVpcId("vpc-1234")))
        .when(proxy).injectCredentialsAndInvoke(any(DescribeSubnetsRequest.class),
any());
        doReturn(new RunInstancesResult().withReservation(new
Reservation().withInstances(instance)))
        .when(proxy).injectCredentialsAndInvoke(any(RunInstancesRequest.class),
any());
        doReturn(new
CreateSecurityGroupResult().withGroupId("sg-1234"))
        .when(proxy).injectCredentialsAndInvoke(any(CreateSecurityGroupRequest.class),
any());
        doReturn(new
AuthorizeSecurityGroupIngressResult())
        .when(proxy).injectCredentialsAndInvoke(any(AuthorizeSecurityGroupIngressRequest.class),
any());

        final CreateHandler handler = new CreateHandler();

        final ResourceModel model =
ResourceModel.builder().name("MyWordPressSite").subnetId("subnet-1234").build();

        final ResourceHandlerRequest<ResourceModel> request =
ResourceHandlerRequest.<ResourceModel>builder()
            .desiredResourceState(model)
            .build();

        final ProgressEvent<ResourceModel, CallbackContext> response
            = handler.handleRequest(proxy, request, null, logger);

        final CallbackContext desiredOutputContext = CallbackContext.builder()
            .stabilizationRetriesRemaining(60)
            .instance(instance)
            .build();

        assertThat(response).isNotNull();
        assertThat(response.getStatus()).isEqualTo(OperationStatus.IN_PROGRESS);

        assertThat(response.getCallbackContext()).isEqualTo(ComparingFieldByField(desiredOutputContext));
        assertThat(response.getCallbackDelaySeconds()).isEqualTo(0);

        assertThat(response.getResourceModel()).isEqualTo(request.getDesiredResourceState());
        assertThat(response.getResourceModels()).isNull();
        assertThat(response.getMessage()).isNull();
        assertThat(response.getErrorCode()).isNull();
    }

    @Test
    public void testInProgressStateInstanceCreationInvoked() {
        final InstanceState inProgressState = new InstanceState().withName("in-
progress");
        final GroupIdentifier group = new GroupIdentifier().withGroupId("sg-1234");
        final Instance instance = new
Instance().withState(inProgressState).withPublicIpAddress("54.0.0.0").withSecurityGroups(group);
        final DescribeInstancesResult describeInstancesResult =
            new DescribeInstancesResult().withReservations(new
Reservation().withInstances(instance));
```

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```
doReturn(describeInstancesResult).when(proxy).injectCredentialsAndInvoke(any(DescribeInstancesRequest.class), any());

    final CreateHandler handler = new CreateHandler();

    final ResourceModel model =
ResourceModel.builder().name("MyWordPressSite").subnetId("subnet-1234").build();

    final ResourceHandlerRequest<ResourceModel> request =
ResourceHandlerRequest.<ResourceModel>builder()
        .desiredResourceState(model)
        .build();

    final CallbackContext context = CallbackContext.builder()
        .stabilizationRetriesRemaining(60)
        .instance(instance)
        .build();

    final ProgressEvent<ResourceModel, CallbackContext> response
        = handler.handleRequest(proxy, request, context, logger);

    final CallbackContext desiredOutputContext = CallbackContext.builder()
        .stabilizationRetriesRemaining(59)
        .instance(instance)
        .build();

    assertThat(response).isNotNull();
    assertThat(response.getStatus()).isEqualTo(OperationStatus.IN_PROGRESS);

    assertThat(response.getCallbackContext()).isEqualToComparingFieldByField(desiredOutputContext);
    assertThat(response.getCallbackDelaySeconds()).isEqualTo(0);

    assertThat(response.getResourceModel()).isEqualTo(request.getDesiredResourceState());
    assertThat(response.getResourceModels()).isNull();
    assertThat(response.getMessage()).isNull();
    assertThat(response.getErrorCode()).isNull();
}

@Test
public void testStabilizationTimeout() {
    final CreateHandler handler = new CreateHandler();

    final ResourceModel model =
ResourceModel.builder().name("MyWordPressSite").subnetId("subnet-1234").build();

    final ResourceHandlerRequest<ResourceModel> request =
ResourceHandlerRequest.<ResourceModel>builder()
        .desiredResourceState(model)
        .build();

    final CallbackContext context = CallbackContext.builder()
        .stabilizationRetriesRemaining(0)
        .instance(new
Instance().withState(new InstanceState().withName("in-progress")))
        .build();

    try {
        handler.handleRequest(proxy, request, context, logger);
    } catch (RuntimeException e) {
        assertThat(e.getMessage()).isEqualTo(EXPECTED_TIMEOUT_MESSAGE);
    }
}
}
```

Implement the Delete handler

We'll also need to implement a delete handler. At a high level, the delete handler needs to accomplish the following:

1. Find the security groups attached to the Amazon EC2 instance that's hosting the WordPress page.
2. Delete the instance.
3. Delete the security groups.

Again, we'll implement the delete handler as a state machine.

Code the Delete handler

1. In your IDE, open the `DeleteHandler.java` file, located in the `src/main/java/com/example/testing/wordpress` folder.
2. Replace the entire contents of the `DeleteHandler.java` file with the following code.

```
package com.example.testing.wordpress;

import software.amazon.cloudformation.proxy.AmazonWebServicesClientProxy;
import software.amazon.cloudformation.proxy.HandlerErrorCode;
import software.amazon.cloudformation.proxy.Logger;
import software.amazon.cloudformation.proxy.OperationStatus;
import software.amazon.cloudformation.proxy.ProgressEvent;
import software.amazon.cloudformation.proxy.ResourceHandlerRequest;
import com.amazonaws.services.ec2.AmazonEC2;
import com.amazonaws.services.ec2.AmazonEC2ClientBuilder;
import com.amazonaws.services.ec2.model.DeleteSecurityGroupRequest;
import com.amazonaws.services.ec2.model.DescribeInstancesRequest;
import com.amazonaws.services.ec2.model.DescribeInstancesResult;
import com.amazonaws.services.ec2.model.GroupIdentifier;
import com.amazonaws.services.ec2.model.Instance;
import com.amazonaws.services.ec2.model.Reservation;
import com.amazonaws.services.ec2.model.TerminateInstancesRequest;

import java.util.List;
import java.util.stream.Collectors;

public class DeleteHandler extends BaseHandler<CallbackContext> {
    private static final String SUPPORTED_REGION = "us-west-2";
    private static final String DELETED_INSTANCE_STATE = "terminated";
    private static final int NUMBER_OF_STATE_POLL_RETRIES = 60;
    private static final int POLL_RETRY_DELAY_IN_MS = 5000;
    private static final String TIMED_OUT_MESSAGE = "Timed out waiting for instance to terminate.";

    private AmazonWebServicesClientProxy clientProxy;
    private AmazonEC2 ec2Client;

    @Override
    public ProgressEvent<ResourceModel, CallbackContext> handleRequest (
        final AmazonWebServicesClientProxy proxy,
        final ResourceHandlerRequest<ResourceModel> request,
        final CallbackContext callbackContext,
        final Logger logger) {

        final ResourceModel model = request.getDesiredResourceState();

        clientProxy = proxy;
        ec2Client =
            AmazonEC2ClientBuilder.standard().withRegion(SUPPORTED_REGION).build();
```

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```
        final CallbackContext currentContext = callbackContext == null ?
CallbackContext.builder().stabilizationRetriesRemaining(NUMBER_OF_STATE_POLL_RETRIES).build() :
                                callbackContext;

        // This Lambda will continually be re-invoked with the current state of the
instance, finally succeeding when state stabilizes.
        return deleteInstanceAndUpdateProgress(model, currentContext);
    }

    private ProgressEvent<ResourceModel, CallbackContext>
deleteInstanceAndUpdateProgress(ResourceModel model, CallbackContext callbackContext) {

        if (callbackContext.getStabilizationRetriesRemaining() == 0) {
            throw new RuntimeException(TIMED_OUT_MESSAGE);
        }

        if (callbackContext.getInstanceSecurityGroups() == null) {
            final Instance currentInstanceState =
currentInstanceState(model.getInstanceId());

            if (DELETED_INSTANCE_STATE.equals(currentInstanceState.getState().getName()))
{
                return ProgressEvent.<ResourceModel, CallbackContext>builder()
                    .status(OperationStatus.FAILED)
                    .errorCode(HandlerErrorCode.NotFound)
                    .build();
            }

            final List<String> instanceSecurityGroups = currentInstanceState
                .getSecurityGroups()
                .stream()
                .map(GroupIdentifier::getGroupId)
                .collect(Collectors.toList());

            return ProgressEvent.<ResourceModel, CallbackContext>builder()
                .resourceModel(model)
                .status(OperationStatus.IN_PROGRESS)
                .callbackContext(CallbackContext.builder()

.stabilizationRetriesRemaining(NUMBER_OF_STATE_POLL_RETRIES)

.instanceSecurityGroups(instanceSecurityGroups)
                                .build())
                .build();
        }

        if (callbackContext.getInstance() == null) {
            return ProgressEvent.<ResourceModel, CallbackContext>builder()
                .resourceModel(model)
                .status(OperationStatus.IN_PROGRESS)
                .callbackContext(CallbackContext.builder()

.instance(deleteInstance(model.getInstanceId()))

.instanceSecurityGroups(callbackContext.getInstanceSecurityGroups())

.stabilizationRetriesRemaining(NUMBER_OF_STATE_POLL_RETRIES)
                                .build())
                .build();
        } else if
(callbackContext.getInstance().getState().getName().equals(DELETED_INSTANCE_STATE)) {
            callbackContext.getInstanceSecurityGroups().forEach(this::deleteSecurityGroup);
            return ProgressEvent.<ResourceModel, CallbackContext>builder()
                .resourceModel(model)
```

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```
        .status(OperationStatus.SUCCESS)
        .build();
    } else {
        try {
            Thread.sleep(POLL_RETRY_DELAY_IN_MS);
        } catch (InterruptedException e) {
            throw new RuntimeException(e);
        }
        return ProgressEvent.<ResourceModel, CallbackContext>builder()
            .resourceModel(model)
            .status(OperationStatus.IN_PROGRESS)
            .callbackContext(CallbackContext.builder())
            .instance(currentInstanceState(model.getInstanceId()))
            .instanceSecurityGroups(callbackContext.getInstanceSecurityGroups())
            .stabilizationRetriesRemaining(callbackContext.getStabilizationRetriesRemaining() - 1)
            .build();
    }
}

private Instance deleteInstance(String instanceId) {
    final TerminateInstancesRequest terminateInstancesRequest = new
    TerminateInstancesRequest().withInstanceIds(instanceId);
    return clientProxy.injectCredentialsAndInvoke(terminateInstancesRequest,
    ec2Client::terminateInstances)
        .getTerminatingInstances()
        .stream()
        .map(instance -> new
    Instance().withState(instance.getCurrentState()).withInstanceId(instance.getInstanceId()))
        .findFirst()
        .orElse(new Instance());
}

private Instance currentInstanceState(String instanceId) {
    DescribeInstancesRequest describeInstancesRequest;
    DescribeInstancesResult describeInstancesResult;

    describeInstancesRequest = new
    DescribeInstancesRequest().withInstanceIds(instanceId);
    describeInstancesResult =
    clientProxy.injectCredentialsAndInvoke(describeInstancesRequest,
    ec2Client::describeInstances);
    return describeInstancesResult.getReservations()
        .stream()
        .map(Reservation::getInstances)
        .flatMap(List::stream)
        .findFirst()
        .orElse(new Instance());
}

private void deleteSecurityGroup(String securityGroupId) {
    final DeleteSecurityGroupRequest deleteSecurityGroupRequest = new
    DeleteSecurityGroupRequest().withGroupId(securityGroupId);
    clientProxy.injectCredentialsAndInvoke(deleteSecurityGroupRequest,
    ec2Client::deleteSecurityGroup);
}
}
```

Update the Delete handler unit test

We'll also need to update the unit test for the delete handler.

1. In your IDE, open the `DeleteHandlerTest.java` file, located in the `src/test/java/com/example/testing/wordpress` folder.
2. Replace the entire contents of the `DeleteHandlerTest.java` file with the following code.

```
package com.example.testing.wordpress;

import software.amazon.cloudformation.proxy.AmazonWebServicesClientProxy;
import software.amazon.cloudformation.proxy.HandlerErrorCode;
import software.amazon.cloudformation.proxy.Logger;
import software.amazon.cloudformation.proxy.OperationStatus;
import software.amazon.cloudformation.proxy.ProgressEvent;
import software.amazon.cloudformation.proxy.ResourceHandlerRequest;
import com.amazonaws.services.ec2.model.DeleteSecurityGroupRequest;
import com.amazonaws.services.ec2.model.DeleteSecurityGroupResult;
import com.amazonaws.services.ec2.model.DescribeInstancesRequest;
import com.amazonaws.services.ec2.model.DescribeInstancesResult;
import com.amazonaws.services.ec2.model.GroupIdentifier;
import com.amazonaws.services.ec2.model.Instance;
import com.amazonaws.services.ec2.model.InstanceState;
import com.amazonaws.services.ec2.model.InstanceStateChange;
import com.amazonaws.services.ec2.model.Reservation;
import com.amazonaws.services.ec2.model.TerminateInstancesRequest;
import com.amazonaws.services.ec2.model.TerminateInstancesResult;

import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.mockito.Mock;
import org.mockito.junit.jupiter.MockitoExtension;

import java.util.Arrays;

import static org.assertj.core.api.Assertions.assertThat;
import static org.mockito.ArgumentMatchers.any;
import static org.mockito.Mockito.doReturn;
import static org.mockito.Mockito.mock;

@ExtendWith(MockitoExtension.class)
public class DeleteHandlerTest {
    private static String EXPECTED_TIMEOUT_MESSAGE = "Timed out waiting for instance to terminate.";

    @Mock
    private AmazonWebServicesClientProxy proxy;

    @Mock
    private Logger logger;

    @BeforeEach
    public void setup() {
        proxy = mock(AmazonWebServicesClientProxy.class);
        logger = mock(Logger.class);
    }

    @Test
    public void testSuccessState() {
        final DeleteSecurityGroupResult deleteSecurityGroupResult = new
DeleteSecurityGroupResult();
```

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```
doReturn(deleteSecurityGroupResult).when(proxy).injectCredentialsAndInvoke(any(DeleteSecurityGroupRequest.class), any());

    final DeleteHandler handler = new DeleteHandler();

    final ResourceModel model = ResourceModel.builder().instanceId("i-1234").build();

    final ResourceHandlerRequest<ResourceModel> request =
ResourceHandlerRequest.<ResourceModel>builder()
    .desiredResourceState(model)
    .build();

    final CallbackContext context = CallbackContext.builder()
                                                .stabilizationRetriesRemaining(1)

.instantiateSecurityGroups(Arrays.asList("sg-1234"))
                                                .instance(new
Instance().withState(new InstanceState().withName("terminated")))
                                                .build());

    final ProgressEvent<ResourceModel, CallbackContext> response
        = handler.handleRequest(proxy, request, context, logger);

    assertThat(response).isNotNull();
    assertThat(response.getStatus()).isEqualTo(OperationStatus.SUCCESS);
    assertThat(response.getCallbackContext()).isNull();
    assertThat(response.getCallbackDelaySeconds()).isEqualTo(0);

assertThat(response.getResourceModel()).isEqualTo(request.getDesiredResourceState());
    assertThat(response.getResourceModels()).isNull();
    assertThat(response.getMessage()).isNull();
    assertThat(response.getErrorCode()).isNull();
}

@Test
public void testHandlerInvokedWhenInstanceIsAlreadyTerminated() {
    final DescribeInstancesResult describeInstancesResult =
        new DescribeInstancesResult().withReservations(new
Reservation().withInstances(new Instance().withState(new
InstanceState().withName("terminated"))

        .withSecurityGroups(new GroupIdentifier().withGroupId("sg-1234"))));

doReturn(describeInstancesResult).when(proxy).injectCredentialsAndInvoke(any(DescribeInstancesRequest.class), any());

    final DeleteHandler handler = new DeleteHandler();

    final ResourceModel model = ResourceModel.builder().instanceId("i-1234").build();

    final ResourceHandlerRequest<ResourceModel> request =
ResourceHandlerRequest.<ResourceModel>builder()
    .desiredResourceState(model)
    .build();

    final ProgressEvent<ResourceModel, CallbackContext> response
        = handler.handleRequest(proxy, request, null, logger);

    assertThat(response).isNotNull();
    assertThat(response.getStatus()).isEqualTo(OperationStatus.FAILED);
    assertThat(response.getCallbackContext()).isNull();
    assertThat(response.getCallbackDelaySeconds()).isEqualTo(0);
    assertThat(response.getResourceModel()).isNull();
    assertThat(response.getResourceModels()).isNull();
    assertThat(response.getMessage()).isNull();
}
```

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```
        assertThat(response.getErrorCode()).isEqualTo(HandlerErrorCode.NotFound);
    }

    @Test
    public void testInProgressStateSecurityGroupsNotGathered() {
        final DescribeInstancesResult describeInstancesResult =
            new DescribeInstancesResult().withReservations(new
Reservation().withInstances(new Instance().withState(new
InstanceState().withName("running")))

                .withSecurityGroups(new GroupIdentifier().withGroupId("sg-1234"))));

doReturn(describeInstancesResult).when(proxy).injectCredentialsAndInvoke(any(DescribeInstancesRequest.class),
any());

        final DeleteHandler handler = new DeleteHandler();

        final ResourceModel model = ResourceModel.builder().instanceId("i-1234").build();

        final ResourceHandlerRequest<ResourceModel> request =
ResourceHandlerRequest.<ResourceModel>builder()
            .desiredResourceState(model)
            .build();

        final ProgressEvent<ResourceModel, CallbackContext> response
            = handler.handleRequest(proxy, request, null, logger);

        final CallbackContext desiredOutputContext = CallbackContext.builder()

.stabilizationRetriesRemaining(60)

.instanceSecurityGroups(Arrays.asList("sg-1234"))

                .build();

        assertThat(response).isNotNull();
        assertThat(response.getStatus()).isEqualTo(OperationStatus.IN_PROGRESS);

assertThat(response.getCallbackContext()).isEqualTo(ComparingFieldByFieldComparer.newInstance(desiredOutputContext));
        assertThat(response.getCallbackDelaySeconds()).isEqualTo(0);

assertThat(response.getResourceModel()).isEqualTo(request.getDesiredResourceState());
        assertThat(response.getResourceModels()).isNull();
        assertThat(response.getMessage()).isNull();
        assertThat(response.getErrorCode()).isNull();
    }

    @Test
    public void testInProgressStateSecurityGroupsGathered() {
        final InstanceState inProgressState = new InstanceState().withName("in-
progress");
        final TerminateInstancesResult terminateInstancesResult =
            new TerminateInstancesResult().withTerminatingInstances(new
InstanceStateChange().withCurrentState(inProgressState));

doReturn(terminateInstancesResult).when(proxy).injectCredentialsAndInvoke(any(TerminateInstancesRequest.class),
any());

        final DeleteHandler handler = new DeleteHandler();

        final ResourceModel model = ResourceModel.builder().instanceId("i-1234").build();

        final ResourceHandlerRequest<ResourceModel> request =
ResourceHandlerRequest.<ResourceModel>builder()
            .desiredResourceState(model)
            .build();

        final CallbackContext context = CallbackContext.builder()
```


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```

                                                                                   .stabilizationRetriesRemaining(60)
.instanceSecurityGroups(Arrays.asList("sg-1234"))
                                                                                   .build();

    final ProgressEvent<ResourceModel, CallbackContext> response
        = handler.handleRequest(proxy, request, context, logger);

    final CallbackContext desiredOutputContext = CallbackContext.builder()
.stabilizationRetriesRemaining(60)
.instanceSecurityGroups(context.getInstanceSecurityGroups())
Instance().withState(inProgressState)
                                                                                   .instance(new
                                                                                   .build());

    assertThat(response).isNotNull();
    assertThat(response.getStatus()).isEqualTo(OperationStatus.IN_PROGRESS);

assertThat(response.getCallbackContext()).isEqualToComparingFieldByField(desiredOutputContext);
    assertThat(response.getCallbackDelaySeconds()).isEqualTo(0);

assertThat(response.getResourceModel()).isEqualTo(request.getDesiredResourceState());
    assertThat(response.getResourceModels()).isNull();
    assertThat(response.getMessage()).isNull();
    assertThat(response.getErrorCode()).isNull();
}

@Test
public void testInProgressStateInstanceTerminationInvoked() {
    final InstanceState inProgressState = new InstanceState().withName("in-
progress");
    final GroupIdentifier group = new GroupIdentifier().withGroupId("sg-1234");
    final Instance instance = new
Instance().withState(inProgressState).withSecurityGroups(group);
    final DescribeInstancesResult describeInstancesResult =
        new DescribeInstancesResult().withReservations(new
Reservation().withInstances(instance));

doReturn(describeInstancesResult).when(proxy).injectCredentialsAndInvoke(any(DescribeInstancesRequest.class),
any());

    final DeleteHandler handler = new DeleteHandler();

    final ResourceModel model = ResourceModel.builder().instanceId("i-1234").build();

    final ResourceHandlerRequest<ResourceModel> request =
ResourceHandlerRequest.<ResourceModel>builder()
        .desiredResourceState(model)
        .build();

    final CallbackContext context = CallbackContext.builder()
                                                                                   .stabilizationRetriesRemaining(60)
                                                                                   .instance(new
Instance().withState(inProgressState).withSecurityGroups(group))
.instanceSecurityGroups(Arrays.asList("sg-1234"))
                                                                                   .build();

    final ProgressEvent<ResourceModel, CallbackContext> response
        = handler.handleRequest(proxy, request, context, logger);

    final CallbackContext desiredOutputContext = CallbackContext.builder()
.stabilizationRetriesRemaining(59)

```

```
.instanceSecurityGroups(context.getInstanceSecurityGroups())
Instance().withState(InProgressState).withSecurityGroups(group))
                                                    .instance(new
                                                    .build());

    assertThat(response).isNotNull();
    assertThat(response.getStatus()).isEqualTo(OperationStatus.IN_PROGRESS);

assertThat(response.getCallbackContext()).isEqualToComparingFieldByField(desiredOutputContext);
    assertThat(response.getCallbackDelaySeconds()).isEqualTo(0);

assertThat(response.getResourceModel()).isEqualTo(request.getDesiredResourceState());
    assertThat(response.getResourceModels()).isNull();
    assertThat(response.getMessage()).isNull();
    assertThat(response.getErrorCode()).isNull();
}

@Test
public void testStabilizationTimeout() {
    final DeleteHandler handler = new DeleteHandler();

    final ResourceModel model = ResourceModel.builder().instanceId("i-1234").build();

    final ResourceHandlerRequest<ResourceModel> request =
ResourceHandlerRequest.<ResourceModel>builder()
    .desiredResourceState(model)
    .build();

    final CallbackContext context = CallbackContext.builder()
                                                    .stabilizationRetriesRemaining(0)

.instanceSecurityGroups(Arrays.asList("sg-1234"))
                                                    .instance(new
Instance().withState(new InstanceState().withName("terminated")))
                                                    .build());

    try {
        handler.handleRequest(proxy, request, context, logger);
    } catch (RuntimeException e) {
        assertThat(e.getMessage()).isEqualTo(EXPECTED_TIMEOUT_MESSAGE);
    }
}
}
```

Test the resource type

Next, we'll use the Amazon SAM CLI to test locally that our resource will work as expected once we submit it to the CloudFormation registry. To do this, we'll need to define tests for the SAM to run against our create and delete handlers.

Create the SAM test files

1. Create two files:

- `package-root/sam-tests/create.json`
- `package-root/sam-tests/delete.json`

Where `package-root` is the root of the resource project. For our walkthrough example, the files would be:

- `example-testing-wordpress/sam-tests/create.json`

- `example-testing-wordpress/sam-tests/delete.json`

2. In `example-testing-wordpress/sam-tests/create.json`, paste the following test.

Note

Add the necessary information, such as credentials and log group name, and remove any comments in the file before testing.

To generate temporary credentials, you can use `aws sts get-session-token`.

For **credentials**, use temporary credentials of your personal Amazon Web Services account. For best practices, see [Set default credentials and Region](#) in the Amazon SDK for Java Developer Guide.

You will need the `accessKeyId`, `secretAccessKey`, and `sessionToken` with their corresponding values.

```
{
  "action": "CREATE",
  "request": {
    "clientRequestToken": "4b90a7e4-b790-456b-a937-0cfdfa211dfe", # Can be any UUID.
    "desiredResourceState": {
      "Name": "MyBlog",
      "SubnetId": "subnet-0bc6136e" # This should be a real subnet that exists in
the account you're testing against.
    },
    "logicalResourceIdentifier": "MyResource"
  },
  "callbackContext": null
}
```

3. In `example-testing-wordpress/sam-tests/delete.json`, paste the following test.

Note

Add the necessary information, such as credentials and log group name, and remove any comments in the file before testing.

To generate temporary credentials, you can use `aws sts get-session-token`.

For **credentials**, use temporary credentials of your personal Amazon Web Services account. For best practices, see [Set default credentials and Region](#) in the Amazon SDK for Java Developer Guide.

You will need the `accessKeyId`, `secretAccessKey`, and `sessionToken` with their corresponding values.

```
{
  "action": "DELETE",
  "request": {
    "clientRequestToken": "4b90a7e4-b790-456b-a937-0cfdfa211dfe", # Can be any UUID.
    "desiredResourceState": {
      "Name": "MyBlog",
      "InstanceId": "i-0167b19dd4c1efbf3", # This should be the instance ID that
was created in the "create.json" test.
      "SubnetId": "subnet-0bc6136e" # This should be a real subnet that exists in
the account you're testing against.
    },
    "logicalResourceIdentifier": "MyResource"
  },
  "callbackContext": null
}
```

Test the Create handler

Once you've created the `example-testing-wordpress/sam-tests/create.json` test file, you can use it to test your create handler.

Ensure Docker is running on your computer.

1. Invoke the SAM function from the resource package root directory using the following commands.

```
$ sam local invoke TestEntrypoint --event sam-tests/create.json
```

Note

Occasionally these tests will fail with a retry-able error. In such a case, run the tests again to determine whether the issue was transient.

Because the create handler was written as a state machine, invoking the tests will return an output that represents a state. For example:

```
{
  "callbackDelaySeconds": 0,
  "resourceModel": {
    "SubnetId": "subnet-0bc6136e",
    "Name": "MyBlog"
  },
  "callbackContext": {
    "instance": {
      "subnetId": "subnet-0bc6136e",
      "virtualizationType": "hvm",
      "capacityReservationSpecification": {
        "capacityReservationPreference": "open"
      },
      "amiLaunchIndex": 0,
      "elasticInferenceAcceleratorAssociations": [],
      "sourceDestCheck": true,
      "stateReason": {
        "code": "pending",
        "message": "pending"
      },
      "instanceId": "i-0b6978477c0e9d358",
      "vpcId": "vpc-eb80788e",
      "hypervisor": "xen",
      "rootDeviceName": "/dev/sda1",
      "productCodes": [],
      "state": {
        "code": 0,
        "name": "pending"
      },
      "architecture": "x86_64",
      "ebsOptimized": false,
      "imageId": "ami-04fb0368671b6f138",
      "blockDeviceMappings": [],
      "stateTransitionReason": "",
      "clientToken": "207dc686-e95c-4df9-8fcb-ee22bbdde963",
      "instanceType": "m4.large",
      "cpuOptions": {
        "threadsPerCore": 2,
        "coreCount": 1
      },
      "monitoring": {
        "state": "disabled"
      },
      "publicDnsName": "",
      "privateIpAddress": "172.0.0.133",
      "rootDeviceType": "ebs",
      "tags": [
        {
          "value": "MyBlog",
          "key": "Name"
        }
      ]
    }
  }
}
```

```
    }
  ],
  "launchTime": 1567718644000,
  "elasticGpuAssociations": [],
  "licenses": [],
  "networkInterfaces": [
    {
      "networkInterfaceId": "eni-0e450b35a159b60fe",
      "privateIpAddresses": [
        {
          "privateIpAddress": "172.0.0.133",
          "primary": true
        }
      ],
      "subnetId": "subnet-0bc6136e",
      "description": "",
      "groups": [
        {
          "groupName": "MyBlog-cbb70fca-4704-430b-b67b-7d6d550e0592",
          "groupId": "sg-063679dc7681610c3"
        }
      ],
      "ipv6Addresses": [],
      "ownerId": "671472782477",
      "sourceDestCheck": true,
      "privateIpAddress": "172.0.0.133",
      "interfaceType": "interface",
      "macAddress": "02:e1:4b:d1:f7:40",
      "attachment": {
        "attachmentId": "eni-attach-0a01c63e4b45c4a5d",
        "deleteOnTermination": true,
        "deviceIndex": 0,
        "attachTime": 1567718644000,
        "status": "attaching"
      },
      "vpcId": "vpc-eb80788e",
      "status": "in-use"
    }
  ],
  "privateDnsName": "ip-172-0-0-133.us-west-2.compute.internal",
  "securityGroups": [
    {
      "groupName": "MyBlog-cbb70fca-4704-430b-b67b-7d6d550e0592",
      "groupId": "sg-063679dc7681610c3"
    }
  ],
  "placement": {
    "groupName": "",
    "tenancy": "default",
    "availabilityZone": "us-west-2b"
  }
},
"stabilizationRetriesRemaining": 60
},
"status": "IN_PROGRESS"
}
```

2. From the test response, copy the contents of the callbackContext, and paste it into the callbackContext section of the example-testing-wordpress/sam-tests/create.json file.
3. Invoke the TestEntrypoint function again.

```
$ sam local invoke TestEntrypoint --event sam-tests/create.json
```

If the resource has yet to complete provisioning, the test returns a response with a status of `IN_PROGRESS`. Once the resource has completed provisioning, the test returns a response with a status of `SUCCESS`. For example:

```
{
  "callbackDelaySeconds": 0,
  "resourceModel": {
    "InstanceId": "i-0b6978477c0e9d358",
    "PublicIp": "34.211.69.121",
    "SubnetId": "subnet-0bc6136e",
    "Name": "MyBlog"
  },
  "status": "SUCCESS"
}
```

4. Repeat the previous two steps until the resource has completed.

When the resource completes provisioning, the test response contains both its `PublicIp` and `InstanceId`:

- You can use the `PublicIp` value to navigate to the WordPress site.
- You can use the `InstanceId` value to test the delete handler, as described below.

Test the Delete handler

Once you've created the `example-testing-wordpress/sam-tests/delete.json` test file, you can use it to test your delete handler.

Ensure Docker is running on your computer.

1. Invoke the `TestEntrypoint` function from the resource package root directory using the following commands.

```
$ sam local invoke TestEntrypoint --event sam-tests/delete.json
```

Note

Occasionally these tests will fail with a retrievable error. In such a case, run the tests again to determine whether the issue was transient.

As with the create handler, the delete handler was written as a state machine, so invoking the test will return an output that represents a state.

2. From the test response, copy the contents of the `callbackContext`, and paste it into the `callbackContext` section of the `example-testing-wordpress/sam-tests/delete.json` file.
3. Invoke the `TestEntrypoint` function again.

```
$ sam local invoke TestEntrypoint --event sam-tests/delete.json
```

If the resource has yet to complete provisioning, the test returns a response with a status of `IN_PROGRESS`. Once the resource has completed provisioning, the test returns a response with a status of `SUCCESS`.

4. Repeat the previous two steps until the resource has completed.

Performing resource contract tests

Resource contract tests verify that the resource type schema you've defined properly catches property values that will fail when passed to the underlying APIs called from within your resource handlers. This provides a way of validating user input before passing it to the resource handlers. For example, in the `Example::Testing::WordPress` resource type provide schema (in the `example-testing-wordpress.json` file), we specified regex patterns for the `Name` and `SubnetId` properties, and set the maximum length of `Name` as 219 characters. Contract tests are intended to stress and validate those input definitions.

Specify resource contract test override values

The CloudFormation CLI performs resource contract tests using input that's generated from the patterns you define in your resource's property definitions. However, some inputs can't be randomly generated. For example, the `Example::Testing::WordPress` resource requires an actual subnet ID for testing, not just a string that matches the appearance of a subnet ID. To test this property, we need to include a file with actual values for the resource contract tests to use `overrides.json` at the root of our project that looks like this:

1. Navigate to the root of your project.
2. Create a file named `overrides.json`.
3. Include the following override, specifying an actual subnet ID to use when performing resource contract tests.

```
{
  "CREATE": {
    "/SubnetId": "subnet-0bc6136e" # This should be a real subnet that exists in the
    account you're testing against.
  }
}
```

Run the resource contract tests

To run resource contract tests, you'll need two shell sessions.

1. In a new session, run the following command:

```
$ sam local start-lambda
```

2. From the resource package root directory, in a session that's aware of the CloudFormation CLI, run the test command:

```
$ cfn test
```

The session that's running `sam local start-lambda` will display information about the status of your tests.

Submit the resource type

Once you have completed implementing and testing your resource provided, the final step is to submit it to the CloudFormation registry. This makes it available for use in stack operations in the account and region in which it was submitted.

- In a terminal, run the `submit` command to register the resource type in the `us-west-2` region.

```
cfn submit -v --region us-west-2
```

The CloudFormation CLI validates the included resource type schema, packages your resource provide project and uploads it to the CloudFormation registry, and then returns a registration token.

```
Validating your resource specification...  
Packaging Java project  
Creating managed upload infrastructure stack  
Managed upload infrastructure stack was successfully created  
Registration in progress with token: 3c27b9e6-dca4-4892-ba4e-3c0example
```

Resource type registration is an asynchronous operation. You can use the supplied registration token to track the progress of your type registration request using the [DescribeTypeRegistration](#) action of the CloudFormation API.

Note

If you update your resource type, you can submit a new version of that resource type. Every time you submit your resource type, CloudFormation generates a new version of that resource type. To set the default version of a resource type, use [set-type-default-version](#). For example:

```
aws cloudformation set-type-default-version \  
  --type "RESOURCE" \  
  --type-name "Example::Testing::WordPress" \  
  --version-id "00000002"
```

To retrieve information about the versions of a resource type, use [list-type-versions](#). For example:

```
aws cloudformation list-type-versions \  
  --type "RESOURCE" \  
  --type-name "Example::Testing::WordPress"
```

Provision the resource in a CloudFormation stack

Once the registration request for your resource type has completed successfully, you can create a stack including resources of that type.

Note

Use [DescribeTypeRegistration](#) to determine when your resource type is successfully registration registered with a status of COMPLETE. You should also see your new resource type listed in the CloudFormation console.

1. Save the following JSON as a stack template, with the name `stack.json`.

```
{  
  "AWSTemplateFormatVersion": "2010-09-09",  
  "Description": "WordPress stack",  
  "Resources": {  
    "MyWordPressSite": {  
      "Type": "Example::Testing::WordPress",  
      "Properties": {  
        "SubnetId": "subnet-0bc6136e", ## Note that this should be replaced with  
a subnet that exists in your account.  
        "Name": "MyWebsite"  
      }  
    }  
  }  
}
```



```
}  
}
```

2. Use the template to create a stack.

Note

This resource uses an official WordPress image on Amazon Web Services Marketplace. In order to create the stack, you'll first need to visit the [Amazon Web Services Marketplace](#) and accept the terms and subscribe.

Navigate to the folder in which you saved the `stack.json` file, and create a stack named `wordpress`.

```
aws cloudformation create-stack  
  --region us-west-2 \  
  --template-body "file://stack.json" \  
  --stack-name "wordpress"
```

As CloudFormation creates the stack, it should invoke your resource type create handler to provision a resource of type `Example::Testing::WordPress` as part of the `wordpress` stack.

As a final test of the resource type delete handler, you can delete the `wordpress` stack.

```
aws cloudformation delete-stack \  
  --region us-west-2 \  
  --stack-name wordpress
```

Resource type FAQ

Below are some Frequently Asked Questions about resource type development.

Updates

- **Q: My service API implements Update actions as an Upsert, can I implement my CloudFormation resource type in this way?**

A: No, CloudFormation requires that update actions to a non-existing resource always throw a `ResourceNotFoundException`.

Schema development

- **Q: How can I re-use existing schemas, or establish relationships to other resource types in my schema?**

A: Relationships and re-use are established using JSON Pointers. These are implemented using the `$ref` keyword in your resource type schema. Refer to [Modeling resource types for use in Amazon CloudFormation \(p. 6\)](#) for more information.

Permissions and authorization

- **Q: Why am I getting an `AccessDeniedException` for my Amazon API calls?**

A: If you are seeing errors in your logs related to `AccessDeniedException` for a Lambda Execution Role like:

```
A downstream service error occurred in a CREATE action on a
AWS::MyService::MyResource: com.amazonaws.services.logs.model.AWSLogsException: User:
arn:aws:sts::111122223333:assumed-role/
UluruResourceHandlerLambdaExecutionRole-123456789012pdx/AWS-MYService-MyResource-
Handler-1h344teffe is not authorized to perform: some:ApiCall on resource: some-resource
(Service: AWSLogs; Status Code: 400; Error Code: AccessDeniedException; Request ID:
36af0cec-a96a-11e9-b204-ddabexample)
```

This is an indication that you are attempting to create and invoke Amazon APIs using the default client, which is injected with environment credentials.

For resource types, you should use the passed-in `AmazonWebServicesClientProxy` object to make Amazon API calls, as in the following example.

```
SesClient client = ClientBuilder.getClient();
final CreateConfigurationSetRequest createConfigurationSetRequest =
    CreateConfigurationSetRequest.builder()
        .configurationSet(ConfigurationSet.builder()
            .name(model.getName())
            .build())
        .build();
proxy.injectCredentialsAndInvokeV2(createConfigurationSetRequest,
    client::createConfigurationSet);
```

- **Q: How do I specify credentials for non-Azure API calls?**

A: For non-Azure API calls which require authentication and authorization, you should create properties in your resource type which contain the credentials. Define these properties in the resource type schema as `writeOnlyProperties`.

Users can then provide their own credentials through their CloudFormation templates. We encourage the use of [dynamic references](#) in CloudFormation templates, which can use Amazon Secrets Manager to fetch credentials at runtime.

Resource type development

- **Q: Can I share functionality between resource by adding common functionality to the `BaseHandler`?**

A: Because the `BaseHandler` is code-generated, it cannot be edited.

- **Q: For Java development, is there a way to include multiple resources in a single maven project?**

A: Not currently. For security and manageability, the CloudFormation Registry registers each resource type as a separate, versioned, type. You could still share code through a shared package. Ideally, the wrapper layer does most of the boilerplate. If you see a need for more boilerplate, we would like to know how we can improve for that use case rather than combine types in a package, so please reach out to the team.

- **Q: Will `software.amazon.cloudformation.proxy.Logger` have debug/info/warning/error levels/?**

A: Currently, all log messages are emitted to CloudWatch, which has no built-in concept of log levels.

- **Q: Does CloudFormation have a sandbox environment I can use to test and experiment with my extensions?**

A: Using extensions from your private registry in stacks created in your account is the same as using a sandbox environment.

Testing

- **Q: For testing, when should I use `sam local invoke`, `cfn test` and `mvn test`?**

A: Use the various test capabilities for the test scenarios described below.

- `sam local invoke`: Creating custom integration test by passing in custom CloudFormation payloads and isolate specific handlers.
 - `cfn test`: Contract tests meant to cycle through CRUDL actions and ideally leave in a clean state (if tests pass).
 - `mvn test`: Used for Unit testing. The goal is to confirm that each method or unit of the resource performs as intended. It also helps to ensure that you have enough code coverage. We expect unit tests to mock dependencies and not create real resources.
- **Q: How do I get the latest changes for a contract test?**

A: Run `pip install cloudformation-cli cloudformation-cli-<language>-plugin --upgrade`.

- **Q: Where can I find the code for contract tests?**

A: You can find the code for the test suite at <https://github.com/aws-cloudformation/cloudformation-cli/tree/master/src/rpdk/core/contract/suite>.

- **Q: How do I check which version of contract tests I'm running?**

A: Run `pip freeze`. The output shows the CloudFormation CLI version. The list of all releases for the CloudFormation CLI can be found at <https://github.com/aws-cloudformation/cloudformation-cli/releases>.

- **Q: I found a bug in the contract tests. How do I report it?**

A: File an issue at <https://github.com/aws-cloudformation/cloudformation-cli/issues>.

- **Q: How can I contribute to the development of contract tests?**

A: Follow [these steps](#) to install a virtual development environment on your local machine.

- **Q: Contract tests time out on my local machine. How do I resolve this issue?**

A: Contract tests assert that `create`, `update`, and `delete` handlers return progress events every 60 seconds, and that `read` and `list` handlers complete in 30 seconds. If you see errors for tests timing out, you can increase the timeout by running contract tests with the following argument: `cfn test --enforce-timeout <value>`. The value specified is the new timeout threshold for the `read` and `list` handlers. The new threshold for the `create`, `update`, and `delete` handlers is double the value specified.

- **Q: How do I run one contract test at a time?**

A: You can run one contract test by running the following command: `cfn test -- -k <test-name>`.

- **Q: How do I define input files for contract tests?**

A: [Specifying input data for use in contract tests \(p. 21\)](#) describes how to pass an input for contract tests and what each file should contain.

- **Q: How do I fix the `json.decoder.JSONDecodeError: Expecting value: line 1 column 1 (char 0)` error?**

A: This exception message indicates that you might be running out of memory or time. Add the following lines under `Globals` in the `template.yaml` file in your code package.

```
Globals:
  Function:
```

```
Timeout: 180  
MemorySize: 256
```

- **Q: Why do create operations fail when the `primaryIdentifier` is null?**

A: The `create` handler should return the `primaryIdentifier` in the model. If the `primaryIdentifier` for your resource is a read-only property, you can update the returned model with the property or invoke the `read` handler in your `create` handler.

- **Q: Some tests fail because the input is not equal to the output. How do I fix this?**

A: Input-output comparisons check that all properties are exactly equal, except for read-only properties, write-only properties, defaults, `insertionOrder`, and `uniqueItems`.

- **Q: Can the update handler update create-only properties?**

A: No. The `update` handler cannot update create-only properties. These properties should remain the same in `update` models.

- **Q: Why does my `delete/read` handler fail with a `NotFound` or `InvalidRequest` error code?**

A: Ensure that your input to these handlers is correct. The `delete` and `read` handlers should be successfully invoked with just the `primaryIdentifier`. The `read` handler can also be invoked with `additionalIdentifiers`.

- **Q: Why do delete operations fail when `resourceModel` isn't null?**

A: The `delete` handler shouldn't return a model when successful. You need to redact the model from the returned progress event.

- **Q: All of my properties are marked as create-only properties. Why do the update contract tests keep running and failing?**

A: Remove the `update` block from the `handlers` section in your schema file.

- **Q: How do I fix permission issues during test execution?**

A: Check the exception message to see which permissions are missing. Add these permissions to `ExecutionRole` in the `resource-role.yaml` file in your code package.

Deployment

- **Q: Is the resource type interface guaranteed to be stable?**

A: The communication protocol between CloudFormation and your resource type package is subject to change. However this will be done in a backwards-compatible way, using versioned interfaces. This will be invisible to you as a developer and is managed as part of the CloudFormation managed platform.

The interface that your handlers implement inside your package is expected to be stable. We may introduce improvements, such as security fixes or other changes to the package, but these will be done with versioned dependency or CloudFormation CLI updates. You aren't required to upgrade your packages to publish them, only to incorporate these improvements.

Developing modules

Modules are a way for you to package resource configurations for inclusion across stack templates, in a transparent, manageable, and repeatable way. Use modules to encapsulate common service configurations and best practices as modular, customizable building blocks that users can then take and include in their stack templates. Modules enable you to capture and disseminate resource configurations that incorporate best practices, expert domain knowledge, and accepted guidelines (for areas such as security, compliance, governance, and industry regulations). Users can then include the module in their template without having to acquire deep knowledge of the intricacies of the resource implementation.

For example, a domain expert in networking could create a module that contains built-in security groups and ingress/egress rules that adhere to security guidelines. A user could then include that module in their template to provision secure networking infrastructure in their stack, without having to spend time figuring out how VPCs, subnets, security groups, and gateways work. And because modules are versioned, if security guidelines change over time, the module author can create a new version of the module that incorporates those changes.

A module can contain:

- Template sections, including resources to be provisioned from the module, along with any associated data, such as outputs or conditions. Modules can also contain other modules.
- Any *module parameters*, which enable you to specify custom values whenever the module is used.

Characteristics of modules include:

- *Predictability*: Because a module must adhere to its schema, the resources and other outputs provisioned from the module are predictable.
- *Reusability*: Develop a module once, then reuse it across multiple templates and accounts.
- *Traceability*: CloudFormation retains knowledge of which resources in a stack were provisioned from a module, enabling users to trace the source of resource changes.
- *Manageability*: Once you've registered a module, you can manage it through the CloudFormation registry, including versioning and account and region availability.

Users are able to register modules as private types in the CloudFormation registry for use in their accounts.

To use a module, users include it in their template as they would an individual resource, including specifying any necessary parameters for the module. When users initiate a stack operation, CloudFormation generates a processed template that resolves any included modules into the appropriate resources.

Users can use [change sets](#) to preview the resources to be added or updated before initiating the stack operation.

For more information about using a module in a template, see [Using modules to encapsulate and reuse resource configurations](#) in the *CloudFormation User Guide*.

Module structure

A module consists of two main pieces:

- A *template fragment*, which defines the resources and associated information you want to provision through use of the module, including any module parameters you define.

- A *module schema* that you generate based on the template fragment. The module schema declares the contract you defined in the template fragment, and is viewable to users in the CloudFormation registry.

Creating the module template fragment

The starting point for developing a module is the template fragment. The template fragment is a file that contains the information that defines the resources for CloudFormation to provision during stack operations, including:

- A **Resources** section that defines the resources to be provisioned.

The **Resources** section is required.

- Additional other template sections related for the provisioning of the resources as necessary, such as **Outputs** and **Conditions**.
- A **Parameters** section for any optional module-level parameters you want to define.

Much like [template parameters](#), module parameters enable the user to input custom values to a module from the template (or module) that contains it. The module can then use these values to set properties of the resources it contains.

Currently, CloudFormation supports template fragments written in JSON or YAML.

For example, the following template fragment creates an S3 bucket resource, and sets the `AccessControl` property to `Private` and the resource `DeletionPolicy` to `Retain`. In addition, the template fragment defines a module-level parameter, `VersioningConfigurationParam`, whose value is used to set the `VersioningConfiguration` status of the S3 bucket.

```
{
  "AWSTemplateFormatVersion": "2010-09-09",
  "Description": "A sample S3 Bucket module (AWS::SampleS3::Bucket::MODULE)",
  "Parameters": {
    "VersioningConfigurationParam": {
      "Description": "Versioning configuration",
      "Type": "String"
    }
  },
  "Resources": {
    "S3BucketName": {
      "Type": "AWS::S3::Bucket",
      "Properties": {
        "AccessControl": "Private",
        "VersioningConfiguration": {
          "Status": {
            "Ref": "VersioningConfigurationParam"
          }
        }
      }
    },
    "DeletionPolicy": "Retain"
  }
}
```

You can author template fragments manually, or use any tool that generates CloudFormation templates. For example, you can use the Amazon Cloud Development Kit (Amazon CDK) to synthesize one or more Amazon CDK [constructs](#) to produce a CloudFormation template, and then use that template as the basis for a module. For more information about the CDK, see the [Amazon Cloud Development Kit \(Amazon CDK\)](#).

Note

Be aware that regardless of the method you use to create a module's template fragment, it must adhere to the restrictions on what can be included in a template fragment for a module.

Considerations when authoring the template fragment

Keep in mind the following considerations when developing modules:

- Modules are, by design, predictable, and transparent. Because of this, you can't include features which can potentially result in external information or resources being imported into the module. These features include:
 - [Importing](#) stack values, using `Fn::ImportValue` intrinsic function.
 - [Exporting](#) stack values, using the `Export` field in the [Outputs](#) template section. (Use of the `Outputs` section is supported.)
 - [Macros](#), including use of the [Transform](#) template section or the `Fn::Transform` function.

This includes transforms provided by CloudFormation, such as `AWS::Include` and `AWS::Serverless`.

- [Nested stacks](#), which are represented in the template by the `AWS::CloudFormation::Stack` resource.
- [Stack sets](#), which are represented in the template by the `AWS::CloudFormation::StackSet` resource.
- Tags can't be specified at the module level. However:
 - You can assign tags to individual resources within the module, as you would assign tags to any resource.
 - You can use module parameters to set tag values.

Create the module parameter, and then have the tag you've assigned to individual resources within the module reference that module parameter. For more information, see [Using parameters to specify module values](#) in the *CloudFormation User Guide*.

- Tags you specify at the *stack* level are assigned to the individual resources derived from the module.
- Helper scripts specified at the module level don't propagate to the individual resources contained in the module when CloudFormation processes the template.
- Outputs specified in the module are propagated to outputs at the template level.

Each output will be assigned a logical ID that's a concatenation of the module logical name and the output name as defined in the module. For more information about outputs, see [Outputs](#) in the *CloudFormation User Guide*.

- Parameters specified in the module Aren't propagated to parameters at the template level.

However, you can create template-level parameters that reference module-level parameters. For more information, see [Using parameters to specify module values](#) in the *CloudFormation User Guide*.

Nesting modules

Modules can contain other modules. You can nest modules up to three levels deep. To include a module in your module, reference it in the `Resources` section of your template fragment, as you would any other resource. For an example, see [Specifying properties on resources in a child module from the parent module](#) in the *CloudFormation User Guide*.

Macros and modules

CloudFormation doesn't support inclusion of modules in macros. A module can't contain a macro.

For more information on macros, see [Using macros to perform custom processing](#) in the *CloudFormation User Guide*.

Defining parameters in a module

Much like template parameters, module parameters enable the user to input custom values to a module from the template (or module) that contains it. The module can then use these values to set properties of the resources it contains.

You define a module parameter as you would a template parameter. For detailed information about parameter requirements and definition, see [Parameters](#) in the *CloudFormation User Guide*.

[Dynamic references](#) aren't resolved when the module is processed by CloudFormation, but when the individual resources are created or updated during stack operations.

Module parameters don't count toward the parameter maximum for template parameters. For information on template parameters and their limits, see [Parameters](#) in the *CloudFormation User Guide*.

Parameters specified in the module are not propagated to parameters at the template level. However, you can create template-level parameters that reference module-level parameters.

For information on how users can specify parameter values in modules, see [Using parameters to specify module values](#) in the *CloudFormation User Guide*.

Specifying constraints for module parameters

Module parameters don't support [Constraint](#) enforcement. To perform constraint checking on a module parameter, create a template parameter with the desired constraints, then reference that template parameter in your module parameter.

Specifying policies on resources contained in a module

If you specify the following resource policy attributes at the module level, CloudFormation applies the policy attribute to *all* resources contained in the module:

- `DeletionPolicy`
- `UpdateReplacePolicy`

This doesn't include specifying the `Snapshot` option for `UpdateReplacePolicy`. Specify this option on the resource directly.

Policy attributes specified at a resource level override any specified at the module level.

You can't specify the following resource policy attributes at the module level:

- `CreationPolicy`
- `UpdatePolicy`

If you use a `DependsOn` attribute to specify that a resource in your template depends on a module, CloudFormation will finish provisioning *all* resources in the module before provisioning the dependent resource.

For more information on resource policies, see [Resource attribute reference](#) in the *CloudFormation User Guide*.

Generating the module schema

The module schema is generated from the template fragment, and defines the contract to which the module adheres, including defining the input it accepts and the possible resources it resolves to when included in a template.

To generate the module schema, use the `validate` command once you've authored your template fragment.

For example, suppose you created a module package and used the template fragment above. The `validate` command would result in the following module schema:

```
{
  "typeName": "AWS::SampleS3::Bucket::MODULE",
  "properties": {
    "VersioningConfigurationParam": {
      "description": "Version Configuration",
      "type": "string"
    }
  },
  "resources": {
    "type": "object",
    "properties": {
      "S3Bucket": {
        "$ref": "aws-s3-bucket.json"
      }
    }
  },
  "additionalProperties": false
}
```

For more information, see [Develop a module](#).

Model requirements for publishing a public module

If you want to make your module publicly available to all CloudFormation users, you can publish it to the CloudFormation registry. In order to publish your module, it must meet the following model requirements. Before publishing, use `TestType` to confirm your module meets these requirements.

For more information on publishing public extensions, see [Publishing extensions to make them available for public use](#).

- Public modules can contain other public modules as child modules, to a level of three deep.
- Public modules can't include circular dependencies on child modules, or vice versa.
- [Custom resources](#) aren't supported in public modules.
- Only public resources are supported in public modules. The public resources can be published by Amazon or third-parties.
- Any third-party public resources included in the module must include the necessary publisher information, as detailed in [Specifying publisher metadata for public third-party resources](#).
- The supported major versions listed in the module for a resource type must be subset of the supported major versions specified for the resource type in any child modules.

Specifying publisher metadata for public third-party resources

For any third-party public resources you include in your public module, you must specify additional publisher information. This enables CloudFormation to determine the resource type specified, and which versions of that resource the module supports. Specify the following properties in a `Metadata` element in your resource definition:

- `PublisherId`
The publisher ID of the resource type publisher.
- `RegionalPublisherId`

An array listing the regions in which the publisher is registered, with the publisher ID in each region.

- `OriginalTypeName`

The original type name of the resource type, as specified by the publisher.

- `SupportMajorVersions`

An array listing the major versions of the resource this module supports.

For example, the following module snippet adds a resource to the module. The module uses a type alias, `Module::DDB::Table`, for the resource type, but also includes the original type name, `Mongodb::DDB::Table`, so that CloudFormation can determine if the resource type is enabled in the user's account. The snippet also includes publisher ID information, in case multiple publishers have published public resource types of the same name, in addition to which major versions of the resource type that the module supports.

```
Resources:
  SampleDDB:
    Type: Module::DDB::Table
    Properties:
      TableName: xx
      IndexName: xxx
    Metadata:
      PublisherId: dfdxdfwed
      RegionalPublisherId:
        us-east-1: c34ntbnrb1
        us-west-2: eer332gfd
      OriginalTypeName:
        Mongodb::DDB::Table
      SupportMajorVersions: [1, 2, 3]
    .....
```

Develop a module using the CFN-CLI

Follow these basic steps to develop and register a module project.

1. In the CFN-CLI, use the `init` command to create a new project. The `init` command creates a `fragments` folder containing a sample fragment file named `sample.json`.

Follow the prompts. Specify that you want to create a **module(m)**, and enter the module name.

```
cfn init
Initializing new project
Do you want to develop a new resource(r) a module(m) or a hook(h)?
>> m
What is the name of your module type?
(<Organization>::<Service>::<Name>::MODULE)
>> My::Sample::SampleBucket::MODULE
```

2. Include your template fragment in the project.

In the `fragments` folder in the project, you should find a file named `sample.json`. This is the template fragment file. Author your template fragment in this file and save.

You can rename this file as necessary. The folder can only contain a single file.

For more information, see [Creating a module template fragment](#).

3. Use `validate` to validate your project. Fix any issues reported.

The `validate` command regenerates the module schema, based on the template fragment you included in the `fragments` folder. The module schema is located in the root folder, and named `schema.json`.

4. Use `submit` to register the module with CloudFormation, in the specified region. Registering a module makes it available for inclusion in CloudFormation templates.

Note

When you register your module using `submit`, CloudFormation regenerates your module schema based on the template fragment in your project. You can't specify a schema file directly. To specify a module schema file when registering a module, use `RegisterType` in the CloudFormation API.

For information about using modules in CloudFormation templates, see [Using modules](#) in the *CloudFormation Users Guide*.

Developing hooks

Hooks proactively inspect the configuration of your Amazon resources before provisioning. If non-compliant resources are found, Amazon CloudFormation returns a failure status and either fails the operation or provides a warning and allows the operation to continue based on the hook failure mode. You can use pre-built hooks or build your own hooks using the CloudFormation Command Line Interface (CloudFormation CLI).

You can use hooks to proactively enforce a variety of requirements and guidelines. For example, a security-related hook might verify security groups for the appropriate inbound and outbound traffic rules for your Amazon Virtual Private Cloud (Amazon VPC). A cost-related hook might restrict development environments to only use smaller Amazon Elastic Compute Cloud (Amazon EC2) instance types. A hook designed for data availability could enforce automatic backups for Amazon Relational Database Service (Amazon RDS). All of these hooks can be registered and invoked in your accounts.

Characteristics of hooks

Characteristics of hooks include:

- **Proactive validation** – Reduces risk, operational overhead, and cost by identifying noncompliant resources before they're provisioned.
- **Automatic enforcement** – Provide enforcement in your Amazon Web Services account to prevent noncompliant resources from being provisioned by CloudFormation.

Your hook logic can return success or failure. A success response will allow the operation to continue. A failure for non-compliant resources can result in the following:

- `FAIL` – Stops provisioning resources.
- `WARN` – Allows provisioning to continue with a warning message.

You can register your hooks as private or third-party public extensions in the CloudFormation registry. For more information, see [Using the Amazon CloudFormation registry](#).

Using the CloudFormation CLI to create hooks

Use the [CloudFormation CLI](#) to develop your hooks. The CloudFormation CLI is an open-source project that provides a consistent way to model and provision both Amazon and third-party extensions using CloudFormation.

There are three major steps in developing a hook:

1. Initiate

To initiate a hook's project and its required files, use the `init` (p. 167) command and specify that you want to create a hook. For more information, see [Initiating a hooks project for Java](#) and [Initiating a hooks project for Python](#).

2. Model

To model, author, and validate your hook schema, define the hook, its properties, and their attributes.

The CloudFormation CLI creates empty handler functions which correspond to a specific hook invocation point. Add your own logic to these handlers to control what happens during your hook invocation at each stage of its target lifecycle. For more information, see [Modeling hooks for Java](#) and [Modeling hooks for Python](#).

3. Register

To register a hook, submit your hook to be registered either as a private or a public third-party extension. Register your hook with the [submit \(p. 171\)](#) operation. For more information, see [Registering hooks for Java](#) and [Registering hooks for Python](#).

The following tasks are associated with registering your hook:

- a. *Publish* – hooks are published to the registry.
- b. *Activate* – hooks are activated when they're enabled in your account.
- c. *Configure* – hooks are configured when the type configuration invokes against stacks.

There are two required type configuration properties:

- `TargetStacks` is used to turn the hook on or off.
 - `TargetStacks` set to `ALL` turns the hook on for all stack operations.
 - `TargetStacks` set to `NONE` turns the hook off, so it doesn't apply to stack operations.
- `FailureMode` determines how CloudFormation responds to a failure response.
 - `FailureMode` set to `FAIL` prevents the operation.
 - `FailureMode` set to `WARN` allows the operation to continue and sends a warning.

Overview

This section provides an overview for hooks and its terminology.

Hook

A *hook* is executable custom logic that automatically inspect resources before they're provisioned. Hooks are able to inspect the resources that CloudFormation is about to provision. If a hook finds any resource that doesn't comply with your organizational guidelines, they're able to prevent CloudFormation from continuing the provisioning process. With hooks, you can validate resource properties and invoke a warning, or prevent the provisioning operation, on non-compliant resources to reduce security and compliance risk, lower operational overhead, and optimize cost.

Hook targets

Hook targets are the destination where hooks are invoked. You can specify targets such as, CloudFormation resources, registry resources, or custom resource. For example, customers can author a hook targeting `AWS::S3::Bucket` resource. Hooks support an unlimited number of resource targets.

Invocation point

Invocation points are points in provisioning logic where hooks are invoked. CloudFormation supports pre-invocation points. Hooks are invoked before the provisioning logic for the target begins but won't invoke for skipped resources.

For example, a hook with an invocation point for `AWS::S3::Bucket`, will invoke before CloudFormation provisions your Amazon S3 bucket resource.

Target action

Target actions are the type of operation that your hook invokes at runtime. For example, if you specify a target action for `CREATE` on an `AWS::S3::Bucket`, your hook only invokes when creating an S3 bucket.

Valid values: CREATE | UPDATE | DELETE

Hook handlers

Invocation points and target actions specify the exact point where the hook is invoked. Hook handlers hosts executable custom logic for these points. For example, an invocation point of the CREATE operation uses a preCreate handler. Your code written in the hook handler will start any time targets and services perform a matching action.

Valid values: preCreate | preUpdate | preDelete

Important

Stacks operations that result in the status of UpdateCleanup will not invoke a hook. For example, during the following two scenarios, the hook's preDelete handler will not be invoked:

- the stack is updated after removing one resource from the template.
- a resource with the update type of [replacement](#) is deleted.

Hooks quotas

This section provides a list of quotas for hooks.

| Category | Quotas | | | |
|-------------------------|--------|--|--|--|
| Hooks per account | 100 | | | |
| Hooks per resource | 100 | | | |
| Versions per hook | 100 | | | |
| Hook configuration size | 300 KB | | | |

Note

The maximum amount of data that a hook's configuration can store is 300 KB. This is in addition to all the constraints imposed on Configuration request parameter of [SetTypeConfiguration](#) operation.

Hooks structure

A *hook schema* is a JSON-formatted text file that defines properties and attributes for a specific hook. The following is an example of a hook schema and its structure.

Hooks schema

A hook includes a hook specification represented by a JSON schema and handlers that are invoked at each hook invocation point.

The first step in creating a hook is modeling a schema that defines the hook, its properties, and their attributes. When you initialize a hook project using the CloudFormation CLI [the section called](#)

`"init"` (p. 167) command, a hook schema file is created for you. Use this schema file as a starting point for defining the shape and semantics of your hook.

The following schema is the structure for a hook.

```
{
  "typeName": "string",
  "description": "string",
  "sourceUrl": "string",
  "documentationUrl": "string",
  "definitions": {
    "definitionName": {
      . . .
    }
  },
  "typeConfiguration": {
    "properties": {
      "propertyName": {
        "description": "string",
        "type": "string",
        . . .
      },
    },
  },
  "required": [
    "propertyName"
    . . .
  ],
  "additionalProperties": false
},
"handlers": {
  "preCreate": {
    "targetNames": [
    ],
    "permissions": [
    ]
  },
  "preUpdate": {
    "targetNames": [
    ],
    "permissions": [
    ]
  },
  "preDelete": {
    "targetNames": [
    ],
    "permissions": [
    ]
  }
},
"additionalProperties": false
}
```

Properties

`typeName`

The unique name for your hook. Specifies a three-part namespace for your hook, with a recommended pattern of `Organization::Service::Hook`.

Note

The following organization namespaces are reserved and can't be used in your hook type names:

- Alexa
- AMZN
- Amazon
- ASK
- AWS
- Custom
- Dev

Required: Yes

Pattern: `^[a-zA-Z0-9]{2,64}:[a-zA-Z0-9]{2,64}:[a-zA-Z0-9]{2,64}$`

Minimum: 10

Maximum: 196

`description`

A short description of the hook that's displayed in the CloudFormation console.

Required: Yes

`sourceUrl`

The URL of the source code for the hook, if public.

Required: No

Maximum: 4096

`documentationUrl`

The URL of a page providing detailed documentation for the hook.

Required: Yes

Pattern: `^https://[/\][0-9a-zA-Z]([-.\w]*[0-9a-zA-Z])(\:[0-9]*)*([\?/#].*)?$`

Maximum: 4096

Note

Although the hook schema should include complete and accurate property descriptions, you can use the `documentationURL` property to provide users with more details, including examples, use cases, and other detailed information.

`definitions`

Use the `definitions` block to provide shared hook property schemas.

It's considered a best practice to use the `definitions` section to define schema elements that can be used at multiple points in your hook type schema. You can then use a JSON pointer to reference that element at the appropriate places in your hook type schema.

Required: No

`typeConfiguration`

The definition of a hook's configuration data.

Required: Yes

properties

The properties of the hook. All properties of a hook must be expressed in the schema. Align the hook schema properties with the hook type configuration properties.

Note

Nested properties aren't allowed. Instead, define any nested properties in the `definitions` element, and use a `$ref` pointer to reference them in the desired property.

additionalProperties

`additionalProperties` must be set to `false`. All properties of a hook must be expressed in the schema: arbitrary inputs aren't allowed.

Required: Yes

Valid values: `false`

handlers

Handlers specify the operations which can initiate the hook defined in the schema, such as hook invocation points. For example, a `preUpdate` handler is invoked before the update operations for all specified targets in the handler.

Valid values: `preCreate` | `preUpdate` | `preDelete`

Note

At least one value must be specified for the handler.

Important

Stacks operations that result in the status of `updateCleanup` will not invoke a hook. For example, during the following two scenarios, the hook's `preDelete` handler will not be invoked:

- the stack is updated after removing one resource from the template.
- a resource with the update type of `replacement` is deleted.

targetNames

A string array of type names that hook targets. For example, if a `preCreate` handler has an `AWS::S3::Bucket` target, the hook initiates for Amazon S3 buckets during the preprovisioning phase.

- `TargetName`

Specify at least one target name for each implemented handler.

Pattern: `^[a-zA-Z0-9]{2,64}:[a-zA-Z0-9]{2,64}:[a-zA-Z0-9]{2,64}$`

Minimum: 1

Required: Yes

permissions

A string array that specifies the Amazon permissions needed to invoke the handler.

Required: Yes

additionalProperties

`additionalProperties` must be set to `false`. All properties of a hook must be expressed in the schema: arbitrary inputs aren't allowed.

Required: Yes

Valid values: false

Example hooks schema

The Java and the Python walkthroughs use the following code example. The following is an example structure for a hook called `mycompany-testing-mytesthook.json`.

```
{
  "typeName": "MyCompany::Testing::MyTestHook",
  "description": "Verifies S3 bucket and SQS queues properties before create and update",
  "sourceUrl": "https://mycorp.com/my-repo.git",
  "documentationUrl": "https://mycorp.com/documentation",
  "typeConfiguration": {
    "properties": {
      "minBuckets": {
        "description": "Minimum number of compliant buckets",
        "type": "string"
      },
      "minQueues": {
        "description": "Minimum number of compliant queues",
        "type": "string"
      },
      "encryptionAlgorithm": {
        "description": "Encryption algorithm for SSE",
        "default": "AES256",
        "type": "string"
      }
    },
    "required": [
    ],
    "additionalProperties": false
  },
  "handlers": {
    "preCreate": {
      "targetNames": [
        "AWS::S3::Bucket",
        "AWS::SQS::Queue"
      ],
      "permissions": [
      ]
    },
    "preUpdate": {
      "targetNames": [
        "AWS::S3::Bucket",
        "AWS::SQS::Queue"
      ],
      "permissions": [
      ]
    },
    "preDelete": {
      "targetNames": [
        "AWS::S3::Bucket",
        "AWS::SQS::Queue"
      ],
      "permissions": [
        "s3:ListBucket",
        "s3:ListAllMyBuckets",
        "s3:GetEncryptionConfiguration",
        "sqs:ListQueues",
        "sqs:GetQueueAttributes",
      ]
    }
  }
}
```

```
        "sqs:GetQueueUrl"  
      ]  
    }  
  },  
  "additionalProperties": false  
}
```

Hook configuration schema

CloudFormation supports hook configurations which are set by the hook users. CloudFormation refers to this configuration schema at runtime when invoking a hook in an Amazon Web Services account. Hooks are configured when the type configuration is set to initiate from the stacks. To enable your hook to proactively inspect the configuration of your stack, you must set the `TargetStacks` to `ALL`, after the hook has been registered and activated in your account. The maximum amount of data that a hook's configuration can store is 300 KB. This is in addition to all the constraints imposed on `Configuration` request parameter of `SetTypeConfiguration` operation.

The following is an example of a hook configuration schema.

```
{  
  "CloudFormationConfiguration": {  
    "HookConfiguration": {  
      "TargetStacks": "ALL",  
      "FailureMode": "FAIL",  
      "Properties": {  
        ...  
      }  
    }  
  }  
}
```

HookConfiguration

Hook configuration supports activating or deactivating hooks at stack level, failure modes, and hook properties values.

The hook configuration supports the following properties.

TargetStacks

If the mode is set to `ALL`, the hook applies to all stacks in your account during a `CREATE`, `UPDATE`, or `DELETE` operation.

If the mode is set to `NONE`, the hook won't apply to stacks in your account.

Valid values: `ALL` | `NONE`

FailureMode

This field tells the service how to treat hook failures.

- If the mode is set to `FAIL`, and the hook fails, then the fail configuration stops provisioning resources.
- If the mode is set to `WARN` and the hook fails, then the warn configuration allows provisioning to continue with a warning message.

Valid values: `FAIL` | `WARN`

Properties

Specifies hook runtime properties. These should match the shape of the properties supported by hooks schema.

To activate a hook in your account, use the [set-type-configuration](#) operation, and specify `ALL` for the `TargetStack` property. This operation enables the hook's properties that are defined in the hook's schema `properties` section.

```
aws cloudformation --region us-west-2 set-type-configuration \
  --configuration "{\"CloudFormationConfiguration\":{\"HookConfiguration\":{\"TargetStacks\
  \":\">ALL\",\"FailureMode\":\">FAIL\",\"Properties\":{}}}}" \
  --type-arn $HOOK_TYPE_ARN
```

Walkthrough: Develop a hook

A hook includes a hook specification represented by a JSON schema and handlers that are invoked at each hook invocation point. This walkthrough covers the typical workflow needed to initiate, model, and register a hook in your account.

Topics

- [Walkthrough: Java \(p. 88\)](#)
- [Walkthrough: Python \(p. 131\)](#)
- [Publishing hooks for public use \(p. 151\)](#)

Walkthrough: Java

Prerequisites for developing hooks

This walkthrough requires the following for developing hooks:

- [Apache Maven](#)
- [JDK 8 or JDK 11](#)

To implement hook handlers for your project, you can download the [Java hook handler example files](#).

Permissions for developing hooks

In addition to the CloudFormation `Create`, `Update`, and `Delete` stack permissions, you'll need access to the following Amazon CloudFormation operations:

- `register-type`
- `list-types`
- `deregister-type`
- `set-type-configuration`

The following walkthrough topics guides you through developing your own hook.

Topics

- [Initiating a hooks project \(p. 89\)](#)
- [Modeling hooks \(p. 90\)](#)
- [Registering hooks \(p. 119\)](#)
- [Testing hooks in your Amazon Web Services account \(p. 122\)](#)

- [Managing hooks \(p. 130\)](#)

Initiating a hooks project

To get started authoring your hook, install the CloudFormation CLI with the language plugin of your choice and initiate a hook project. In this walkthrough, we will install the Java plugin.

Installing CloudFormation CLI and Java plugin

1. From your command prompt, create a directory. In this example, we will create the directory `CloudFormationHooksCLI`.

```
$ mkdir CloudFormationHooksCLI
$ cd CloudFormationHooksCLI
```

2. If you already have the CloudFormation CLI installed, run the upgrade command to upgrade. If not, proceed to the next step.

In your `CloudFormationHooksCLI` directory: download and upgrade the CloudFormation CLI.

```
$ pip3 install cloudformation-cli cloudformation-cli-java-plugin
$ pip3 install --upgrade cloudformation-cli cloudformation-cli-java-plugin
```

Results: You've successfully installed the CloudFormation CLI and Java plugin.

To initiate a hook project

The first step in creating your hook project is to initiate your hook project. You can use the CloudFormation CLI [the section called "init" \(p. 167\)](#) command to initiate your hook project.

The `init` command launches a wizard that walks you through setting up the project, including a hook schema file. Use this schema file as a starting point for defining the shape and semantics of your hook. For more information about hook schemas, see [Hooks structure](#).

Follow these steps to initiate your hook project.

1. In the CloudFormation CLI, create a directory that stores your hooks project. This example uses the directory `mycompany-testing-mytesthook`.

```
$ mkdir ~/mycompany-testing-mytesthook
$ cd ~/mycompany-testing-mytesthook
```

2. Use the [the section called "init" \(p. 167\)](#) command to initialize your hooks project.

```
cfn init
```

The command returns the following output.

```
Initializing new project
```

3. The `init` command launches a wizard that walks you through setting up the project.

When prompted, enter `h` to specify a hooks project.

```
Do you want to develop a new resource(r) a module(m) or a hook(h)?
```

The wizard returns the following output.

```
Enter resource hook type identifier (Organization::Service::Hook):
```

4. Enter your resource hook type identifier. For example, `MyCompany::Testing::MyTestHook`.
5. The wizard defaults to the available language plugin, or you can select an appropriate language plugin if more than one exists.

```
One language plugin found, defaulting to java
```

Specify the package name. For example, `com.mycompany.testing.mytesthook`.

```
Enter a package name (empty for default 'com.mycompany.testing.mytesthook'):  
com.mycompany.testing.mytesthook
```

The wizard returns the following output.

```
Initialized a new project in /workplace/mycompany-testing-mytesthook
```

6. Enter the option for the codegen model.

```
Choose codegen model - 1 (default) or 2 (guided-aws):
```

For example, specify the integer 2. This option specifies the level of code fragments that you want the CloudFormation CLI to generate.

- The integer 1 specifies , which generates empty handler code with a sample hook status format.
- The integer 2 specifies `guided-aws`, which generates code snippets to read your hook input, target properties, and sample hook status to return.

Results: You have successfully initiated the project, which includes generating the files needed to develop a hook. The following is an example hooks project.

```
README.md  
mycompany-testing-mytesthook.json  
lombok.config  
pom.xml  
rpdk.log  
docs  
src  
target  
template.yml  
hook-role.yaml
```

Note

Initializing a hook project generates source code and test code for your handlers, like `PreCreateHandler.java` and `PreCreateHandlerTest.java`. Updates to your hook handler source code may require updates.

Modeling hooks

Invocation points and target actions specify the exact point where the hook is invoked. *Hook handlers* hosts executable custom logic for these points. For example, an invocation point of the `CREATE` operation uses a `preCreate` handler. Your code written in the handler will invoke when hook targets

and services perform a matching action. *Hook targets* are the destination where hooks are invoked. You can specify targets such as Amazon CloudFormation resources, registry resources, or custom resources. Hooks support an unlimited number of hook targets.

The schema contains permissions required for the hook. Authoring the hook requires your to specifying permissions for each hook handler. Amazon CloudFormation encourages authors to write policies that follow the standard security advice of granting *least privilege*, or granting only the permissions required to perform a task. Determine what users (and roles) need to do and then craft policies that allow them to perform *only* those tasks for hook operations. CloudFormation uses these permissions to scope-down hook users provided permissions. These permissions are passed down to the hook. Hook handler can make sure of these permissions to make mutated and or read actions on Amazon resources. These permissions are visible publicly so customers or hook users are aware of what permissions they're giving to a particular hook.

To author a hook, you model a [Hook syntax](#) that defines the hook, its properties, and their attributes. Use the [Example hooks schema](#) as a starting point for defining the shape and semantics of your hook.

Modeling hook schema

A hook includes a hook specification represented by a [Hook syntax](#) and handlers that are invoked at each hook invocation point.

The first step in creating a hook is modeling a schema that defines the hook, its properties, and their attributes. When you initialize a hook project using the CloudFormation CLI [the section called "init" \(p. 167\)](#) command, a hook schema file is created for you. Add your hook handler runtime code to these handlers to control what happens during your hook invocation at each stage of its target lifecycle.

Use the hook schema to specify which handlers you want to implement. If you choose not to implement a specific handler, remove it from the handlers' section of the hook schema.

The following hook schema as a starting point for defining the shape and semantics of your hook.

```
{
  "typeName": "MyCompany::Testing::MyTestHook",
  "description": "Verifies S3 bucket and SQS queues properties before create and update",
  "sourceUrl": "https://mycorp.com/my-repo.git",
  "documentationUrl": "https://mycorp.com/documentation",
  "typeConfiguration": {
    "properties": {
      "minBuckets": {
        "description": "Minimum number of compliant buckets",
        "type": "string"
      },
      "minQueues": {
        "description": "Minimum number of compliant queues",
        "type": "string"
      },
      "encryptionAlgorithm": {
        "description": "Encryption algorithm for SSE",
        "default": "AES256",
        "type": "string"
      }
    }
  },
  "required": [
  ],
  "additionalProperties": false
},
"handlers": {
  "preCreate": {
```

```
        "targetNames":[
            "AWS::S3::Bucket",
            "AWS::SQS::Queue"
        ],
        "permissions":[
        ]
    },
    "preUpdate":{
        "targetNames":[
            "AWS::S3::Bucket",
            "AWS::SQS::Queue"
        ],
        "permissions":[
        ]
    },
    "preDelete":{
        "targetNames":[
            "AWS::S3::Bucket",
            "AWS::SQS::Queue"
        ],
        "permissions":[
            "s3:ListBucket",
            "s3:ListAllMyBuckets",
            "s3:GetEncryptionConfiguration",
            "sqs:ListQueues",
            "sqs:GetQueueAttributes",
            "sqs:GetQueueUrl"
        ]
    }
},
"additionalProperties":false
}
```

Setting up project dependencies

The hooks project is initialized and relies on Maven's pom.xml file as a dependency. Update this file to include your dependencies.

- Open the pom.xml file in the root of the project and replace it with the following.

```
<?xml version="1.0" encoding="UTF-8"?>
<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>com.mycompany.testing.mytesthook</groupId>
  <artifactId>mycompany-testing-mytesthook-handler</artifactId>
  <name>mycompany-testing-mytesthook-handler</name>
  <version>1.0-SNAPSHOT</version>
  <packaging>jar</packaging>

  <properties>
    <maven.compiler.source>1.8</maven.compiler.source>
    <maven.compiler.target>1.8</maven.compiler.target>
    <project.build.sourceEncoding>UTF-8</project.build.sourceEncoding>
    <project.reporting.outputEncoding>UTF-8</project.reporting.outputEncoding>
    <aws.java.sdk.version>2.16.1</aws.java.sdk.version>
    <checkstyle.version>8.36.2</checkstyle.version>
    <commons-io.version>2.8.0</commons-io.version>
```


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```
<jackson.version>2.11.3</jackson.version>
<maven-checkstyle-plugin.version>3.1.1</maven-checkstyle-plugin.version>
<mockito.version>3.6.0</mockito.version>
<spotbugs.version>4.1.4</spotbugs.version>
<spotless.version>2.5.0</spotless.version>
<maven-javadoc-plugin.version>3.2.0</maven-javadoc-plugin.version>
<maven-source-plugin.version>3.2.1</maven-source-plugin.version>
<cfm.generate.args/>
</properties>

<dependencyManagement>
  <dependencies>
    <dependency>
      <groupId>software.amazon.awssdk</groupId>
      <artifactId>bom</artifactId>
      <version>2.16.1</version>
      <type>pom</type>
      <scope>import</scope>
    </dependency>
  </dependencies>
</dependencyManagement>

<dependencies>
  <!-- https://mvnrepository.com/artifact/software.amazon.cloudformation/aws-
cloudformation-rpdk-java-plugin -->
  <dependency>
    <groupId>software.amazon.cloudformation</groupId>
    <artifactId>aws-cloudformation-rpdk-java-plugin</artifactId>
    <version>[2.0.0,3.0.0)</version>
  </dependency>

  <!-- AWS Java SDK v2 Dependencies -->
  <dependency>
    <groupId>software.amazon.awssdk</groupId>
    <artifactId>sdk-core</artifactId>
  </dependency>
  <dependency>
    <groupId>software.amazon.awssdk</groupId>
    <artifactId>cloudformation</artifactId>
  </dependency>
  <dependency>
    <groupId>software.amazon.awssdk</groupId>
    <artifactId>s3</artifactId>
  </dependency>
  <dependency>
    <groupId>software.amazon.awssdk</groupId>
    <artifactId>utils</artifactId>
  </dependency>
  <dependency>
    <groupId>software.amazon.awssdk</groupId>
    <artifactId>apache-client</artifactId>
  </dependency>
  <dependency>
    <groupId>software.amazon.awssdk</groupId>
    <artifactId>sqs</artifactId>
  </dependency>

  <!-- Test dependency for Java Providers -->
  <dependency>
    <groupId>software.amazon.cloudformation</groupId>
    <artifactId>cloudformation-cli-java-plugin-testing-support</artifactId>
    <version>1.0.0</version>
  </dependency>

  <!-- https://mvnrepository.com/artifact/com.amazonaws/aws-java-sdk-s3 -->
  <dependency>
```

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```
        <groupId>com.amazonaws</groupId>
        <artifactId>aws-java-sdk-s3</artifactId>
        <version>1.12.85</version>
    </dependency>

    <!-- https://mvnrepository.com/artifact/commons-io/commons-io -->
    <dependency>
        <groupId>commons-io</groupId>
        <artifactId>commons-io</artifactId>
        <version>${commons-io.version}</version>
    </dependency>
    <!-- https://mvnrepository.com/artifact/org.apache.commons/commons-lang3 -->
    <dependency>
        <groupId>org.apache.commons</groupId>
        <artifactId>commons-lang3</artifactId>
        <version>3.9</version>
    </dependency>
    <!-- https://mvnrepository.com/artifact/org.apache.commons/commons-collections4
-->
    <dependency>
        <groupId>org.apache.commons</groupId>
        <artifactId>commons-collections4</artifactId>
        <version>4.4</version>
    </dependency>
    <!-- https://mvnrepository.com/artifact/com.google.guava/guava -->
    <dependency>
        <groupId>com.google.guava</groupId>
        <artifactId>guava</artifactId>
        <version>29.0-jre</version>
    </dependency>
    <!-- https://mvnrepository.com/artifact/com.amazonaws/aws-java-sdk-
cloudformation -->
    <dependency>
        <groupId>com.amazonaws</groupId>
        <artifactId>aws-java-sdk-cloudformation</artifactId>
        <version>1.11.555</version>
        <scope>test</scope>
    </dependency>

    <!-- https://mvnrepository.com/artifact/commons-codec/commons-codec -->
    <dependency>
        <groupId>commons-codec</groupId>
        <artifactId>commons-codec</artifactId>
        <version>1.14</version>
    </dependency>
    <!-- https://mvnrepository.com/artifact/software.amazon.cloudformation/aws-
cloudformation-resource-schema -->
    <dependency>
        <groupId>software.amazon.cloudformation</groupId>
        <artifactId>aws-cloudformation-resource-schema</artifactId>
        <version>[2.0.5, 3.0.0)</version>
    </dependency>
    <!-- https://mvnrepository.com/artifact/com.fasterxml.jackson.dataformat/
jackson-databind -->
    <dependency>
        <groupId>com.fasterxml.jackson.core</groupId>
        <artifactId>jackson-databind</artifactId>
        <version>${jackson.version}</version>
    </dependency>
    <!-- https://mvnrepository.com/artifact/com.fasterxml.jackson.dataformat/
jackson-dataformat-cbor -->
    <dependency>
        <groupId>com.fasterxml.jackson.dataformat</groupId>
        <artifactId>jackson-dataformat-cbor</artifactId>
        <version>${jackson.version}</version>
    </dependency>
```

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```
<dependency>
  <groupId>com.fasterxml.jackson.datatype</groupId>
  <artifactId>jackson-datatype-jsr310</artifactId>
  <version>${jackson.version}</version>
</dependency>

<!-- https://mvnrepository.com/artifact/com.fasterxml.jackson.module/jackson-
modules-java8 -->
<dependency>
  <groupId>com.fasterxml.jackson.module</groupId>
  <artifactId>jackson-modules-java8</artifactId>
  <version>${jackson.version}</version>
  <type>pom</type>
  <scope>runtime</scope>
</dependency>

<!-- https://mvnrepository.com/artifact/org.json/json -->
<dependency>
  <groupId>org.json</groupId>
  <artifactId>json</artifactId>
  <version>20180813</version>
</dependency>
<!-- https://mvnrepository.com/artifact/com.amazonaws/aws-java-sdk-core -->
<dependency>
  <groupId>com.amazonaws</groupId>
  <artifactId>aws-java-sdk-core</artifactId>
  <version>1.11.1034</version>
</dependency>
<!-- https://mvnrepository.com/artifact/com.amazonaws/aws-lambda-java-core -->
<dependency>
  <groupId>com.amazonaws</groupId>
  <artifactId>aws-lambda-java-core</artifactId>
  <version>1.2.0</version>
</dependency>
> <!-- https://mvnrepository.com/artifact/com.amazonaws/aws-lambda-java-log4j2 -->
<dependency>
  <groupId>com.amazonaws</groupId>
  <artifactId>aws-lambda-java-log4j2</artifactId>
  <version>1.2.0</version>
</dependency>

<!-- https://mvnrepository.com/artifact/com.google.code.gson/gson -->
<dependency>
  <groupId>com.google.code.gson</groupId>
  <artifactId>gson</artifactId>
  <version>2.8.8</version>
</dependency>

<!-- https://mvnrepository.com/artifact/org.projectlombok/lombok -->
<dependency>
  <groupId>org.projectlombok</groupId>
  <artifactId>lombok</artifactId>
  <version>1.18.4</version>
  <scope>provided</scope>
</dependency>
<!-- https://mvnrepository.com/artifact/org.apache.logging.log4j/log4j-api -->
<dependency>
  <groupId>org.apache.logging.log4j</groupId>
  <artifactId>log4j-api</artifactId>
  <version>2.17.1</version>
</dependency>
> <!-- https://mvnrepository.com/artifact/org.apache.logging.log4j/log4j-core -->
```

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```
<dependency>
  <groupId>org.apache.logging.log4j</groupId>
  <artifactId>log4j-core</artifactId>
  <version>2.17.1</version>
</dependency>
<!-- https://mvnrepository.com/artifact/org.apache.logging.log4j/log4j-slf4j-
impl -->
<dependency>
  <groupId>org.apache.logging.log4j</groupId>
  <artifactId>log4j-slf4j-impl</artifactId>
  <version>2.17.1</version>
</dependency>

<!-- https://mvnrepository.com/artifact/org.assertj/assertj-core -->
<dependency>
  <groupId>org.assertj</groupId>
  <artifactId>assertj-core</artifactId>
  <version>3.12.2</version>
  <scope>test</scope>
</dependency>
<!-- https://mvnrepository.com/artifact/org.junit.jupiter/junit-jupiter -->
<dependency>
  <groupId>org.junit.jupiter</groupId>
  <artifactId>junit-jupiter</artifactId>
  <version>5.5.0-M1</version>
  <scope>test</scope>
</dependency>
<!-- https://mvnrepository.com/artifact/org.mockito/mockito-core -->
<dependency>
  <groupId>org.mockito</groupId>
  <artifactId>mockito-core</artifactId>
  <version>3.6.0</version>
  <scope>test</scope>
</dependency>
<!-- https://mvnrepository.com/artifact/org.mockito/mockito-junit-jupiter -->
<dependency>
  <groupId>org.mockito</groupId>
  <artifactId>mockito-junit-jupiter</artifactId>
  <version>3.6.0</version>
  <scope>test</scope>
</dependency>
</dependencies>

<build>
  <plugins>
    <plugin>
      <groupId>org.apache.maven.plugins</groupId>
      <artifactId>maven-compiler-plugin</artifactId>
      <version>3.8.1</version>
      <configuration>
        <compilerArgs>
          <arg>-Xlint:all,-options,-processing</arg>
        </compilerArgs>
      </configuration>
    </plugin>
    <plugin>
      <groupId>org.apache.maven.plugins</groupId>
      <artifactId>maven-shade-plugin</artifactId>
      <version>2.3</version>
      <configuration>
        <createDependencyReducedPom>>false</createDependencyReducedPom>
        <filters>
          <filter>
            <artifact>*:*</artifact>
            <excludes>
              <exclude>*/Log4j2Plugins.dat</exclude>
            </excludes>
          </filter>
        </filters>
      </configuration>
    </plugin>
  </plugins>
</build>
```

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```
        </excludes>
      </filter>
    </filters>
  </configuration>
<executions>
  <execution>
    <phase>package</phase>
    <goals>
      <goal>shade</goal>
    </goals>
  </execution>
</executions>
</plugin>
<plugin>
  <groupId>org.codehaus.mojo</groupId>
  <artifactId>exec-maven-plugin</artifactId>
  <version>1.6.0</version>
  <executions>
    <execution>
      <id>generate</id>
      <phase>generate-sources</phase>
      <goals>
        <goal>exec</goal>
      </goals>
      <configuration>
        <executable>cfn</executable>
        <commandlineArgs>generate ${cfn.generate.args}</
commandlineArgs>
        <workingDirectory>${project.basedir}</workingDirectory>
      </configuration>
    </execution>
  </executions>
</plugin>
<plugin>
  <groupId>org.codehaus.mojo</groupId>
  <artifactId>build-helper-maven-plugin</artifactId>
  <version>3.0.0</version>
  <executions>
    <execution>
      <id>add-source</id>
      <phase>generate-sources</phase>
      <goals>
        <goal>add-source</goal>
      </goals>
      <configuration>
        <sources>
          <source>${project.basedir}/target/generated-sources/
rpdk</source>
        </sources>
      </configuration>
    </execution>
  </executions>
</plugin>
<plugin>
  <groupId>org.apache.maven.plugins</groupId>
  <artifactId>maven-resources-plugin</artifactId>
  <version>2.4</version>
</plugin>
<plugin>
  <artifactId>maven-surefire-plugin</artifactId>
  <version>3.0.0-M3</version>
</plugin>
<plugin>
  <groupId>org.jacoco</groupId>
  <artifactId>jacoco-maven-plugin</artifactId>
  <version>0.8.4</version>
```

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```
<configuration>
  <excludes>
    <exclude>**/BaseHookConfiguration*</exclude>
    <exclude>**/BaseHookHandler*</exclude>
    <exclude>**/HookHandlerWrapper*</exclude>
    <exclude>**/ResourceModel*</exclude>
    <exclude>**/TypeConfigurationModel*</exclude>
    <exclude>**/model/**/*</exclude>
  </excludes>
</configuration>
<executions>
  <execution>
    <goals>
      <goal>prepare-agent</goal>
    </goals>
  </execution>
  <execution>
    <id>report</id>
    <phase>test</phase>
    <goals>
      <goal>report</goal>
    </goals>
  </execution>
  <execution>
    <id>jacoco-check</id>
    <goals>
      <goal>check</goal>
    </goals>
    <configuration>
      <rules>
        <rule>
          <element>PACKAGE</element>
          <limits>
            <limit>
              <counter>BRANCH</counter>
              <value>COVEREDRATIO</value>
              <minimum>0.8</minimum>
            </limit>
            <limit>
              <counter>INSTRUCTION</counter>
              <value>COVEREDRATIO</value>
              <minimum>0.8</minimum>
            </limit>
          </limits>
        </rule>
      </rules>
    </configuration>
  </execution>
</executions>
</plugin>
</plugins>
<resources>
  <resource>
    <directory>${project.basedir}</directory>
    <includes>
      <include>mycompany-testing-mytesthook.json</include>
    </includes>
  </resource>
  <resource>
    <directory>${project.basedir}/target/loaded-target-schemas</directory>
    <includes>
      <include>**/*.json</include>
    </includes>
  </resource>
</resources>
</build>
```

```
</project>
```

This artifact will be added by Maven from the [Maven Repository](#).

For more information about how to add dependencies, see the [Maven documentation](#).

Implementing hook handlers for your hook project

When generating your hook project, the CloudFormation CLI generates empty handler functions, each of which corresponds to a specific hook invocation point in the runtime. You can specify a single handler for each invocation point, or you can specify multiple target types that invoke the hook handler for each invocation point.

To add runtime code to handlers in a hook schema

1. In the CloudFormation CLI, run the [the section called “generate” \(p. 168\)](#) command.

```
cfn generate
```

The command returns the following output.

```
Generated files for MyCompany::Testing::MyTestHook
```

2. Add your own hook handler runtime code to the handlers that you choose to implement. For example, you can add the following code for logging.

```
logger.log("Internal testing hook triggered for target: " +  
    request.getHookContext().getTargetName());
```

3. The CloudFormation CLI generates a Plain Old Java Objects (Java POJO). The following are output examples generated from `AWS::S3::Bucket`.

Example `AwsS3BucketTargetModel.java`

```
package com.mycompany.testing.mytesthook.model.aws.s3.bucket;  
  
import...  
  
@Data  
@NoArgsConstructor  
@EqualsAndHashCode(callSuper = true)  
@ToString(callSuper = true)  
@JsonAutoDetect(fieldVisibility = Visibility.ANY, getterVisibility = Visibility.NONE,  
    setterVisibility = Visibility.NONE)  
public class AwsS3BucketTargetModel extends ResourceHookTargetModel<AwsS3Bucket> {  
  
    @JsonIgnore  
    private static final TypeReference<AwsS3Bucket> TARGET_REFERENCE =  
        new TypeReference<AwsS3Bucket>() {};  
  
    @JsonIgnore  
    private static final TypeReference<AwsS3BucketTargetModel> MODEL_REFERENCE =  
        new TypeReference<AwsS3BucketTargetModel>() {};  
  
    @JsonIgnore  
    public static final String TARGET_TYPE_NAME = "AWS::S3::Bucket";  
}
```

```
@JsonIgnore
public TypeReference<AwsS3Bucket> getHookTargetTypeReference() {
    return TARGET_REFERENCE;
}

@JsonIgnore
public TypeReference<AwsS3BucketTargetModel> getTargetModelTypeReference() {
    return MODEL_REFERENCE;
}
}
```

Example AwsS3Bucket.java

```
package com.mycompany.testing.mytesthook.model.aws.s3.bucket;

import ...

@Data
@Builder
@AllArgsConstructor
@NoArgsConstructor
@EqualsAndHashCode(callSuper = true)
@ToString(callSuper = true)
@JsonAutoDetect(fieldVisibility = Visibility.ANY, getterVisibility = Visibility.NONE,
    setterVisibility = Visibility.NONE)
public class AwsS3Bucket extends ResourceHookTarget {
    @JsonIgnore
    public static final String TYPE_NAME = "AWS::S3::Bucket";

    @JsonIgnore
    public static final String IDENTIFIER_KEY_ID = "/properties/Id";

    @JsonProperty("InventoryConfigurations")
    private List<InventoryConfiguration> inventoryConfigurations;

    @JsonProperty("WebsiteConfiguration")
    private WebsiteConfiguration websiteConfiguration;

    @JsonProperty("DualStackDomainName")
    private String dualStackDomainName;

    @JsonProperty("AccessControl")
    private String accessControl;

    @JsonProperty("AnalyticsConfigurations")
    private List<AnalyticsConfiguration> analyticsConfigurations;

    @JsonProperty("AccelerateConfiguration")
    private AccelerateConfiguration accelerateConfiguration;

    @JsonProperty("PublicAccessBlockConfiguration")
    private PublicAccessBlockConfiguration publicAccessBlockConfiguration;

    @JsonProperty("BucketName")
    private String bucketName;

    @JsonProperty("RegionalDomainName")
    private String regionalDomainName;

    @JsonProperty("OwnershipControls")
    private OwnershipControls ownershipControls;

    @JsonProperty("ObjectLockConfiguration")
```



```
private ObjectLockConfiguration objectLockConfiguration;

@JsonProperty("ObjectLockEnabled")
private Boolean objectLockEnabled;

@JsonProperty("LoggingConfiguration")
private LoggingConfiguration loggingConfiguration;

@JsonProperty("ReplicationConfiguration")
private ReplicationConfiguration replicationConfiguration;

@JsonProperty("Tags")
private List<Tag> tags;

@JsonProperty("DomainName")
private String domainName;

@JsonProperty("BucketEncryption")
private BucketEncryption bucketEncryption;

@JsonProperty("WebsiteURL")
private String websiteURL;

@JsonProperty("NotificationConfiguration")
private NotificationConfiguration notificationConfiguration;

@JsonProperty("LifecycleConfiguration")
private LifecycleConfiguration lifecycleConfiguration;

@JsonProperty("VersioningConfiguration")
private VersioningConfiguration versioningConfiguration;

@JsonProperty("MetricsConfigurations")
private List<MetricsConfiguration> metricsConfigurations;

@JsonProperty("IntelligentTieringConfigurations")
private List<IntelligentTieringConfiguration> intelligentTieringConfigurations;

@JsonProperty("CorsConfiguration")
private CorsConfiguration corsConfiguration;

@JsonProperty("Id")
private String id;

@JsonProperty("Arn")
private String arn;

@JsonIgnore
public JSONObject getPrimaryIdentifier() {
    final JSONObject identifier = new JSONObject();
    if (this.getId() != null) {
        identifier.put(IDENTIFIER_KEY_ID, this.getId());
    }

    // only return the identifier if it can be used, i.e. if all components are
present
    return identifier.length() == 1 ? identifier : null;
}

@JsonIgnore
public List<JSONObject> getAdditionalIdentifiers() {
    final List<JSONObject> identifiers = new ArrayList<JSONObject>();
    // only return the identifiers if any can be used
    return identifiers.isEmpty() ? null : identifiers;
}
```

```
}
```

Example BucketEncryption.java

```
package software.amazon.testing.mytesthook.model.aws.s3.bucket;

import ...

@Data
@Builder
@AllArgsConstructor
@NoArgsConstructor
@JsonAutoDetect(fieldVisibility = Visibility.ANY, getterVisibility = Visibility.NONE,
    setterVisibility = Visibility.NONE)
public class BucketEncryption {
    @JsonProperty("ServerSideEncryptionConfiguration")
    private List<ServerSideEncryptionRule> serverSideEncryptionConfiguration;
}
}
```

Example ServerSideEncryptionRule.java

```
package com.mycompany.testing.mytesthook.model.aws.s3.bucket;

import ...

@Data
@Builder
@AllArgsConstructor
@NoArgsConstructor
@JsonAutoDetect(fieldVisibility = Visibility.ANY, getterVisibility = Visibility.NONE,
    setterVisibility = Visibility.NONE)
public class ServerSideEncryptionRule {
    @JsonProperty("BucketKeyEnabled")
    private Boolean bucketKeyEnabled;

    @JsonProperty("ServerSideEncryptionByDefault")
    private ServerSideEncryptionByDefault serverSideEncryptionByDefault;
}
}
```

Example ServerSideEncryptionByDefault.java

```
package com.mycompany.testing.mytesthook.model.aws.s3.bucket;

import ...

@Data
@Builder
@AllArgsConstructor
@NoArgsConstructor
@JsonAutoDetect(fieldVisibility = Visibility.ANY, getterVisibility = Visibility.NONE,
    setterVisibility = Visibility.NONE)
public class ServerSideEncryptionByDefault {
    @JsonProperty("SSEAlgorithm")
    private String SSEAlgorithm;

    @JsonProperty("KMSMasterKeyID")
```

```
private String kmsMasterKeyID;  
}
```

With the POJOs generated, you can now write the handlers that actually implement the hook's functionality. For this example, implement the `preCreate` and `preUpdate` invocation point for the handlers.

Coding the API client builder

1. In your IDE, open the `ClientBuilder.java` file, located in the `src/main/java/com/mycompany/testing/mytesthook` folder.
2. Replace the entire contents of the `ClientBuilder.java` file with the following code.

Example ClientBuilder.java

Coding the API request maker

1. In your IDE, open the `Translator.java` file, located in the `src/main/java/com/mycompany/testing/mytesthook` folder.
2. Replace the entire contents of the `Translator.java` file with the following code.

Example Translator.java

```
package com.mycompany.testing.mytesthook;  
  
import software.amazon.awssdk.services.s3.model.GetBucketEncryptionRequest;  
import software.amazon.awssdk.services.s3.model.ListBucketsRequest;  
import software.amazon.awssdk.services.sqs.model.ListQueuesRequest;  
import software.amazon.cloudformation.proxy.hook.targetmodel.HookTargetModel;  
  
/**  
 * This class is a centralized placeholder for  
 * - api request construction  
 * - object translation to/from aws sdk  
 */  
  
public class Translator {  
  
    static ListBucketsRequest translateToListBucketsRequest(final HookTargetModel  
targetModel) {  
        return ListBucketsRequest.builder().build();  
    }  
  
    static ListQueuesRequest translateToListQueuesRequest(final String nextToken) {  
        return ListQueuesRequest.builder().nextToken(nextToken).build();  
    }  
  
    static ListBucketsRequest createListBucketsRequest() {  
        return ListBucketsRequest.builder().build();  
    }  
  
    static ListQueuesRequest createListQueuesRequest() {  
        return createListQueuesRequest(null);  
    }  
}
```

```
static ListQueuesRequest createListQueuesRequest(final String nextToken) {
    return ListQueuesRequest.builder().nextToken(nextToken).build();
}

static GetBucketEncryptionRequest createGetBucketEncryptionRequest(final String
bucket) {
    return GetBucketEncryptionRequest.builder().bucket(bucket).build();
}
}
```

Implementing the helper code

1. In your IDE, open the `AbstractTestBase.java` file, located in the `src/main/java/com/mycompany/testing/mytesthook` folder.
2. Replace the entire contents of the `AbstractTestBase.java` file with the following code.

Example Translator.java

```
package com.mycompany.testing.mytesthook;

import com.google.common.collect.ImmutableMap;
import org.mockito.Mockito;
import software.amazon.awssdk.auth.credentials.AwsCredentialsProvider;
import software.amazon.awssdk.auth.credentials.AwsSessionCredentials;
import software.amazon.awssdk.auth.credentials.StaticCredentialsProvider;
import software.amazon.awssdk.awscore.AwsRequest;
import software.amazon.awssdk.awscore.AwsRequestOverrideConfiguration;
import software.amazon.awssdk.awscore.AwsResponse;
import software.amazon.awssdk.core.SdkClient;
import software.amazon.awssdk.core.pagination.sync.SdkIterable;
import software.amazon.cloudformation.proxy.AmazonWebServicesClientProxy;
import software.amazon.cloudformation.proxy.Credentials;
import software.amazon.cloudformation.proxy.LoggerProxy;
import software.amazon.cloudformation.proxy.OperationStatus;
import software.amazon.cloudformation.proxy.ProgressEvent;
import software.amazon.cloudformation.proxy.ProxyClient;
import software.amazon.cloudformation.proxy.hook.targetmodel.HookTargetModel;

import javax.annotation.Nonnull;
import java.time.Duration;
import java.util.concurrent.CompletableFuture;
import java.util.function.Function;
import java.util.function.Supplier;

import static org.assertj.core.api.Assertions.assertThat;

@lombok.Getter
public class AbstractTestBase {
    protected final AwsSessionCredentials awsSessionCredential;
    protected final AwsCredentialsProvider v2CredentialsProvider;
    protected final AwsRequestOverrideConfiguration configuration;
    protected final LoggerProxy loggerProxy;
    protected final Supplier<Long> awsLambdaRuntime = () ->
Duration.ofMinutes(15).toMillis();
    protected final AmazonWebServicesClientProxy proxy;
    protected final Credentials mockCredentials =
        new Credentials("mockAccessId", "mockSecretKey", "mockSessionToken");

    @lombok.Setter
    private SdkClient serviceClient;

    protected AbstractTestBase() {
```

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```
        loggerProxy = Mockito.mock(LoggerProxy.class);
        awsSessionCredential =
        AwsSessionCredentials.create(mockCredentials.getAccessKeyId(),
            mockCredentials.getSecretAccessKey(), mockCredentials.getSessionToken());
        v2CredentialsProvider =
        StaticCredentialsProvider.create(awsSessionCredential);
        configuration = AwsRequestOverrideConfiguration.builder()
            .credentialsProvider(v2CredentialsProvider)
            .build();
        proxy = new AmazonWebServicesClientProxy(
            loggerProxy,
            mockCredentials,
            awsLambdaRuntime
        ) {
            @Override
            public <ClientT> ProxyClient<ClientT> newProxy(@NonNull Supplier<ClientT>
client) {
                return new ProxyClient<ClientT>() {
                    @Override
                    public <RequestT extends AwsRequest, ResponseT extends
AwsResponse>
                        ResponseT injectCredentialsAndInvokeV2(RequestT request,
                            Function<RequestT,
ResponseT> requestFunction) {
                                return proxy.injectCredentialsAndInvokeV2(request,
requestFunction);
                            }

                    @Override
                    public <RequestT extends AwsRequest, ResponseT extends AwsResponse>
CompletableFuture<ResponseT>
                        injectCredentialsAndInvokeV2Async(RequestT request,
                            Function<RequestT, CompletableFuture<ResponseT>> requestFunction) {
                                return proxy.injectCredentialsAndInvokeV2Async(request,
requestFunction);
                            }

                    @Override
                    public <RequestT extends AwsRequest, ResponseT extends AwsResponse,
IterableT extends SdkIterable<ResponseT>>
                        IterableT
                        injectCredentialsAndInvokeIterableV2(RequestT request,
                            Function<RequestT, IterableT> requestFunction) {
                                return proxy.injectCredentialsAndInvokeIterableV2(request,
requestFunction);
                            }

                    @SuppressWarnings("unchecked")
                    @Override
                    public ClientT client() {
                        return (ClientT) serviceClient;
                    }
                };
            }
        };

        protected void assertResponse(final ProgressEvent<HookTargetModel, CallbackContext>
response, final OperationStatus expectedStatus, final String expectedMsg) {
            assertThat(response).isNotNull();
            assertThat(response.getStatus()).isEqualTo(expectedStatus);
            assertThat(response.getCallbackContext()).isNull();
            assertThat(response.getCallbackDelaySeconds()).isEqualTo(0);
            assertThat(response.getMessage()).isNotNull();
            assertThat(response.getMessage()).isEqualTo(expectedMsg);
        }
    }
}
```

```
        protected HookTargetModel createHookTargetModel(final Object resourceProperties) {
            return HookTargetModel.of(ImmutableMap.of("ResourceProperties",
resourceProperties));
        }

        protected HookTargetModel createHookTargetModel(final Object resourceProperties,
final Object previousResourceProperties) {
            return HookTargetModel.of(
                ImmutableMap.of(
                    "ResourceProperties", resourceProperties,
                    "PreviousResourceProperties", previousResourceProperties
                )
            );
        }
    }
}
```

Implementing the base handler

1. In your IDE, open the BaseHookHandlerStd.java file, located in the src/main/java/com/mycompany/testing/mytesthook folder.
2. Replace the entire contents of the BaseHookHandlerStd.java file with the following code.

Example Translator.java

```
package com.mycompany.testing.mytesthook;

import com.mycompany.testing.mytesthook.model.aws.s3.bucket.AwsS3Bucket;
import com.mycompany.testing.mytesthook.model.aws.sqs.queue.AwsSqsQueue;
import software.amazon.awssdk.services.s3.S3Client;
import software.amazon.awssdk.services.sqs.SqsClient;
import software.amazon.cloudformation.exceptions.UnsupportedTargetException;
import software.amazon.cloudformation.proxy.AmazonWebServicesClientProxy;
import software.amazon.cloudformation.proxy.Logger;
import software.amazon.cloudformation.proxy.ProgressEvent;
import software.amazon.cloudformation.proxy.ProxyClient;
import software.amazon.cloudformation.proxy.hook.HookHandlerRequest;
import software.amazon.cloudformation.proxy.hook.targetmodel.HookTargetModel;

public abstract class BaseHookHandlerStd extends BaseHookHandler<CallbackContext,
TypeConfigurationModel> {
    public static final String HOOK_TYPE_NAME = "MyCompany::Testing::MyTestHook";

    protected Logger logger;

    @Override
    public ProgressEvent<HookTargetModel, CallbackContext> handleRequest(
        final AmazonWebServicesClientProxy proxy,
        final HookHandlerRequest request,
        final CallbackContext callbackContext,
        final Logger logger,
        final TypeConfigurationModel typeConfiguration
    ) {
        this.logger = logger;

        final String targetName = request.getHookContext().getTargetName();

        final ProgressEvent<HookTargetModel, CallbackContext> result;
        if (AwsS3Bucket.TYPE_NAME.equals(targetName)) {
            result = handleS3BucketRequest(
                proxy,
```

```
        request,
        callbackContext != null ? callbackContext : new CallbackContext(),
        proxy.newProxy(ClientBuilder::createS3Client),
        typeConfiguration
    );
} else if (AwsSqsQueue.TYPE_NAME.equals(targetName)) {
    result = handleSqsQueueRequest(
        proxy,
        request,
        callbackContext != null ? callbackContext : new CallbackContext(),
        proxy.newProxy(ClientBuilder::createSqsClient),
        typeConfiguration
    );
} else {
    throw new UnsupportedTargetException(targetName);
}

log(
    String.format(
        "Result for [%s] invocation for target [%s] returned status [%s] with
message [%s]",
        request.getHookContext().getInvocationPoint(),
        targetName,
        result.getStatus(),
        result.getMessage()
    )
);

return result;
}

protected abstract ProgressEvent<HookTargetModel, CallbackContext>
handleS3BucketRequest(
    final AmazonWebServicesClientProxy proxy,
    final HookHandlerRequest request,
    final CallbackContext callbackContext,
    final ProxyClient<S3Client> proxyClient,
    final TypeConfigurationModel typeConfiguration
);

protected abstract ProgressEvent<HookTargetModel, CallbackContext>
handleSqsQueueRequest(
    final AmazonWebServicesClientProxy proxy,
    final HookHandlerRequest request,
    final CallbackContext callbackContext,
    final ProxyClient<SqsClient> proxyClient,
    final TypeConfigurationModel typeConfiguration
);

protected void log(final String message) {
    if (logger != null) {
        logger.log(message);
    } else {
        System.out.println(message);
    }
}
}
```

Implementing the preCreate handler

The preCreate handler verifies the server-side encryption settings for either an `AWS::S3::Bucket` or `AWS::SQS::Queue` resource.

- For an `AWS::S3::Bucket` resource, the hook will only pass if the following is true:
 - The Amazon S3 bucket encryption is set.
 - The Amazon S3 bucket key is enabled for the bucket.
 - The encryption algorithm set for the Amazon S3 bucket is the correct algorithm required.
 - The Amazon Key Management Service key ID is set.
- For an `AWS::SQS::Queue` resource, the hook will only pass if the following is true:
 - The Amazon Key Management Service key ID is set.

Coding the `preCreate` handler

1. In your IDE, open the `PreCreateHookHandler.java` file, located in the `src/main/java/software/mycompany/testing/mytesthook` folder.
2. Replace the entire contents of the `PreCreateHookHandler.java` file with the following code.

```
package com.mycompany.testing.mytesthook;

import com.mycompany.testing.mytesthook.model.aws.s3.bucket.AwsS3Bucket;
import com.mycompany.testing.mytesthook.model.aws.s3.bucket.AwsS3BucketTargetModel;
import com.mycompany.testing.mytesthook.model.aws.s3.bucket.BucketEncryption;
import
    com.mycompany.testing.mytesthook.model.aws.s3.bucket.ServerSideEncryptionByDefault;
import com.mycompany.testing.mytesthook.model.aws.s3.bucket.ServerSideEncryptionRule;
import com.mycompany.testing.mytesthook.model.aws.sqs.queue.AwsSqsQueue;
import com.mycompany.testing.mytesthook.model.aws.sqs.queue.AwsSqsQueueTargetModel;
import org.apache.commons.collections.CollectionUtils;
import org.apache.commons.lang3.StringUtils;
import software.amazon.cloudformation.exceptions.UnsupportedTargetException;
import software.amazon.cloudformation.proxy.HandlerErrorCode;
import software.amazon.cloudformation.proxy.Logger;
import software.amazon.cloudformation.proxy.AmazonWebServicesClientProxy;
import software.amazon.cloudformation.proxy.hook.HookStatus;
import software.amazon.cloudformation.proxy.hook.HookProgressEvent;
import software.amazon.cloudformation.proxy.hook.HookHandlerRequest;
import software.amazon.cloudformation.proxy.hook.targetmodel.ResourceHookTargetModel;

import java.util.List;

public class PreCreateHookHandler extends BaseHookHandler<TypeConfigurationModel,
    CallbackContext> {

    @Override
    public HookProgressEvent<CallbackContext> handleRequest(
        final AmazonWebServicesClientProxy proxy,
        final HookHandlerRequest request,
        final CallbackContext callbackContext,
        final Logger logger,
        final TypeConfigurationModel typeConfiguration) {

        final String targetName = request.getHookContext().getTargetName();
        if ("AWS::S3::Bucket".equals(targetName)) {
            final ResourceHookTargetModel<AwsS3Bucket> targetModel =
                request.getHookContext().getTargetModel(AwsS3BucketTargetModel.class);

            final AwsS3Bucket bucket = targetModel.getResourceProperties();
            final String encryptionAlgorithm =
                typeConfiguration.getEncryptionAlgorithm();

            return validateS3BucketEncryption(bucket, encryptionAlgorithm);

        } else if ("AWS::SQS::Queue".equals(targetName)) {
```


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```
        final ResourceHookTargetModel<AwsSqsQueue> targetModel =
request.getHookContext().getTargetModel(AwsSqsQueueTargetModel.class);

        final AwsSqsQueue queue = targetModel.getResourceProperties();
        return validateSqsQueueEncryption(queue);
    } else {
        throw new UnsupportedTargetException(targetName);
    }
}

private HookProgressEvent<CallbackContext> validateS3BucketEncryption(final
AwsS3Bucket bucket, final String requiredEncryptionAlgorithm) {
    HookStatus resultStatus = null;
    String resultMessage = null;

    if (bucket != null) {
        final BucketEncryption bucketEncryption = bucket.getBucketEncryption();
        if (bucketEncryption != null) {
            final List<ServerSideEncryptionRule> serverSideEncryptionRules =
bucketEncryption.getServerSideEncryptionConfiguration();
            if (CollectionUtils.isNotEmpty(serverSideEncryptionRules)) {
                for (final ServerSideEncryptionRule rule :
serverSideEncryptionRules) {
                    final Boolean bucketKeyEnabled = rule.getBucketKeyEnabled();
                    if (bucketKeyEnabled) {
                        final ServerSideEncryptionByDefault
serverSideEncryptionByDefault = rule.getServerSideEncryptionByDefault();

                        final String encryptionAlgorithm =
serverSideEncryptionByDefault.getSSEAlgorithm();
                        final String kmsKeyId =
serverSideEncryptionByDefault.getKMSTMasterKeyID(); // "KMSTMasterKeyID" is name of the
property for an AWS::S3::Bucket;

                        if (!StringUtils.equals(encryptionAlgorithm,
requiredEncryptionAlgorithm) && StringUtils.isBlank(kmsKeyId)) {
                            resultStatus = HookStatus.FAILED;
                            resultMessage = "KMS Key ID not set and SSE Encryption
Algorithm is incorrect for bucket with name: " + bucket.getBucketName();
                        } else if (!StringUtils.equals(encryptionAlgorithm,
requiredEncryptionAlgorithm)) {
                            resultStatus = HookStatus.FAILED;
                            resultMessage = "SSE Encryption Algorithm is incorrect
for bucket with name: " + bucket.getBucketName();
                        } else if (StringUtils.isBlank(kmsKeyId)) {
                            resultStatus = HookStatus.FAILED;
                            resultMessage = "KMS Key ID not set for bucket with
name: " + bucket.getBucketName();
                        } else {
                            resultStatus = HookStatus.SUCCESS;
                            resultMessage = "Successfully invoked
PreCreateHookHandler for target: AWS::S3::Bucket";
                        }
                    } else {
                        resultStatus = HookStatus.FAILED;
                        resultMessage = "Bucket key not enabled for bucket with
name: " + bucket.getBucketName();
                    }

                    if (resultStatus == HookStatus.FAILED) {
                        break;
                    }
                }
            } else {
                resultStatus = HookStatus.FAILED;
            }
        }
    }
}
```

```
        resultMessage = "No SSE Encryption configurations for bucket with
name: " + bucket.getBucketName();
    }
    } else {
        resultStatus = HookStatus.FAILED;
        resultMessage = "Bucket Encryption not enabled for bucket with name: "
+ bucket.getBucketName();
    }
    } else {
        resultStatus = HookStatus.FAILED;
        resultMessage = "Resource properties for S3 Bucket target model are
empty";
    }

    return HookProgressEvent.<CallbackContext>builder()
        .status(resultStatus)
        .message(resultMessage)
        .errorCode(resultStatus == HookStatus.FAILED ?
HandlerErrorCode.ResourceConflict : null)
        .build();
    }

    private HookProgressEvent<CallbackContext> validateSQSQueueEncryption(final
AwsSqsQueue queue) {
        if (queue == null) {
            return HookProgressEvent.<CallbackContext>builder()
                .status(HookStatus.FAILED)
                .message("Resource properties for SQS Queue target model are
empty")
                .errorCode(HandlerErrorCode.ResourceConflict)
                .build();
        }

        final String kmsKeyId = queue.getKmsMasterKeyId(); // "KmsMasterKeyId" is name
of the property for an AWS::SQS::Queue
        if (StringUtils.isBlank(kmsKeyId)) {
            return HookProgressEvent.<CallbackContext>builder()
                .status(HookStatus.FAILED)
                .message("Server side encryption turned off for queue with name: "
+ queue.getQueueName())
                .errorCode(HandlerErrorCode.ResourceConflict)
                .build();
        }

        return HookProgressEvent.<CallbackContext>builder()
            .status(HookStatus.SUCCESS)
            .message("Successfully invoked PreCreateHookHandler for target:
AWS::SQS::Queue")
            .build();
    }
}
```

Updating the preCreate handler

1. In your IDE, open the `PreCreateHandlerTest.java` file, located in the `src/test/java/software/mycompany/testing/mytesthook` folder.
2. Replace the entire contents of `PreCreateHandlerTest.java` file with the following code.

```
package com.mycompany.testing.mytesthook;

import com.google.common.collect.ImmutableMap;
import com.mycompany.testing.mytesthook.model.aws.s3.bucket.AwsS3Bucket;
```

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```
import com.mycompany.testing.mytesthook.model.aws.s3.bucket.BucketEncryption;
import
    com.mycompany.testing.mytesthook.model.aws.s3.bucket.ServerSideEncryptionByDefault;
import com.mycompany.testing.mytesthook.model.aws.s3.bucket.ServerSideEncryptionRule;
import com.mycompany.testing.mytesthook.model.aws.sqs.queue.AwsSqsQueue;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.mockito.Mock;
import org.mockito.junit.jupiter.MockitoExtension;
import software.amazon.cloudformation.exceptions.UnsupportedTargetException;
import software.amazon.cloudformation.proxy.AmazonWebServicesClientProxy;
import software.amazon.cloudformation.proxy.HandlerErrorCode;
import software.amazon.cloudformation.proxy.Logger;
import software.amazon.cloudformation.proxy.hook.HookContext;
import software.amazon.cloudformation.proxy.hook.HookHandlerRequest;
import software.amazon.cloudformation.proxy.hook.HookProgressEvent;
import software.amazon.cloudformation.proxy.hook.HookStatus;
import software.amazon.cloudformation.proxy.hook.targetmodel.HookTargetModel;

import java.util.Collections;
import java.util.Map;

import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.api.Assertions.assertThatExceptionOfType;
import static org.mockito.Mockito.mock;

@ExtendWith(MockitoExtension.class)
public class PreCreateHookHandlerTest {

    @Mock
    private AmazonWebServicesClientProxy proxy;

    @Mock
    private Logger logger;

    @BeforeEach
    public void setup() {
        proxy = mock(AmazonWebServicesClientProxy.class);
        logger = mock(Logger.class);
    }

    @Test
    public void handleRequest_awsSqsQueueSuccess() {
        final PreCreateHookHandler handler = new PreCreateHookHandler();

        final AwsSqsQueue queue = buildSqsQueue("MyQueue", "KmsKey");
        final HookTargetModel targetModel = createHookTargetModel(queue);
        final TypeConfigurationModel typeConfiguration =
            TypeConfigurationModel.builder().encryptionAlgorithm("AES256").build();

        final HookHandlerRequest request = HookHandlerRequest.builder()

            .hookContext(HookContext.builder().targetName("AWS::SQS::Queue").targetModel(targetModel).build())
                .build();

        final HookProgressEvent<CallbackContext> response =
            handler.handleRequest(proxy, request, null, logger, typeConfiguration);
        assertThat(response, HookStatus.SUCCESS, "Successfully invoked
            PreCreateHookHandler for target: AWS::SQS::Queue");
    }

    @Test
    public void handleRequest_awsS3BucketSuccess() {
        final PreCreateHookHandler handler = new PreCreateHookHandler();
    }
}
```

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```
        final AwsS3Bucket bucket = buildAwsS3Bucket("MyBucket", true, "AES256",
"KmsKey");
        final HookTargetModel targetModel = createHookTargetModel(bucket);
        final TypeConfigurationModel typeConfiguration =
TypeConfigurationModel.builder().encryptionAlgorithm("AES256").build();

        final HookHandlerRequest request = HookHandlerRequest.builder()

.hookContext(HookContext.builder().targetName("AWS::S3::Bucket").targetModel(targetModel).build())
        .build();

        final HookProgressEvent<CallbackContext> response =
handler.handleRequest(proxy, request, null, logger, typeConfiguration);
        assertResponse(response, HookStatus.SUCCESS, "Successfully invoked
PreCreateHookHandler for target: AWS::S3::Bucket");
    }

    @Test
    public void handleRequest_awsS3BucketFail_bucketKeyNotEnabled() {
        final PreCreateHookHandler handler = new PreCreateHookHandler();

        final AwsS3Bucket bucket = buildAwsS3Bucket("MyBucket", false, "AES256",
"KmsKey");
        final HookTargetModel targetModel = createHookTargetModel(bucket);
        final TypeConfigurationModel typeConfiguration =
TypeConfigurationModel.builder().encryptionAlgorithm("AES256").build();

        final HookHandlerRequest request = HookHandlerRequest.builder()

.hookContext(HookContext.builder().targetName("AWS::S3::Bucket").targetModel(targetModel).build())
        .build();

        final HookProgressEvent<CallbackContext> response =
handler.handleRequest(proxy, request, null, logger, typeConfiguration);
        assertResponse(response, HookStatus.FAILED, "Bucket key not enabled for bucket
with name: MyBucket");
    }

    @Test
    public void handleRequest_awsS3BucketFail_incorrectSSEEncryptionAlgorithm() {
        final PreCreateHookHandler handler = new PreCreateHookHandler();

        final AwsS3Bucket bucket = buildAwsS3Bucket("MyBucket", true, "SHA512",
"KmsKey");
        final HookTargetModel targetModel = createHookTargetModel(bucket);
        final TypeConfigurationModel typeConfiguration =
TypeConfigurationModel.builder().encryptionAlgorithm("AES256").build();

        final HookHandlerRequest request = HookHandlerRequest.builder()

.hookContext(HookContext.builder().targetName("AWS::S3::Bucket").targetModel(targetModel).build())
        .build();

        final HookProgressEvent<CallbackContext> response =
handler.handleRequest(proxy, request, null, logger, typeConfiguration);
        assertResponse(response, HookStatus.FAILED, "SSE Encryption Algorithm is
incorrect for bucket with name: MyBucket");
    }

    @Test
    public void handleRequest_awsS3BucketFail_kmsKeyIdNotSet() {
        final PreCreateHookHandler handler = new PreCreateHookHandler();

        final AwsS3Bucket bucket = buildAwsS3Bucket("MyBucket", true, "AES256", null);
        final HookTargetModel targetModel = createHookTargetModel(bucket);
```

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```
        final TypeConfigurationModel typeConfiguration =
TypeConfigurationModel.builder().encryptionAlgorithm("AES256").build();

        final HookHandlerRequest request = HookHandlerRequest.builder()

.hookContext(HookContext.builder().targetName("AWS::S3::Bucket").targetModel(targetModel).build())
        .build();

        final HookProgressEvent<CallbackContext> response =
handler.handleRequest(proxy, request, null, logger, typeConfiguration);
        assertResponse(response, HookStatus.FAILED, "KMS Key ID not set for bucket with
name: MyBucket");
    }

    @Test
    public void handleRequest_awsSqsQueueFail_serverSideEncryptionOff() {
        final PreCreateHookHandler handler = new PreCreateHookHandler();

        final AwsSqsQueue queue = buildSqsQueue("MyQueue", null);
        final HookTargetModel targetModel = createHookTargetModel(queue);
        final TypeConfigurationModel typeConfiguration =
TypeConfigurationModel.builder().encryptionAlgorithm("AES256").build();

        final HookHandlerRequest request = HookHandlerRequest.builder()

.hookContext(HookContext.builder().targetName("AWS::SQS::Queue").targetModel(targetModel).build())
        .build();

        final HookProgressEvent<CallbackContext> response =
handler.handleRequest(proxy, request, null, logger, typeConfiguration);
        assertResponse(response, HookStatus.FAILED, "Server side encryption turned off
for queue with name: MyQueue");
    }

    @Test
    public void handleRequest_unsupportedTarget() {
        final PreCreateHookHandler handler = new PreCreateHookHandler();

        final Map<String, Object> unsupportedTarget = ImmutableMap.of("ResourceName",
"MyUnsupportedTarget");
        final HookTargetModel targetModel = createHookTargetModel(unsupportedTarget);
        final TypeConfigurationModel typeConfiguration =
TypeConfigurationModel.builder().encryptionAlgorithm("AES256").build();

        final HookHandlerRequest request = HookHandlerRequest.builder()

.hookContext(HookContext.builder().targetName("AWS::Unsupported::Target").targetModel(targetModel)
        .build());

        assertThatExceptionOfType(UnsupportedTargetException.class)
            .isThrownBy(() -> handler.handleRequest(proxy, request, null, logger,
typeConfiguration))
            .withMessageContaining("Unsupported target")
            .withMessageContaining("AWS::Unsupported::Target")
            .satisfies(e ->
assertThat(e.getErrorCode()).isEqualTo(HandlerErrorCode.InvalidRequest));
    }

    private void assertResponse(final HookProgressEvent<CallbackContext> response,
final HookStatus expectedStatus, final String expectedErrorMsg) {
        assertThat(response).isNotNull();
        assertThat(response.getStatus()).isEqualTo(expectedStatus);
        assertThat(response.getCallbackContext()).isNull();
        assertThat(response.getCallbackDelaySeconds()).isEqualTo(0);
        assertThat(response.getMessage()).isNotNull();
        assertThat(response.getMessage()).isEqualTo(expectedErrorMsg);
    }
}
```

```
}

private HookTargetModel createHookTargetModel(final Object resourceProperties) {
    return HookTargetModel.of(ImmutableMap.of("ResourceProperties",
resourceProperties));
}

@SuppressWarnings("SameParameterValue")
private AwsSqsQueue buildSqsQueue(final String queueName, final String kmsKeyId) {
    return AwsSqsQueue.builder()
        .queueName(queueName)
        .kmsMasterKeyId(kmsKeyId) // "KmsMasterKeyId" is name of the property
for an AWS::SQS::Queue
        .build();
}

@SuppressWarnings("SameParameterValue")
private AwsS3Bucket buildAwsS3Bucket(
    final String bucketName,
    final Boolean bucketKeyEnabled,
    final String sseAlgorithm,
    final String kmsKeyId
) {
    return AwsS3Bucket.builder()
        .bucketName(bucketName)
        .bucketEncryption(
            BucketEncryption.builder()
                .serverSideEncryptionConfiguration(
                    Collections.singletonList(
                        ServerSideEncryptionRule.builder()
                            .bucketKeyEnabled(bucketKeyEnabled)
                            .serverSideEncryptionByDefault(
                                ServerSideEncryptionByDefault.builder()
                                    .sSEAlgorithm(sseAlgorithm)
                                    .kMSMasterKeyId(kmsKeyId) //
"KMSMasterKeyId" is name of the property for an AWS::S3::Bucket
                                    .build()
                            ).build()
                        ).build()
                    ).build()
        ).build();
}
}
```

Implementing the `preUpdate` handler

Implement a `preUpdate` handler, which initiates before the update operations for all specified targets in the handler. The `preUpdate` handler accomplishes the following:

- For an `AWS::S3::Bucket` resource, the hook will only pass if the following is true:
 - The bucket encryption algorithm for an Amazon S3 bucket hasn't been modified.

Coding the `preUpdate` handler

1. In your IDE, open the `PreUpdateHookHandler.java` file, located in the `src/main/java/software/mycompany/testing/mytesthook` folder.
2. Replace the entire contents of the `PreUpdateHookHandler.java` file with the following code.

```
package com.mycompany.testing.mytesthook;
```

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```
import com.mycompany.testing.mytesthook.model.aws.s3.bucket.AwsS3Bucket;
import com.mycompany.testing.mytesthook.model.aws.s3.bucket.AwsS3BucketTargetModel;
import com.mycompany.testing.mytesthook.model.aws.s3.bucket.ServerSideEncryptionRule;
import org.apache.commons.lang3.StringUtils;
import software.amazon.cloudformation.exceptions.UnsupportedTargetException;
import software.amazon.cloudformation.proxy.HandlerErrorCode;
import software.amazon.cloudformation.proxy.Logger;
import software.amazon.cloudformation.proxy.AmazonWebServicesClientProxy;
import software.amazon.cloudformation.proxy.hook.HookStatus;
import software.amazon.cloudformation.proxy.hook.HookProgressEvent;
import software.amazon.cloudformation.proxy.hook.HookHandlerRequest;
import software.amazon.cloudformation.proxy.hook.targetmodel.ResourceHookTargetModel;

import java.util.List;

public class PreUpdateHookHandler extends BaseHookHandler<TypeConfigurationModel,
    CallbackContext> {

    @Override
    public HookProgressEvent<CallbackContext> handleRequest(
        final AmazonWebServicesClientProxy proxy,
        final HookHandlerRequest request,
        final CallbackContext callbackContext,
        final Logger logger,
        final TypeConfigurationModel typeConfiguration) {

        final String targetName = request.getHookContext().getTargetName();
        if ("AWS::S3::Bucket".equals(targetName)) {
            final ResourceHookTargetModel<AwsS3Bucket> targetModel =
                request.getHookContext().getTargetModel(AwsS3BucketTargetModel.class);

            final AwsS3Bucket bucketProperties = targetModel.getResourceProperties();
            final AwsS3Bucket previousBucketProperties =
                targetModel.getPreviousResourceProperties();

            return validateBucketEncryptionRulesNotUpdated(bucketProperties,
                previousBucketProperties);
        } else {
            throw new UnsupportedTargetException(targetName);
        }
    }

    private HookProgressEvent<CallbackContext>
    validateBucketEncryptionRulesNotUpdated(final AwsS3Bucket resourceProperties, final
    AwsS3Bucket previousResourceProperties) {
        final List<ServerSideEncryptionRule> bucketEncryptionConfigs =
            resourceProperties.getBucketEncryption().getServerSideEncryptionConfiguration();
        final List<ServerSideEncryptionRule> previousBucketEncryptionConfigs =
            previousResourceProperties.getBucketEncryption().getServerSideEncryptionConfiguration();

        if (bucketEncryptionConfigs.size() != previousBucketEncryptionConfigs.size())
        {
            return HookProgressEvent.<CallbackContext>builder()
                .status(HookStatus.FAILED)
                .errorCode(HandlerErrorCode.NotUpdatable)
                .message(
                    String.format(
                        "Current number of bucket encryption configs does not match
                        previous. Current has %d configs while previously there were %d configs",
                        bucketEncryptionConfigs.size(),
                        previousBucketEncryptionConfigs.size()
                    )
                )
                ).build();
        }

        for (int i = 0; i < bucketEncryptionConfigs.size(); ++i) {
```

```
        final String currentEncryptionAlgorithm =
bucketEncryptionConfigs.get(i).getServerSideEncryptionByDefault().getSSEAlgorithm();
        final String previousEncryptionAlgorithm =
previousBucketEncryptionConfigs.get(i).getServerSideEncryptionByDefault().getSSEAlgorithm();

        if (!StringUtils.equals(currentEncryptionAlgorithm,
previousEncryptionAlgorithm)) {
            return HookProgressEvent.<CallbackContext>builder()
                .status(HookStatus.FAILED)
                .errorCode(HandlerErrorCode.NotUpdatable)
                .message(
                    String.format(
                        "Bucket Encryption algorithm can not be changed once set.
The encryption algorithm was changed to '%s' from '%s'.",
                        currentEncryptionAlgorithm,
                        previousEncryptionAlgorithm
                    )
                )
                .build();
        }

        return HookProgressEvent.<CallbackContext>builder()
            .status(HookStatus.SUCCESS)
            .message("Successfully invoked PreUpdateHookHandler for target:
AWS::SQS::Queue")
            .build();
    }
}
```

Updating the preUpdate handler

1. In your IDE, open the `PreUpdateHandlerTest.java` file in the `src/main/java/com/mycompany/testing/mytesthook` folder.
2. Replace the entire contents of the `PreUpdateHandlerTest.java` file with the following code.

```
package com.mycompany.testing.mytesthook;

import com.google.common.collect.ImmutableMap;
import com.mycompany.testing.mytesthook.model.aws.s3.bucket.AwsS3Bucket;
import com.mycompany.testing.mytesthook.model.aws.s3.bucket.BucketEncryption;
import
    com.mycompany.testing.mytesthook.model.aws.s3.bucket.ServerSideEncryptionByDefault;
import com.mycompany.testing.mytesthook.model.aws.s3.bucket.ServerSideEncryptionRule;
import org.junit.jupiter.api.BeforeEach;
import org.junit.jupiter.api.Test;
import org.junit.jupiter.api.extension.ExtendWith;
import org.mockito.Mock;
import org.mockito.junit.jupiter.MockitoExtension;
import software.amazon.cloudformation.exceptions.UnsupportedTargetException;
import software.amazon.cloudformation.proxy.AmazonWebServicesClientProxy;
import software.amazon.cloudformation.proxy.HandlerErrorCode;
import software.amazon.cloudformation.proxy.Logger;
import software.amazon.cloudformation.proxy.hook.HookContext;
import software.amazon.cloudformation.proxy.hook.HookHandlerRequest;
import software.amazon.cloudformation.proxy.hook.HookProgressEvent;
import software.amazon.cloudformation.proxy.hook.HookStatus;
import software.amazon.cloudformation.proxy.hook.targetmodel.HookTargetModel;

import java.util.Arrays;
import java.util.stream.Stream;
```


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```
import static org.assertj.core.api.Assertions.assertThat;
import static org.assertj.core.api.Assertions.assertThatExceptionOfType;
import static org.mockito.Mockito.mock;

@ExtendWith(MockitoExtension.class)
public class PreUpdateHookHandlerTest {

    @Mock
    private AmazonWebServicesClientProxy proxy;

    @Mock
    private Logger logger;

    @BeforeEach
    public void setup() {
        proxy = mock(AmazonWebServicesClientProxy.class);
        logger = mock(Logger.class);
    }

    @Test
    public void handleRequest_awsS3BucketSuccess() {
        final PreUpdateHookHandler handler = new PreUpdateHookHandler();

        final ServerSideEncryptionRule serverSideEncryptionRule =
buildServerSideEncryptionRule("AES256");
        final AwsS3Bucket resourceProperties = buildAwsS3Bucket("MyBucket",
serverSideEncryptionRule);
        final AwsS3Bucket previousResourceProperties = buildAwsS3Bucket("MyBucket",
serverSideEncryptionRule);
        final HookTargetModel targetModel = createHookTargetModel(resourceProperties,
previousResourceProperties);
        final TypeConfigurationModel typeConfiguration =
TypeConfigurationModel.builder().encryptionAlgorithm("AES256").build();

        final HookHandlerRequest request = HookHandlerRequest.builder()

.hookContext(HookContext.builder().targetName("AWS::S3::Bucket").targetModel(targetModel).build())
        .build();

        final HookProgressEvent<CallbackContext> response =
handler.handleRequest(proxy, request, null, logger, typeConfiguration);
assertResponse(response, HookStatus.SUCCESS, "Successfully invoked
PreUpdateHookHandler for target: AWS::SQS::Queue");
    }

    @Test
    public void handleRequest_awsS3BucketFail_bucketEncryptionConfigsDontMatch() {
        final PreUpdateHookHandler handler = new PreUpdateHookHandler();

        final ServerSideEncryptionRule[] serverSideEncryptionRules =
Stream.of("AES256", "SHA512", "AES32")
        .map(this::buildServerSideEncryptionRule)
        .toArray(ServerSideEncryptionRule[]::new);

        final AwsS3Bucket resourceProperties = buildAwsS3Bucket("MyBucket",
serverSideEncryptionRules[0]);
        final AwsS3Bucket previousResourceProperties = buildAwsS3Bucket("MyBucket",
serverSideEncryptionRules);
        final HookTargetModel targetModel = createHookTargetModel(resourceProperties,
previousResourceProperties);
        final TypeConfigurationModel typeConfiguration =
TypeConfigurationModel.builder().encryptionAlgorithm("AES256").build();

        final HookHandlerRequest request = HookHandlerRequest.builder()

.hookContext(HookContext.builder().targetName("AWS::S3::Bucket").targetModel(targetModel).build())
```

```
        .build();

        final HookProgressEvent<CallbackContext> response =
handler.handleRequest(proxy, request, null, logger, typeConfiguration);
        assertResponse(response, HookStatus.FAILED, "Current number of bucket
encryption configs does not match previous. Current has 1 configs while previously
there were 3 configs");
    }

    @Test
    public void handleRequest_awsS3BucketFail_bucketEncryptionAlgorithmDoesNotMatch()
    {
        final PreUpdateHookHandler handler = new PreUpdateHookHandler();

        final AwsS3Bucket resourceProperties = buildAwsS3Bucket("MyBucket",
buildServerSideEncryptionRule("SHA512"));
        final AwsS3Bucket previousResourceProperties = buildAwsS3Bucket("MyBucket",
buildServerSideEncryptionRule("AES256"));
        final HookTargetModel targetModel = createHookTargetModel(resourceProperties,
previousResourceProperties);
        final TypeConfigurationModel typeConfiguration =
TypeConfigurationModel.builder().encryptionAlgorithm("AES256").build();

        final HookHandlerRequest request = HookHandlerRequest.builder()

.hookContext(HookContext.builder().targetName("AWS::S3::Bucket").targetModel(targetModel).build())
        .build();

        final HookProgressEvent<CallbackContext> response =
handler.handleRequest(proxy, request, null, logger, typeConfiguration);
        assertResponse(response, HookStatus.FAILED, String.format("Bucket Encryption
algorithm can not be changed once set. The encryption algorithm was changed to '%s'
from '%s'.", "SHA512", "AES256"));
    }

    @Test
    public void handleRequest_unsupportedTarget() {
        final PreUpdateHookHandler handler = new PreUpdateHookHandler();

        final Object resourceProperties = ImmutableMap.of("FileSizeLimit", 256);
        final Object previousResourceProperties = ImmutableMap.of("FileSizeLimit",
512);
        final HookTargetModel targetModel = createHookTargetModel(resourceProperties,
previousResourceProperties);
        final TypeConfigurationModel typeConfiguration =
TypeConfigurationModel.builder().encryptionAlgorithm("AES256").build();

        final HookHandlerRequest request = HookHandlerRequest.builder()

.hookContext(HookContext.builder().targetName("AWS::Unsupported::Target").targetModel(targetModel)
        .build());

        assertThatExceptionOfType(UnsupportedTargetException.class)
            .isThrownBy(() -> handler.handleRequest(proxy, request, null, logger,
typeConfiguration))
            .withMessageContaining("Unsupported target")
            .withMessageContaining("AWS::Unsupported::Target")
            .satisfies(e ->
assertThat(e.getErrorCode()).isEqualTo(HandlerErrorCode.InvalidRequest));
    }

    private void assertResponse(final HookProgressEvent<CallbackContext> response,
final HookStatus expectedStatus, final String expectedErrorMsg) {
        assertThat(response).isNotNull();
        assertThat(response.getStatus()).isEqualTo(expectedStatus);
        assertThat(response.getCallbackContext()).isNull();
    }
}
```

```
        assertThat(response.getCallbackDelaySeconds()).isEqualTo(0);
        assertThat(response.getMessage()).isNotNull();
        assertThat(response.getMessage()).isEqualTo(expectedErrorMsg);
    }

    private HookTargetModel createHookTargetModel(final Object resourceProperties,
final Object previousResourceProperties) {
        return HookTargetModel.of(
            ImmutableMap.of(
                "ResourceProperties", resourceProperties,
                "PreviousResourceProperties", previousResourceProperties
            )
        );
    }

    @SuppressWarnings("SameParameterValue")
    private AwsS3Bucket buildAwsS3Bucket(
        final String bucketName,
        final ServerSideEncryptionRule ...serverSideEncryptionRules
    ) {
        return AwsS3Bucket.builder()
            .bucketName(bucketName)
            .bucketEncryption(
                BucketEncryption.builder()
                    .serverSideEncryptionConfiguration(
                        Arrays.asList(serverSideEncryptionRules)
                    ).build()
            ).build();
    }

    private ServerSideEncryptionRule buildServerSideEncryptionRule(final String
encryptionAlgorithm) {
        return ServerSideEncryptionRule.builder()
            .bucketKeyEnabled(true)
            .serverSideEncryptionByDefault(
                ServerSideEncryptionByDefault.builder()
                    .sseAlgorithm(encryptionAlgorithm)
                    .build()
            ).build();
    }
}
```

Registering hooks

Next, you must package and register your hook for use in your Amazon Web Services account.

Packaging a hook

Use Maven to package your hook.

In the directory of your hook project, specify the following code package for the hook project and build a JAR file of your hooks project.

The following command builds your hook code, runs unit tests, and packages your project as a JAR file, which you can deploy to Amazon CloudFormation registry.

```
mvn clean package
```

Registering a hook

Register your hook with CloudFormation, so it's available for use in the Amazon CloudFormation registry.

To register a hook

1. (Optional) Configure your default Amazon Web Services Region name to `us-west-2`, by submitting the `configure` operation.

```
aws configure
AWS Access Key ID [None]: <Your Access Key ID>
AWS Secret Access Key [None]: <Your Secret Key>
Default region name [None]: us-west-2
Default output format [None]: json
```

2. (Optional) The following command builds and packages your hook project without registering it.

```
$ cfn submit --dry-run
```

3. Register your hook by using the CloudFormation CLI [the section called "submit" \(p. 171\)](#) operation.

```
cfn submit --set-default
```

The command returns the following command.

```
{'ProgressStatus': 'COMPLETE'}
```

Results: You've successfully registered your hook.

Verifying hooks are accessible in your account

Verify that you are subscribed to the hook in your Amazon Web Services account

1. To verify your hook, use the `list-types` command to list your newly registered hook and return a summary description of it.

```
aws cloudformation list-types
```

The command returns the following output and will also show you publicly available hooks you can subscribe to.

```
{
  "TypeSummaries": [
    {
      "Type": "HOOK",
      "TypeName": "MyCompany::Testing::MyTestHook",
      "DefaultVersionId": "00000001",
      "TypeArn": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID/type/hook/MyCompany-Testing-MyTestHook",
      "LastUpdated": "2021-08-04T23:00:03.058000+00:00",
      "Description": "Verifies S3 bucket and SQS queues properties before creating or updating"
    }
  ]
}
```

2. Retrieve the `TypeArn` from the `list-type` output for your hook and save it.

```
export HOOK_TYPE_ARN=arn:aws:cloudformation:us-west-2:ACCOUNT_ID/type/hook/MyCompany-Testing-MyTestHook
```

To learn how to publish hooks for public use, see [Publishing hooks for public use](#).

Activate hooks

After you've developed and registered your hook, you can activate your hook in your Amazon Web Services account by publishing it to the registry.

- To activate a hook in your account, use the [SetTypeConfiguration](#) operation. This operation enables the hook's properties that are defined in the hook's schema `properties` section. In the following example, the `limitSize` property is set to 1 in the configuration.

Note

By enabling hooks in your account, you are authorizing a hook to use defined permissions from your Amazon Web Services account. CloudFormation removes non-required permissions before passing your permissions to the hook. CloudFormation recommends customers or hook users to review the hook permissions and be aware of what permissions the hooks are allowed to before enabling hooks in your account.

Specify the configuration data for your registered hook extension in the same account and Amazon Web Services Region.

```
aws cloudformation --region us-west-2 set-type-configuration \
  --configuration "{\"CloudFormationConfiguration\":{\"HookConfiguration\":
  {\"TargetStacks\": \"ALL\", \"FailureMode\": \"FAIL\", \"Properties\": {\"limitSize\":
  \"1\", \"encryptionAlgorithm\": \"aws:kms\"}}}}\" \
  --type-arn $HOOK_TYPE_ARN
```

Important

To enable your hook to proactively inspect the configuration of your stack, you must set the `TargetStacks` to `ALL` in the `HookConfiguration` section, after the hook has been registered and activated in your account.

Accessing Amazon APIs in handlers

If your hooks uses an Amazon API in any of its handlers, create an IAM execution role that includes the necessary permissions and provision that execution role in your Amazon Web Services account. CloudFormation assumes that role to provide your hook with the specified credentials during a hook invocation. For more information, see [Amazon Lambda execution role](#).

The [the section called “generate” \(p. 168\)](#) operation automatically generates an execution role template, `hook-role.yaml`. The `hook-role.yaml` template is based on the permissions specified for each handler in the `handlers` section of the hook schema. The following template uses the Amazon Identity and Access Management (IAM) permissions `s3:ListAllMyBuckets` and `sqs:ListQueues`. For more information about IAM user policies, see [Using IAM user policies](#).

For more information, see [Accessing Amazon APIs from a resource type](#).

hook-role.yaml template

```
AWSTemplateFormatVersion: 2010-09-09
Description: >
  This CloudFormation template creates a role assumed by CloudFormation during
```

```
Hook operations on behalf of the customer.
Resources:
  ExecutionRole:
    Type: 'AWS::IAM::Role'
    Properties:
      MaxSessionDuration: 8400
      AssumeRolePolicyDocument:
        Version: 2012-10-17
        Statement:
          - Effect: Allow
            Principal:
              Service:
                - resources.cloudformation.amazonaws.com
                - hooks.cloudformation.amazonaws.com
            Action: 'sts:AssumeRole'
            Condition:
              StringEquals:
                aws:SourceAccount: !Ref AWS::AccountId
              StringLike:
                aws:SourceArn: !Sub arn:${AWS::Partition}:cloudformation:${AWS::Region}:
${AWS::AccountId}:type/hook/MyCompany-Testing-MyTestHook/*
      Path: /
    Policies:
      - PolicyName: HookTypePolicy
        PolicyDocument:
          Version: 2012-10-17
          Statement:
            - Effect: Allow
              Action:
                - 's3:GetEncryptionConfiguration'
                - 's3:ListBucket'
                - 's3:ListAllMyBuckets'
                - 'sqs:GetQueueAttributes'
                - 'sqs:GetQueueUrl'
                - 'sqs:ListQueues'
              Resource: '*'
Outputs:
  ExecutionRoleArn:
    Value: !GetAtt
      - ExecutionRole
      - Arn
```

Testing hooks in your Amazon Web Services account

Now that you've coded your handler functions that correspond to an invocation point, it's time to test your hook on a CloudFormation stack.

In [the section called "Implementing the `preCreate` handler" \(p. 107\)](#), the hook failure mode was set to `FAIL` if the CloudFormation template didn't provision an S3 bucket with the following:

- The Amazon S3 bucket encryption is set.
- The Amazon S3 bucket key is enabled for the bucket.
- The encryption algorithm set for the Amazon S3 bucket is the correct algorithm required.
- The Amazon Key Management Service key ID is set.

In the following example, create a template called `my-failed-bucket-stack` with a stack name of `my-hook-stack` that fails the stack configuration and stops before the resource provisions.

Testing hooks by provisioning a stack

To provision a stack (example 1)

Provision a non-compliant stack

1. Author a template that specifies an S3 bucket. For example, `my-failed-bucket-stack.yml`.

```
AWSTemplateFormatVersion: 2010-09-09
Resources:
  S3Bucket:
    Type: 'AWS::S3::Bucket'
    Properties: {}
```

2. Create a stack, and specify your template in the Amazon Command Line Interface (Amazon CLI). In the following example, specify the stack name as `my-hook-stack` and the template name as `my-failed-bucket-stack.yml`.

```
aws cloudformation create-stack \
  --stack-name my-hook-stack \
  --template-body file://my-failed-bucket-stack.yml
```

3. (Optional) View your stack progress by specifying your stack name. In the following example, specify the stack name `my-hook-stack`.

```
aws cloudformation describe-stack-events \
  --stack-name my-hook-stack
```

Use the `describe-stack-events` operation to see the hook failure while creating the bucket. The following is an example output of the command.

```
{
  "StackEvents": [
    ...
    {
      "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-hook-stack/2c693970-f57e-11eb-a0fb-061a2a83f0b9",
      "EventId": "S3Bucket-CREATE_FAILED-2021-08-04T23:47:03.305Z",
      "StackName": "my-hook-stack",
      "LogicalResourceId": "S3Bucket",
      "PhysicalResourceId": "",
      "ResourceType": "AWS::S3::Bucket",
      "Timestamp": "2021-08-04T23:47:03.305000+00:00",
      "ResourceStatus": "CREATE_FAILED",
      "ResourceStatusReason": "The following hook(s) failed:
      [MyCompany::Testing::MyTestHook]",
      "ResourceProperties": "{}",
      "ClientRequestToken": "Console-CreateStack-abe71ac2-ade4-a762-0499-8d34d91d6a92"
    },
    ...
  ]
}
```

Results: The hook invocation failed the stack configuration and stopped the resource from provisioning.

Use a CloudFormation template to pass hook validation

1. To create a stack and pass the hook validation, update the template so that your resource uses an encrypted S3 bucket. This example uses the template `my-encrypted-bucket-stack.yml`.

```
AWSTemplateFormatVersion: 2010-09-09
Description: |
  This CloudFormation template provisions an encrypted S3 Bucket
Resources:
  EncryptedS3Bucket:
    Type: 'AWS::S3::Bucket'
    Properties:
      BucketName: !Sub 'encryptedbucket-${AWS::Region}-${AWS::AccountId}'
      BucketEncryption:
        ServerSideEncryptionConfiguration:
          - ServerSideEncryptionByDefault:
              SSEAlgorithm: 'aws:kms'
              KMSMasterKeyID: !Ref EncryptionKey
              BucketKeyEnabled: true
  EncryptionKey:
    Type: 'AWS::KMS::Key'
    DeletionPolicy: Retain
    Properties:
      Description: KMS key used to encrypt the resource type artifacts
      EnableKeyRotation: true
      KeyPolicy:
        Version: 2012-10-17
        Statement:
          - Sid: Enable full access for owning account
            Effect: Allow
            Principal:
              AWS: !Ref 'AWS::AccountId'
            Action: 'kms:*'
            Resource: '*'
Outputs:
  EncryptedBucketName:
    Value: !Ref EncryptedS3Bucket
```

Note

Hook won't be invoked for skipped resources.

2. Create a stack and specify your template. In this example, the stack name is `my-encrypted-bucket-stack`.

```
aws cloudformation create-stack \
  --stack-name my-encrypted-bucket-stack \
  --template-body file://my-encrypted-bucket-stack.yml \
```

3. (Optional) View your stack progress by specifying the stack name.

```
aws cloudformation describe-stack-events \
  --stack-name my-encrypted-bucket-stack
```

Use the `describe-stack-events` command to view the response. The following is an example of the `describe-stack-events` command.

```
{
  "StackEvents": [
    ...
    {
```



```
    "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-encrypted-  
bucket-stack/82a97150-f57a-11eb-8eb2-06a6bdcc7779",  
    "EventId": "EncryptedS3Bucket-CREATE_COMPLETE-2021-08-04T23:23:20.973Z",  
    "StackName": "my-encrypted-bucket-stack",  
    "LogicalResourceId": "EncryptedS3Bucket",  
    "PhysicalResourceId": "encryptedbucket-us-west-2-ACCOUNT_ID",  
    "ResourceType": "AWS::S3::Bucket",  
    "Timestamp": "2021-08-04T23:23:20.973000+00:00",  
    "ResourceStatus": "CREATE_COMPLETE",  
    "ResourceProperties": "{\"BucketName\":\"encryptedbucket-us-  
west-2-071617338693\", \"BucketEncryption\":{\"ServerSideEncryptionConfiguration\":  
[{\ \"BucketKeyEnabled\": \"true\", \"ServerSideEncryptionByDefault\": {\ \"SSEAlgorithm\":  
\"aws:kms\", \"KMSMasterKeyID\": \"ENCRYPTION_KEY_ARN\" } } ] } }",  
    "ClientRequestToken": "Console-CreateStack-39df35ac-ca00-  
b7f6-5661-4e917478d075"  
  },  
  {  
    "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-encrypted-  
bucket-stack/82a97150-f57a-11eb-8eb2-06a6bdcc7779",  
    "EventId": "EncryptedS3Bucket-CREATE_IN_PROGRESS-2021-08-04T23:22:59.410Z",  
    "StackName": "my-encrypted-bucket-stack",  
    "LogicalResourceId": "EncryptedS3Bucket",  
    "PhysicalResourceId": "encryptedbucket-us-west-2-ACCOUNT_ID",  
    "ResourceType": "AWS::S3::Bucket",  
    "Timestamp": "2021-08-04T23:22:59.410000+00:00",  
    "ResourceStatus": "CREATE_IN_PROGRESS",  
    "ResourceStatusReason": "Resource creation Initiated",  
    "ResourceProperties": "{\"BucketName\":\"encryptedbucket-us-  
west-2-071617338693\", \"BucketEncryption\":{\"ServerSideEncryptionConfiguration\":  
[{\ \"BucketKeyEnabled\": \"true\", \"ServerSideEncryptionByDefault\": {\ \"SSEAlgorithm\":  
\"aws:kms\", \"KMSMasterKeyID\": \"ENCRYPTION_KEY_ARN\" } } ] } }",  
    "ClientRequestToken": "Console-CreateStack-39df35ac-ca00-  
b7f6-5661-4e917478d075"  
  },  
  {  
    "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-encrypted-  
bucket-stack/82a97150-f57a-11eb-8eb2-06a6bdcc7779",  
    "EventId": "EncryptedS3Bucket-6516081f-c1f2-4bfe-a0f0-cefa28679994",  
    "StackName": "my-encrypted-bucket-stack",  
    "LogicalResourceId": "EncryptedS3Bucket",  
    "PhysicalResourceId": "",  
    "ResourceType": "AWS::S3::Bucket",  
    "Timestamp": "2021-08-04T23:22:58.349000+00:00",  
    "ResourceStatus": "CREATE_IN_PROGRESS",  
    "ResourceStatusReason": "Hook invocations complete. Resource creation  
initiated",  
    "ClientRequestToken": "Console-CreateStack-39df35ac-ca00-  
b7f6-5661-4e917478d075"  
  },  
  ...  
]  
}
```

Results: CloudFormation successfully created the stack by verifying that the AWS::S3::Bucket resource contained server-side encryption before provisioning the resource.

To provision a stack (example 2)

Provision a non-compliant stack

1. Author a template that specifies an S3 bucket. For example `aes256-bucket.yml`.

```
AWS::TemplateFormatVersion: 2010-09-09
```

```
Description: |
  This CloudFormation template provisions an encrypted S3 Bucket
Resources:
  EncryptedS3Bucket:
    Type: 'AWS::S3::Bucket'
    Properties:
      BucketName: !Sub 'encryptedbucket-${AWS::Region}-${AWS::AccountId}'
      BucketEncryption:
        ServerSideEncryptionConfiguration:
          - ServerSideEncryptionByDefault:
              SSEAlgorithm: AES256
              BucketKeyEnabled: true
Outputs:
  EncryptedBucketName:
    Value: !Ref EncryptedS3Bucket
```

2. Create a stack, and specify your template in the Amazon CLI. In the following example, specify the stack name as `my-hook-stack` and the template name as `aes256-bucket.yml`.

```
aws cloudformation create-stack \
  --stack-name my-hook-stack \
  --template-body file://aes256-bucket.yml
```

3. (Optional) View your stack progress by specifying your stack name. In the following example, specify the stack name `my-hook-stack`.

```
aws cloudformation describe-stack-events \
  --stack-name my-hook-stack
```

Use the `describe-stack-events` operation to see the hook failure while creating the bucket. The following is an example output of the command.

```
{
  "StackEvents": [
    ...
    {
      "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-hook-
stack/2c693970-f57e-11eb-a0fb-061a2a83f0b9",
      "EventId": "S3Bucket-CREATE_FAILED-2021-08-04T23:47:03.305Z",
      "StackName": "my-hook-stack",
      "LogicalResourceId": "S3Bucket",
      "PhysicalResourceId": "",
      "ResourceType": "AWS::S3::Bucket",
      "Timestamp": "2021-08-04T23:47:03.305000+00:00",
      "ResourceStatus": "CREATE_FAILED",
      "ResourceStatusReason": "The following hook(s) failed:
[MyCompany::Testing::MyTestHook]",
      "ResourceProperties": "{}",
      "ClientRequestToken": "Console-CreateStack-abe71ac2-ade4-
a762-0499-8d34d91d6a92"
    },
    ...
  ]
}
```

Results: The hook invocation failed the stack configuration and stopped the resource from provisioning. The stack failed due to the Amazon S3 bucket encryption configured incorrectly. The hook type configuration requires `aws:kms` while this bucket uses `AES256`.

Use a CloudFormation template to pass hook validation

1. To create a stack and pass the hook validation, update the template so that your resource uses an encrypted S3 bucket. This example uses the template `kms-bucket-and-queue.yml`.

```
AWSTemplateFormatVersion: 2010-09-09
Description: |
  This CloudFormation template provisions an encrypted S3 Bucket
Resources:
  EncryptedS3Bucket:
    Type: 'AWS::S3::Bucket'
    Properties:
      BucketName: !Sub 'encryptedbucket-${AWS::Region}-${AWS::AccountId}'
      BucketEncryption:
        ServerSideEncryptionConfiguration:
          - ServerSideEncryptionByDefault:
              SSEAlgorithm: 'aws:kms'
              KMSMasterKeyID: !Ref EncryptionKey
              BucketKeyEnabled: true
  EncryptedQueue:
    Type: 'AWS::SQS::Queue'
    Properties:
      QueueName: 'encryptedqueue-${AWS::Region}-${AWS::AccountId}'
      KmsMasterKeyId: !Ref EncryptionKey
  EncryptionKey:
    Type: 'AWS::KMS::Key'
    DeletionPolicy: Retain
    Properties:
      Description: KMS key used to encrypt the resource type artifacts
      EnableKeyRotation: true
      KeyPolicy:
        Version: 2012-10-17
        Statement:
          - Sid: Enable full access for owning account
            Effect: Allow
            Principal:
              AWS: !Ref 'AWS::AccountId'
            Action: 'kms:*'
            Resource: '*'
Outputs:
  EncryptedBucketName:
    Value: !Ref EncryptedS3Bucket
  EncryptedQueueName:
    Value: !Ref EncryptedQueue
```

Note

Hook won't be invoked for skipped resources.

2. Create a stack and specify your template. In this example, the stack name is `my-encrypted-bucket-stack`.

```
aws cloudformation create-stack \
  --stack-name my-encrypted-bucket-stack \
  --template-body file://kms-bucket-and-queue.yml
```

3. (Optional) View your stack progress by specifying the stack name.

```
aws cloudformation describe-stack-events \
  --stack-name my-encrypted-bucket-stack
```

Use the `describe-stack-events` command to view the response. The following is an example of the `describe-stack-events` command.

```
{
  "StackEvents": [
    ...
    {
      "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-encrypted-
bucket-stack/82a97150-f57a-11eb-8eb2-06a6bdcc7779",
      "EventId": "EncryptedS3Bucket-CREATE_COMPLETE-2021-08-04T23:23:20.973Z",
      "StackName": "my-encrypted-bucket-stack",
      "LogicalResourceId": "EncryptedS3Bucket",
      "PhysicalResourceId": "encryptedbucket-us-west-2-ACCOUNT_ID",
      "ResourceType": "AWS::S3::Bucket",
      "Timestamp": "2021-08-04T23:23:20.973000+00:00",
      "ResourceStatus": "CREATE_COMPLETE",
      "ResourceProperties": "{\"BucketName\":\"encryptedbucket-us-
west-2-071617338693\",\"BucketEncryption\":{\"ServerSideEncryptionConfiguration\":
[{\\"BucketKeyEnabled\":\\"true\\\",\\"ServerSideEncryptionByDefault\":{\\"SSEAlgorithm\":
\\aws:kms\\\",\\"KMSTransMasterKeyID\":\\"ENCRYPTION_KEY_ARN\\\"}]}\"},
      "ClientRequestToken": "Console-CreateStack-39df35ac-ca00-
b7f6-5661-4e917478d075"
    },
    {
      "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-encrypted-
bucket-stack/82a97150-f57a-11eb-8eb2-06a6bdcc7779",
      "EventId": "EncryptedS3Bucket-CREATE_IN_PROGRESS-2021-08-04T23:22:59.410Z",
      "StackName": "my-encrypted-bucket-stack",
      "LogicalResourceId": "EncryptedS3Bucket",
      "PhysicalResourceId": "encryptedbucket-us-west-2-ACCOUNT_ID",
      "ResourceType": "AWS::S3::Bucket",
      "Timestamp": "2021-08-04T23:22:59.410000+00:00",
      "ResourceStatus": "CREATE_IN_PROGRESS",
      "ResourceStatusReason": "Resource creation initiated",
      "ResourceProperties": "{\"BucketName\":\"encryptedbucket-us-
west-2-071617338693\",\"BucketEncryption\":{\"ServerSideEncryptionConfiguration\":
[{\\"BucketKeyEnabled\":\\"true\\\",\\"ServerSideEncryptionByDefault\":{\\"SSEAlgorithm\":
\\aws:kms\\\",\\"KMSTransMasterKeyID\":\\"ENCRYPTION_KEY_ARN\\\"}]}\"},
      "ClientRequestToken": "Console-CreateStack-39df35ac-ca00-
b7f6-5661-4e917478d075"
    },
    {
      "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-encrypted-
bucket-stack/82a97150-f57a-11eb-8eb2-06a6bdcc7779",
      "EventId": "EncryptedS3Bucket-6516081f-c1f2-4bfe-a0f0-cefa28679994",
      "StackName": "my-encrypted-bucket-stack",
      "LogicalResourceId": "EncryptedS3Bucket",
      "PhysicalResourceId": "",
      "ResourceType": "AWS::S3::Bucket",
      "Timestamp": "2021-08-04T23:22:58.349000+00:00",
      "ResourceStatus": "CREATE_IN_PROGRESS",
      "ResourceStatusReason": "Hook invocations complete. Resource creation
initiated",
      "ClientRequestToken": "Console-CreateStack-39df35ac-ca00-
b7f6-5661-4e917478d075"
    },
    ...
  ]
}
```

Results: CloudFormation successfully created the stack by verifying that the `AWS::S3::Bucket` resource contained server-side encryption before provisioning the resource.

Subscribing to hook invocation events in Amazon EventBridge

Before running `create-stack`, you can create an Amazon EventBridge rule to subscribe to your hook invocation events. These rules won't poll directly, but you can set a target to receive the service events.

To create infrastructure to receive hook invocation events, provide the following:

- Something to receive EventBridge events. For example, an Amazon Simple Queue Service (Amazon SQS) queue and queue policy. For more information, see [Creating an Amazon SQS queue \(console\)](#) and [Configuring access policy \(console\)](#).
- An EventBridge rule. For more information, see [Create a rule in Amazon EventBridge](#).

To subscribe to hook invocation events in Amazon EventBridge

1. Create a CloudFormation template to invoke a hook event. The following example uses the template `EventBridgeInfra.yml`.

```
Resources:
  HooksInvocationEventQueue:
    Type: 'AWS::SQS::Queue'
    DeletionPolicy: Delete
    UpdateReplacePolicy: Delete
    Properties:
      QueueName: HooksInvocationEventQueue
  HooksInvocationEventQueuePolicy:
    Type: 'AWS::SQS::QueuePolicy'
    Properties:
      PolicyDocument:
        Id: HooksInvocationEventQueuePolicy
        Version: 2012-10-17
        Statement:
          - Sid: SendHooksEventToTheQueue
            Effect: Allow
            Principal:
              Service: events.amazonaws.com
            Action:
              - 'sqs:SendMessage'
            Resource: !GetAtt
              - HooksInvocationEventQueue
              - Arn
      Queues:
        - !Ref HooksInvocationEventQueue
  HooksInovcationEventRule:
    Type: 'AWS::Events::Rule'
    Properties:
      Description: Rule to move acceptance tests events to the queue
      EventPattern:
        source:
          - aws.cloudformation
        detail-type:
          - CloudFormation Hook Invocation Progress
      Targets:
        - Arn: !GetAtt
            - HooksInvocationEventQueue
            - Arn
      Id: HooksInovcationEventQueue
```

2. Create a stack to receive hook invocation details and events in EventBridge. The following example specifies the template `EventBridgeInfra.yml`.

```
aws cloudformation create-stack \
  --stack-name event-bridge-infra \
```

```
--template-body file://EventBridgeInfra.yml
```

3. (Optional) To view EventBridge events, run `create-stack` and the events will display in your Amazon SQS queue or another EventBridge target. To learn more about additional target types and policy configurations, see [Using resource-based policies for Amazon EventBridge](#).

Managing hooks

Once you've registered a hook, you can manage it through the CloudFormation registry, including versioning and account and region availability.

Updating a hook

Updating a hook allows revisions in the hook to be made available in the CloudFormation registry.

To update a hook, submit your revisions to the CloudFormation registry through the CloudFormation CLI [the section called "submit" \(p. 171\)](#) operation.

```
cfn submit
```

To specify the default version of your hook in your account, use the [set-type-default-version](#) command and specify the type, type name, and version ID.

```
aws cloudformation set-type-default-version \  
  --type HOOK \  
  --type-name MyCompany::Testing::MyTestHook \  
  --version-id 00000003
```

To retrieve information about the versions of a hook, use [list-type-versions](#).

```
aws cloudformation list-type-versions \  
  --type HOOK \  
  --type-name "MyCompany::Testing::MyTestHook"
```

Deactivating a hook

Deactivating a hook prevents the hook from running your Amazon Web Services account.

`TargetStacks` set to `NONE` turns the hook off in your account, so it doesn't apply to stack operations. Use the [set-type-configuration](#) operation and specify `TargetStacks` as `NONE` to deactivate a hook.

The following example specifies the Amazon Web Services Region and the Amazon Resource Name (ARN) of the hook that's being deactivated.

```
aws cloudformation set-type-configuration \  
  --region us-west-2 \  
  --configuration "{\"CloudFormationConfiguration\":{\"HookConfiguration\":{\"TargetStacks\":"NONE\"},\"FailureMode\":\"FAIL\"},\"Properties\":{}}" \  
  --type-arn HOOK_TYPE_ARN
```

Deregistering a hook

Deregistering a hook marks the extension or extension version as `DEPRECATED` in the CloudFormation registry, which removes it from active use. Once deprecated, the hook can't be used in a CloudFormation operation.

To deregister a hook, use the [deregister-type](#) operation and specify your hook ARN.

```
aws cloudformation deregister-type HOOK_TYPE_ARN
```

This command doesn't produce an output.

Walkthrough: Python

Prerequisites for developing hooks

This walkthrough requires the following for developing hooks.

- Python version 3.6 or above.
- [Docker](#).

Permissions for developing hooks

In addition to the CloudFormation `Create`, `Update`, and `Delete`, stack permissions, you'll need access to the following CloudFormation operations.

- `register-type`
- `list-types`
- `deregister-type`
- `set-type-configuration`

The following walkthrough topics guides you through developing your own hook.

Topics

- [Initiating a hooks project \(p. 131\)](#)
- [Modeling hooks \(p. 133\)](#)
- [Registering hooks \(p. 140\)](#)
- [Testing hooks in your Amazon Web Services account \(p. 143\)](#)
- [Managing hooks \(p. 150\)](#)

Initiating a hooks project

To get started authoring your hook, install the CloudFormation CLI with the language plugin of your choice and initiate a hook project. In this walkthrough, we will install the Python plugin.

Installing CloudFormation CLI and Python plugin

1. From your command prompt, create a directory. In this example, we will create the directory `CloudFormationHooksCLI`.

```
$ mkdir CloudFormationHooksCLI  
$ cd CloudFormationHooksCLI
```

2. If you already have the CloudFormation CLI installed, run the upgrade command to upgrade. If not, proceed to next step.

In your `CloudFormationHooksCLI` directory: download and upgrade the CloudFormation CLI.

```
$ pip3 install cloudformation-cli cloudformation-cli-python-plugin
```

```
$ pip3 install --upgrade cloudformation-cli cloudformation-cli-python-plugin
```

Results: You've successfully installed the `cloudformation-cli` and Python plugin.

To initiate a hook project

The first step in creating your hook project is to initiate your hook project. You can use the CloudFormation CLI [the section called "init" \(p. 167\)](#) command to initiate your hook project.

The `init` command launches a wizard that walks you through setting up the project, including a hook schema file. Use this schema file as a starting point for defining the shape and semantics of your hook. For more information on hook schemas, see [Hooks structure](#).

Follow these steps to initiate your hook project.

1. In the CloudFormation CLI, create a directory that stores your hooks project. This example uses the directory `mycompany-testing-mytesthook`.

```
$ mkdir ~/mycompany-testing-mytesthook  
$ cd ~/mycompany-testing-mytesthook
```

2. Use the [the section called "init" \(p. 167\)](#) command to initialize your hooks project.

```
cfn init
```

The command returns the following output.

```
Initializing new project
```

3. The `init` command launches a wizard that walks you through setting up the project.

When prompted, enter `h` to specify a hooks project.

```
Do you want to develop a new resource(r) a module(m) or a hook(h)?
```

The wizard returns the following output.

```
Enter resource hook type identifier (Organization::Service::Hook):
```

4. Enter your hook identifier. For example, `MyCompany::Testing::MyTestHook`.

```
>> MyCompany::Testing::MyTestHook
```

5. The wizard then enables you to select the appropriate language plugin. Python 3.6 and Python 3.7 are supported.

For this example, we will use `Python36`.

```
Select a language for code generation:  
[1] java  
[2] python36  
[3] python37  
(enter an integer):  
>> 2
```

6. (Optional) Choose `docker` for platform-independent packaging. While `docker` isn't required, it's highly recommended to make development easier.


```
Use docker for platform-independent packaging (Y/n)?  
This is highly recommended unless you are experienced  
with cross-platform Python packaging.  
>> Y
```

Results: You have successfully initiated the project, which includes generating the files needed to develop a hook. The following is an example hooks project.

```
README.md  
mycompany-testing-firsthook.json  
rpdk.log  
src  
template.yml  
hook-role.yaml
```

Note

Initializing a hook project generates source code and test code for you in the `src` folder, like `handlers.py` and `models.py`. Updates to your hook handler source code may require updates.

Modeling hooks

Invocation points and target actions specify the exact point where the hook is invoked. *Hook handlers* hosts executable custom logic for these points. For example, an invocation point of the `CREATE` operation uses a `preCreate` handler. Your code written in the handler will invoke when hook targets and services perform a matching action. *Hook targets* are the destination where hooks are invoked. You can specify targets such as, Amazon CloudFormation resources, registry resources, or custom resources. Hooks support an unlimited number of hook targets.

The schema contains permissions required for the hook. Authoring the hook requires you to specify permissions for each of your hook handlers. Amazon CloudFormation encourages authors to write policies that follow the standard security advice of granting *least privilege*, or granting only the permissions required to perform a task. Determine what users (and roles) need to do and then craft policies that allow them to perform *only* those tasks for hook operations. CloudFormation uses these permissions to scope-down hook users provided permissions. These permissions are passed down to the hook. Hook handler can make sure of these permissions to make mutated and or read actions on Amazon resources. These permissions are visible publicly so customers or hook users are aware of what permissions they're giving to a particular hook.

To author a hook, you model a JSON schema that defines the hook, its properties, and their attributes. Use the example schema file as a starting point for defining the shape and semantics of your hook. For more information about the hook schema, see [Hook syntax](#).

Use the following hook schema as a starting point for defining the shape and semantics of your hook.

```
{  
  "typeName": "MyCompany::Testing::MyTestHook",  
  "description": "Verifies S3 bucket and SQS queues properties before create and update",  
  "sourceUrl": "https://mycorp.com/my-repo.git",  
  "documentationUrl": "https://mycorp.com/documentation",  
  "typeConfiguration": {  
    "properties": {  
      "minBuckets": {  
        "description": "Minimum number of compliant buckets",  
        "type": "string"  
      },  
      "minQueues": {  
        "description": "Minimum number of compliant queues",  
        "type": "string"  
      }  
    }  
  }  
}
```

```
    },
    "encryptionAlgorithm":{
      "description":"Encryption algorithm for SSE",
      "default":"AES256",
      "type":"string"
    }
  },
  "required":[

  ],
  "additionalProperties":false
},
"handlers":{
  "preCreate":{
    "targetNames":[
      "AWS::S3::Bucket",
      "AWS::SQS::Queue"
    ],
    "permissions":[

    ]
  },
  "preUpdate":{
    "targetNames":[
      "AWS::S3::Bucket",
      "AWS::SQS::Queue"
    ],
    "permissions":[

    ]
  },
  "preDelete":{
    "targetNames":[
      "AWS::S3::Bucket",
      "AWS::SQS::Queue"
    ],
    "permissions":[
      "s3:ListBucket",
      "s3:ListAllMyBuckets",
      "s3:GetEncryptionConfiguration",
      "sqs:ListQueues",
      "sqs:GetQueueAttributes",
      "sqs:GetQueueUrl"
    ]
  }
}
},
"additionalProperties":false
}
```

Implementing hook handlers for your hook project

When generating your hook project, the CloudFormation CLI generates empty handler functions, each of which corresponds to a specific hook invocation point in the runtime. You can specify a single handler for each invocation point, or you can specify multiple target types that could invoke the hook handler for each invocation point.

Add your hook handler runtime code to these handlers to control what happens during your hook invocation at each stage of its target lifecycle. For python projects, code for handlers are in the `src/handlers.py` file.

Use the hook schema to specify which handlers you want to implement. If you choose not to implement a specific handler, remove it from the handlers' section of the hook schema.

1. In the CloudFormation CLI, run the [the section called "generate" \(p. 168\)](#) command.

```
cfn generate
```

The command returns the following output.

```
Generated files for MyCompany::Testing::MyTestHook
```

2. Add your own hook handler runtime code to the handlers that you choose to implement. For example, you can add the following code for logging.

```
LOG.setLevel(logging.INFO)
LOG.info("Internal testing hook triggered for target: " +
        request.hookContext.targetName);
```

3. The CloudFormation CLI generates the `src/handlers.py` file from the [the section called "Hook configuration schema" \(p. 87\)](#).

Example `models.py`

```
import sys
from dataclasses import dataclass
from inspect import getmembers, isclass
from typing import (
    AbstractSet,
    Any,
    Generic,
    Mapping,
    MutableMapping,
    Optional,
    Sequence,
    Type,
    TypeVar,
)

from cloudformation_cli_python_lib.interface import (
    BaseModel,
    BaseHookHandlerRequest,
)
from cloudformation_cli_python_lib.recast import recast_object
from cloudformation_cli_python_lib.utils import deserialize_list

T = TypeVar("T")

def set_or_none(value: Optional[Sequence[T]]) -> Optional[AbstractSet[T]]:
    if value:
        return set(value)
    return None

@dataclass
class HookHandlerRequest(BaseHookHandlerRequest):
    pass

@dataclass
class TypeConfigurationModel(BaseModel):
    limitSize: Optional[str]
    cidr: Optional[str]
    encryptionAlgorithm: Optional[str]

    @classmethod
```

```
def _deserialize(
    cls: Type["_TypeConfigurationModel"],
    json_data: Optional[Mapping[str, Any]],
) -> Optional["_TypeConfigurationModel"]:
    if not json_data:
        return None
    return cls(
        limitSize=json_data.get("limitSize"),
        cidr=json_data.get("cidr"),
        encryptionAlgorithm=json_data.get("encryptionAlgorithm"),
    )

_TypeConfigurationModel = TypeConfigurationModel
```

Implementing the hook handler code

With the python data classes generated, we can now start writing the handlers that actually implement the hook's functionality. For our example, we'll implement the `preCreate`, `preUpdate`, and `preDelete` invocation point for our handlers.

The `preCreate` handler verifies the server-side encryption settings for either an `AWS::S3::Bucket` or `AWS::SQS::Queue` resource.

- For an `AWS::S3::Bucket` resource, the hook will only pass if the following is true.
 - The Amazon S3 bucket encryption is set.
 - The Amazon S3 bucket key is enabled for the bucket.
 - The encryption algorithm set for the Amazon S3 bucket is the correct algorithm required.
 - The Amazon Key Management Service key ID is set.
- For an `AWS::SQS::Queue` resource, the hook will only pass if the following is true.
 - The Amazon Key Management Service key ID is set.

Implement a `preUpdate` handler, which initiates before the update operations for all specified targets in the handler. The `preUpdate` handler accomplishes the following:

- For an `AWS::S3::Bucket` resource, the hook will only pass if the following is true:
 - The bucket encryption algorithm for an Amazon S3 bucket hasn't been modified.

Implement a `preDelete` handler, which initiates before the delete operations for all specified targets in the handler. The `preDelete` handler accomplishes the following:

- For an `AWS::S3::Bucket` resource, the hook will only pass if the following is true:
 - Verifies that the minimum required complaint resources will exist in the account after delete the resource.
 - The minimum required complaint resources amount is set in the hook's configuration.

Coding the handlers

1. In your IDE, open the `handlers.py` file, located in the `src` folder.
2. Replace the entire contents of the `handlers.py` file with the following code.

Example handlers.py

```
import logging
```

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```
from typing import Any, MutableMapping, Optional
import botocore

from cloudformation_cli_python_lib import (
    BaseHookHandlerRequest,
    HandlerErrorCode,
    Hook,
    HookInvocationPoint,
    OperationStatus,
    ProgressEvent,
    SessionProxy,
    exceptions,
)

from .models import HookHandlerRequest, TypeConfigurationModel

# Use this logger to forward log messages to CloudWatch Logs.
LOG = logging.getLogger(__name__)
TYPE_NAME = "MyCompany::Testing::MyTestHook"

LOG.setLevel(logging.INFO)

hook = Hook(TYPE_NAME, TypeConfigurationModel)
test_entrypoint = hook.test_entrypoint

def _validate_s3_bucket_encryption(
    bucket: MutableMapping[str, Any], required_encryption_algorithm: str
) -> ProgressEvent:
    status = None
    message = ""
    error_code = None

    if bucket:
        bucket_name = bucket.get("BucketName")

        bucket_encryption = bucket.get("BucketEncryption")
        if bucket_encryption:
            server_side_encryption_rules = bucket_encryption.get(
                "ServerSideEncryptionConfiguration"
            )
            if server_side_encryption_rules:
                for rule in server_side_encryption_rules:
                    bucket_key_enabled = rule.get("BucketKeyEnabled")
                    if bucket_key_enabled:
                        server_side_encryption_by_default = rule.get(
                            "ServerSideEncryptionByDefault"
                        )

                        encryption_algorithm = server_side_encryption_by_default.get(
                            "SSEAlgorithm"
                        )
                        kms_key_id = server_side_encryption_by_default.get(
                            "KMSTMasterKeyID"
                        ) # "KMSTMasterKeyID" is name of the property for an
AWS::S3::Bucket

                        if encryption_algorithm == required_encryption_algorithm:
                            if encryption_algorithm == "aws:kms" and not kms_key_id:
                                status = OperationStatus.FAILED
                                message = f"KMS Key ID not set for bucket with name:
f{bucket_name}"
                            else:
                                status = OperationStatus.SUCCESS
                                message = f"Successfully invoked PreCreateHookHandler
for AWS::S3::Bucket with name: {bucket_name}"
```

```
        else:
            status = OperationStatus.FAILED
            message = f"SSE Encryption Algorithm is incorrect for
bucket with name: {bucket_name}"
        else:
            status = OperationStatus.FAILED
            message = f"Bucket key not enabled for bucket with name:
{bucket_name}"

        if status == OperationStatus.FAILED:
            break
    else:
        status = OperationStatus.FAILED
        message = f"No SSE Encryption configurations for bucket with name:
{bucket_name}"
    else:
        status = OperationStatus.FAILED
        message = (
            f"Bucket Encryption not enabled for bucket with name: {bucket_name}"
        )
    else:
        status = OperationStatus.FAILED
        message = "Resource properties for S3 Bucket target model are empty"

    if status == OperationStatus.FAILED:
        error_code = HandlerErrorCode.NonCompliant

    return ProgressEvent(status=status, message=message, errorCode=error_code)

def _validate_sqs_queue_encryption(queue: MutableMapping[str, Any]) -> ProgressEvent:
    if not queue:
        return ProgressEvent(
            status=OperationStatus.FAILED,
            message="Resource properties for SQS Queue target model are empty",
            errorCode=HandlerErrorCode.NonCompliant,
        )
    queue_name = queue.get("QueueName")

    kms_key_id = queue.get(
        "KmsMasterKeyId"
    ) # "KmsMasterKeyId" is name of the property for an AWS::SQS::Queue
    if not kms_key_id:
        return ProgressEvent(
            status=OperationStatus.FAILED,
            message=f"Server side encryption turned off for queue with name:
{queue_name}",
            errorCode=HandlerErrorCode.NonCompliant,
        )

    return ProgressEvent(
        status=OperationStatus.SUCCESS,
        message=f"Successfully invoked PreCreateHookHandler for targetAWS::SQS::Queue
with name: {queue_name}",
    )

@hook.handler(HookInvocationPoint.CREATE_PRE_PROVISION)
def pre_create_handler(
    session: Optional[SessionProxy],
    request: HookHandlerRequest,
    callback_context: MutableMapping[str, Any],
    type_configuration: TypeConfigurationModel,
) -> ProgressEvent:
    target_name = request.hookContext.targetName
    if "AWS::S3::Bucket" == target_name:
```

```
        return _validate_s3_bucket_encryption(
            request.hookContext.targetModel.get("resourceProperties"),
            type_configuration.encryptionAlgorithm,
        )
    elif "AWS::SQS::Queue" == target_name:
        return _validate_sqs_queue_encryption(
            request.hookContext.targetModel.get("resourceProperties")
        )
    else:
        raise exceptions.InvalidRequest(f"Unknown target type: {target_name}")

def _validate_bucket_encryption_rules_not_updated(
    resource_properties, previous_resource_properties
) -> ProgressEvent:
    bucket_encryption_configs = resource_properties.get("BucketEncryption", {}).get(
        "ServerSideEncryptionConfiguration", []
    )
    previous_bucket_encryption_configs = previous_resource_properties.get(
        "BucketEncryption", {}
    ).get("ServerSideEncryptionConfiguration", [])

    if len(bucket_encryption_configs) != len(previous_bucket_encryption_configs):
        return ProgressEvent(
            status=OperationStatus.FAILED,
            message=f"Current number of bucket encryption configs does not match
previous. Current has {str(len(bucket_encryption_configs))} configs while previously
there were {str(len(previous_bucket_encryption_configs))} configs",
            errorCode=HandlerErrorCode.NonCompliant,
        )

    for i in range(len(bucket_encryption_configs)):
        current_encryption_algorithm = (
            bucket_encryption_configs[i]
            .get("ServerSideEncryptionByDefault", {})
            .get("SSEAlgorithm")
        )
        previous_encryption_algorithm = (
            previous_bucket_encryption_configs[i]
            .get("ServerSideEncryptionByDefault", {})
            .get("SSEAlgorithm")
        )

        if current_encryption_algorithm != previous_encryption_algorithm:
            return ProgressEvent(
                status=OperationStatus.FAILED,
                message=f"Bucket Encryption algorithm can not be changed once
set. The encryption algorithm was changed to {current_encryption_algorithm} from
{previous_encryption_algorithm}.",
                errorCode=HandlerErrorCode.NonCompliant,
            )

    return ProgressEvent(
        status=OperationStatus.SUCCESS,
        message="Successfully invoked PreUpdateHookHandler for target:
AWS::SQS::Queue",
    )

def _validate_queue_encryption_not_disabled(
    resource_properties, previous_resource_properties
) -> ProgressEvent:
    if previous_resource_properties.get(
        "KmsMasterKeyId"
    ) and not resource_properties.get("KmsMasterKeyId"):
        return ProgressEvent(
```

```
        status=OperationStatus.FAILED,
        errorCode=HandlerErrorCode.NonCompliant,
        message="Queue encryption can not be disable",
    )
    else:
        return ProgressEvent(status=OperationStatus.SUCCESS)

@hook.handler(HookInvocationPoint.UPDATE_PRE_PROVISION)
def pre_update_handler(
    session: Optional[SessionProxy],
    request: BaseHookHandlerRequest,
    callback_context: MutableMapping[str, Any],
    type_configuration: MutableMapping[str, Any],
) -> ProgressEvent:
    target_name = request.hookContext.targetName
    if "AWS::S3::Bucket" == target_name:
        resource_properties =
request.hookContext.targetModel.get("resourceProperties")
        previous_resource_properties = request.hookContext.targetModel.get(
            "previousResourceProperties"
        )

        return _validate_bucket_encryption_rules_not_updated(
            resource_properties, previous_resource_properties
        )
    elif "AWS::SQS::Queue" == target_name:
        resource_properties =
request.hookContext.targetModel.get("resourceProperties")
        previous_resource_properties = request.hookContext.targetModel.get(
            "previousResourceProperties"
        )

        return _validate_queue_encryption_not_disabled(
            resource_properties, previous_resource_properties
        )
    else:
        raise exceptions.InvalidRequest(f"Unknown target type: {target_name}")
```

Registering hooks

Next, you must package and register your hook for use in your Amazon Web Services account.

Packaging a hook

Build and package the hook to deploy it to the registry.

Registering a hook

Register your hook with CloudFormation, so it's available for use in the Amazon CloudFormation registry.

To register a hook

1. (Optional) Configure your default Amazon Web Services Region name to `us-west-2`, by submitting the `configure` operation.

```
aws configure
AWS Access Key ID [None]: <Your Access Key ID>
AWS Secret Access Key [None]: <Your Secret Key>
Default region name [None]: us-west-2
Default output format [None]: json
```


-
2. (Optional) The following command builds and packages your hook project without registering it.

```
$ cfn submit --dry-run
```

-
-
3. Register your hook by using the CloudFormation CLI [the section called "submit" \(p. 171\)](#) operation.

```
cfn submit --set-default
```

The command returns the following command.

```
{'ProgressStatus': 'COMPLETE'}
```

Results: You've successfully registered your hook.

Verifying hooks are accessible in your account

Verify that you are subscribed to the hook in your Amazon Web Services account

1. To verify your hook, use the [list-types](#) command to list your newly registered hook and return a summary description of it.

```
aws cloudformation list-types
```

The command returns the following output and will also show you publicly available hooks you can subscribe to.

```
{
  "TypeSummaries": [
    {
      "Type": "HOOK",
      "TypeName": "MyCompany::Testing::MyTestHook",
      "DefaultVersionId": "00000001",
      "TypeArn": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID/type/hook/MyCompany-Testing-MyTestHook",
      "LastUpdated": "2021-08-04T23:00:03.058000+00:00",
      "Description": "Verifies S3 bucket and SQS queues properties before creating or updating"
    }
  ]
}
```

-
2. Retrieve the `TypeArn` from the `list-type` output for your hook and save it.

```
export HOOK_TYPE_ARN=arn:aws:cloudformation:us-west-2:ACCOUNT_ID/type/hook/MyCompany-Testing-MyTestHook
```

To learn how to publish hooks for public use, see [Publishing hooks for public use](#).

Activate hooks

After you've developed and registered your hook, you can activate your hook in your Amazon Web Services account by publishing it to the registry.

- To activate a hook in your account, use the [SetTypeConfiguration](#) operation. This operation enables the hook's properties that are defined in the hook's schema `properties` section. In the following example, the `limitSize` property is set to 1 in the configuration.

Note

By enabling hooks in your account, you are authorizing a hook to use defined permissions from your Amazon Web Services account. CloudFormation removes non-required permissions before passing your permissions to the hook. CloudFormation recommends customers or hook users to review the hook permissions and be aware of what permissions the hooks are allowed to before enabling hooks in your account.

Specify the configuration data for your registered hook extension in the same account and Amazon Web Services Region.

```
aws cloudformation --region us-west-2 set-type-configuration \
  --configuration "{\"CloudFormationConfiguration\":{\"HookConfiguration\":
  {\"TargetStacks\": \"ALL\", \"FailureMode\": \"FAIL\", \"Properties\": {\"limitSize\":
  \"1\", \"encryptionAlgorithm\": \"aws:kms\"}}}}\" \
  --type-arn $HOOK_TYPE_ARN
```

Important

To enable your hook to proactively inspect the configuration of your stack, you must set the `TargetStacks` to `ALL` in the `HookConfiguration` section, after the hook has been registered and activated in your account.

Accessing Amazon APIs in handlers

If your hooks uses an Amazon API in any of its handlers, create an IAM execution role that includes the necessary permissions and provision that execution role in your Amazon Web Services account. CloudFormation assumes that role to provide your hook with the specified credentials during a hook invocation. For more information, see [Amazon Lambda execution role](#).

The [the section called “generate” \(p. 168\)](#) operation automatically generates an execution role template, `hook-role.yaml`. The `hook-role.yaml` template is based on the permissions specified for each handler in the `handlers` section of the hook schema. The following template uses the Amazon Identity and Access Management (IAM) permissions `s3:ListAllMyBuckets` and `sqs:ListQueues`. For more information about IAM user policies, see [Using IAM user policies](#).

For more information, see [Accessing Amazon APIs from a resource type](#).

hook-role.yaml template

```
AWSTemplateFormatVersion: 2010-09-09
Description: >
  This CloudFormation template creates a role assumed by CloudFormation during
  Hook operations on behalf of the customer.
Resources:
  ExecutionRole:
    Type: 'AWS::IAM::Role'
    Properties:
      MaxSessionDuration: 8400
      AssumeRolePolicyDocument:
        Version: 2012-10-17
        Statement:
          - Effect: Allow
            Principal:
              Service:
                - resources.cloudformation.amazonaws.com
                - hooks.cloudformation.amazonaws.com
            Action: 'sts:AssumeRole'
```

```
Condition:
  StringEquals:
    aws:SourceAccount: !Ref AWS::AccountId
  StringLike:
    aws:SourceArn: !Sub arn:${AWS::Partition}:cloudformation:${AWS::Region}:
${AWS::AccountId}:type/hook/MyCompany-Testing-MyTestHook/*
  Path: /
  Policies:
    - PolicyName: HookTypePolicy
      PolicyDocument:
        Version: 2012-10-17
        Statement:
          - Effect: Allow
            Action:
              - 's3:GetEncryptionConfiguration'
              - 's3:ListBucket'
              - 's3:ListAllMyBuckets'
              - 'sqs:GetQueueAttributes'
              - 'sqs:GetQueueUrl'
              - 'sqs:ListQueues'
            Resource: '*'
Outputs:
  ExecutionRoleArn:
    Value: !GetAtt
      - ExecutionRole
      - Arn
```

Testing hooks in your Amazon Web Services account

Now that you've coded your handler functions that correspond to an invocation point, it's time to test your hook on a CloudFormation stack.

In [Implementing hook handlers](#), the hook failure mode was set to `FAIL` if the CloudFormation template didn't provision an S3 bucket with the following:

- The Amazon S3 bucket encryption is set.
- The Amazon S3 bucket key is enabled for the bucket.
- The encryption algorithm set for the Amazon S3 bucket is the correct algorithm required.
- The Amazon Key Management Service key ID is set.

In the following example, create a template called `my-failed-bucket-stack` with a stack name of `my-hook-stack` that fails the stack configuration and stops before the resource provisions.

Testing hooks by provisioning a stack

To provision a stack (example 1)

Provision a non-compliant stack

1. Author a template that specifies an S3 bucket. For example, `my-failed-bucket-stack.yml`.

```
AWSTemplateFormatVersion: 2010-09-09
Resources:
  S3Bucket:
    Type: 'AWS::S3::Bucket'
    Properties: {}
```

2. Create a stack, and specify your template in the Amazon Command Line Interface (Amazon CLI). In the following example, specify the stack name as `my-hook-stack` and the template name as `my-failed-bucket-stack.yml`.

```
aws cloudformation create-stack \  
  --stack-name my-hook-stack \  
  --template-body file://my-failed-bucket-stack.yml
```

3. (Optional) View your stack progress by specifying your stack name. In the following example, specify the stack name my-hook-stack.

```
aws cloudformation describe-stack-events \  
  --stack-name my-hook-stack
```

Use the describe-stack-events operation to see the hook failure while creating the bucket. The following is an example output of the command.

```
{  
  "StackEvents": [  
    ...  
    {  
      "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-hook-  
stack/2c693970-f57e-11eb-a0fb-061a2a83f0b9",  
      "EventId": "S3Bucket-CREATE_FAILED-2021-08-04T23:47:03.305Z",  
      "StackName": "my-hook-stack",  
      "LogicalResourceId": "S3Bucket",  
      "PhysicalResourceId": "",  
      "ResourceType": "AWS::S3::Bucket",  
      "Timestamp": "2021-08-04T23:47:03.305000+00:00",  
      "ResourceStatus": "CREATE_FAILED",  
      "ResourceStatusReason": "The following hook(s) failed:  
[MyCompany::Testing::MyTestHook]",  
      "ResourceProperties": "{}",  
      "ClientRequestToken": "Console-CreateStack-abe71ac2-ade4-  
a762-0499-8d34d91d6a92"  
    },  
    ...  
  ]  
}
```

Results: The hook invocation failed the stack configuration and stopped the resource from provisioning.

Use a CloudFormation template to pass hook validation

1. To create a stack and pass the hook validation, update the template so that your resource uses an encrypted S3 bucket. This example uses the template my-encrypted-bucket-stack.yml.

```
AWSTemplateFormatVersion: 2010-09-09  
Description: |  
  This CloudFormation template provisions an encrypted S3 Bucket  
Resources:  
  EncryptedS3Bucket:  
    Type: 'AWS::S3::Bucket'  
    Properties:  
      BucketName: !Sub 'encryptedbucket-${AWS::Region}-${AWS::AccountId}'  
      BucketEncryption:  
        ServerSideEncryptionConfiguration:  
          - ServerSideEncryptionByDefault:  
              SSEAlgorithm: 'aws:kms'  
              KMSMasterKeyID: !Ref EncryptionKey  
              BucketKeyEnabled: true  
      EncryptionKey:
```

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```
Type: 'AWS::KMS::Key'
DeletionPolicy: Retain
Properties:
  Description: KMS key used to encrypt the resource type artifacts
  EnableKeyRotation: true
  KeyPolicy:
    Version: 2012-10-17
    Statement:
      - Sid: Enable full access for owning account
        Effect: Allow
        Principal:
          AWS: !Ref 'AWS::AccountId'
        Action: 'kms:*'
        Resource: '*'
Outputs:
  EncryptedBucketName:
    Value: !Ref EncryptedS3Bucket
```

Note

Hook won't be invoked for skipped resources.

2. Create a stack and specify your template. In this example, the stack name is `my-encrypted-bucket-stack`.

```
aws cloudformation create-stack \
  --stack-name my-encrypted-bucket-stack \
  --template-body file://my-encrypted-bucket-stack.yml \
```

3. (Optional) View your stack progress by specifying the stack name.

```
aws cloudformation describe-stack-events \
  --stack-name my-encrypted-bucket-stack
```

Use the `describe-stack-events` command to view the response. The following is an example of the `describe-stack-events` command.

```
{
  "StackEvents": [
    ...
    {
      "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-encrypted-
bucket-stack/82a97150-f57a-11eb-8eb2-06a6bdcc7779",
      "EventId": "EncryptedS3Bucket-CREATE_COMPLETE-2021-08-04T23:23:20.973Z",
      "StackName": "my-encrypted-bucket-stack",
      "LogicalResourceId": "EncryptedS3Bucket",
      "PhysicalResourceId": "encryptedbucket-us-west-2-ACCOUNT_ID",
      "ResourceType": "AWS::S3::Bucket",
      "Timestamp": "2021-08-04T23:23:20.973000+00:00",
      "ResourceStatus": "CREATE_COMPLETE",
      "ResourceProperties": "{\"BucketName\": \"encryptedbucket-us-
west-2-071617338693\", \"BucketEncryption\": {\"ServerSideEncryptionConfiguration\":
[ {\"BucketKeyEnabled\": \"true\", \"ServerSideEncryptionByDefault\": {\"SSEAlgorithm\":
\"aws:kms\", \"KMSMasterKeyID\": \"ENCRYPTION_KEY_ARN\" } } ] }",
      "ClientRequestToken": "Console-CreateStack-39df35ac-ca00-
b7f6-5661-4e917478d075"
    },
    {
      "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-encrypted-
bucket-stack/82a97150-f57a-11eb-8eb2-06a6bdcc7779",
      "EventId": "EncryptedS3Bucket-CREATE_IN_PROGRESS-2021-08-04T23:22:59.410Z",
      "StackName": "my-encrypted-bucket-stack",
      "LogicalResourceId": "EncryptedS3Bucket",
```

```
    "PhysicalResourceId": "encryptedbucket-us-west-2-ACCOUNT_ID",
    "ResourceType": "AWS::S3::Bucket",
    "Timestamp": "2021-08-04T23:22:59.410000+00:00",
    "ResourceStatus": "CREATE_IN_PROGRESS",
    "ResourceStatusReason": "Resource creation Initiated",
    "ResourceProperties": "{\"BucketName\": \"encryptedbucket-us-
west-2-071617338693\", \"BucketEncryption\": {\"ServerSideEncryptionConfiguration\":
[ {\"BucketKeyEnabled\": \"true\", \"ServerSideEncryptionByDefault\": {\"SSEAlgorithm\":
\"aws:kms\", \"KMSMasterKeyID\": \"ENCRYPTION_KEY_ARN\" } } ] }\",
    \"ClientRequestToken\": \"Console-CreateStack-39df35ac-ca00-
b7f6-5661-4e917478d075\"
  },
  {
    \"StackId\": \"arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-encrypted-
bucket-stack/82a97150-f57a-11eb-8eb2-06a6bdcc7779\",
    \"EventId\": \"EncryptedS3Bucket-6516081f-clf2-4bfe-a0f0-cefa28679994\",
    \"StackName\": \"my-encrypted-bucket-stack\",
    \"LogicalResourceId\": \"EncryptedS3Bucket\",
    \"PhysicalResourceId\": \"\",
    \"ResourceType\": \"AWS::S3::Bucket\",
    \"Timestamp\": \"2021-08-04T23:22:58.349000+00:00\",
    \"ResourceStatus\": \"CREATE_IN_PROGRESS\",
    \"ResourceStatusReason\": \"Hook invocations complete. Resource creation
initiated\",
    \"ClientRequestToken\": \"Console-CreateStack-39df35ac-ca00-
b7f6-5661-4e917478d075\"
  },
  ...
]
}
```

Results: CloudFormation successfully created the stack by verifying that the `AWS::S3::Bucket` resource contained server-side encryption before provisioning the resource.

To provision a stack (example 2)

Provision a non-compliant stack

1. Author a template that specifies an S3 bucket. For example `aes256-bucket.yml`.

```
AWSTemplateFormatVersion: 2010-09-09
Description: |
  This CloudFormation template provisions an encrypted S3 Bucket
Resources:
  EncryptedS3Bucket:
    Type: 'AWS::S3::Bucket'
    Properties:
      BucketName: !Sub 'encryptedbucket-${AWS::Region}-${AWS::AccountId}'
      BucketEncryption:
        ServerSideEncryptionConfiguration:
          - ServerSideEncryptionByDefault:
              SSEAlgorithm: AES256
              BucketKeyEnabled: true
Outputs:
  EncryptedBucketName:
    Value: !Ref EncryptedS3Bucket
```

2. Create a stack, and specify your template in the Amazon CLI. In the following example, specify the stack name as `my-hook-stack` and the template name as `aes256-bucket.yml`.

```
aws cloudformation create-stack \
  --stack-name my-hook-stack \
```

```
--template-body file://aes256-bucket.yml
```

3. (Optional) View your stack progress by specifying your stack name. In the following example, specify the stack name `my-hook-stack`.

```
aws cloudformation describe-stack-events \  
  --stack-name my-hook-stack
```

Use the `describe-stack-events` operation to see the hook failure while creating the bucket. The following is an example output of the command.

```
{  
  "StackEvents": [  
    ...  
    {  
      "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-hook-  
stack/2c693970-f57e-11eb-a0fb-061a2a83f0b9",  
      "EventId": "S3Bucket-CREATE_FAILED-2021-08-04T23:47:03.305Z",  
      "StackName": "my-hook-stack",  
      "LogicalResourceId": "S3Bucket",  
      "PhysicalResourceId": "",  
      "ResourceType": "AWS::S3::Bucket",  
      "Timestamp": "2021-08-04T23:47:03.305000+00:00",  
      "ResourceStatus": "CREATE_FAILED",  
      "ResourceStatusReason": "The following hook(s) failed:  
[MyCompany::Testing::MyTestHook]",  
      "ResourceProperties": "{}",  
      "ClientRequestToken": "Console-CreateStack-abe71ac2-ade4-  
a762-0499-8d34d91d6a92"  
    },  
    ...  
  ]  
}
```

Results: The hook invocation failed the stack configuration and stopped the resource from provisioning. The stack failed due to the Amazon S3 bucket encryption configured incorrectly. The hook type configuration requires `aws:kms` while this bucket uses `AES256`.

Use a CloudFormation template to pass hook validation

1. To create a stack and pass the hook validation, update the template so that your resource uses an encrypted S3 bucket. This example uses the template `kms-bucket-and-queue.yml`.

```
AWSTemplateFormatVersion: 2010-09-09  
Description: |  
  This CloudFormation template provisions an encrypted S3 Bucket  
Resources:  
  EncryptedS3Bucket:  
    Type: 'AWS::S3::Bucket'  
    Properties:  
      BucketName: !Sub 'encryptedbucket-${AWS::Region}-${AWS::AccountId}'  
      BucketEncryption:  
        ServerSideEncryptionConfiguration:  
          - ServerSideEncryptionByDefault:  
              SSEAlgorithm: 'aws:kms'  
              KMSMasterKeyID: !Ref EncryptionKey  
          BucketKeyEnabled: true  
  EncryptedQueue:  
    Type: 'AWS::SQS::Queue'  
    Properties:
```

```
QueueName: 'encryptedqueue-${AWS::Region}-${AWS::AccountId}'
KmsMasterKeyId: !Ref EncryptionKey
EncryptionKey:
  Type: 'AWS::KMS::Key'
  DeletionPolicy: Retain
  Properties:
    Description: KMS key used to encrypt the resource type artifacts
    EnableKeyRotation: true
    KeyPolicy:
      Version: 2012-10-17
      Statement:
        - Sid: Enable full access for owning account
          Effect: Allow
          Principal:
            AWS: !Ref 'AWS::AccountId'
          Action: 'kms:*'
          Resource: '*'
Outputs:
  EncryptedBucketName:
    Value: !Ref EncryptedS3Bucket
  EncryptedQueueName:
    Value: !Ref EncryptedQueue
```

Note

Hook won't be invoked for skipped resources.

2. Create a stack and specify your template. In this example, the stack name is `my-encrypted-bucket-stack`.

```
aws cloudformation create-stack \  
  --stack-name my-encrypted-bucket-stack \  
  --template-body file://kms-bucket-and-queue.yml
```

3. (Optional) View your stack progress by specifying the stack name.

```
aws cloudformation describe-stack-events \  
  --stack-name my-encrypted-bucket-stack
```

Use the `describe-stack-events` command to view the response. The following is an example of the `describe-stack-events` command.

```
{  
  "StackEvents": [  
    ...  
    {  
      "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-encrypted-  
bucket-stack/82a97150-f57a-11eb-8eb2-06a6bdcc7779",  
      "EventId": "EncryptedS3Bucket-CREATE_COMPLETE-2021-08-04T23:23:20.973Z",  
      "StackName": "my-encrypted-bucket-stack",  
      "LogicalResourceId": "EncryptedS3Bucket",  
      "PhysicalResourceId": "encryptedbucket-us-west-2-ACCOUNT_ID",  
      "ResourceType": "AWS::S3::Bucket",  
      "Timestamp": "2021-08-04T23:23:20.973000+00:00",  
      "ResourceStatus": "CREATE_COMPLETE",  
      "ResourceProperties": "{\"BucketName\": \"encryptedbucket-us-  
west-2-071617338693\", \"BucketEncryption\": {\"ServerSideEncryptionConfiguration\":  
[ {\"BucketKeyEnabled\": \"true\", \"ServerSideEncryptionByDefault\": {\"SSEAlgorithm\":  
\"aws:kms\", \"KMSMasterKeyID\": \"ENCRYPTION_KEY_ARN\" } } ] }",  
      "ClientRequestToken": "Console-CreateStack-39df35ac-ca00-  
b7f6-5661-4e917478d075"  
    },  
  ]  
}
```



```
    "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-encrypted-  
bucket-stack/82a97150-f57a-11eb-8eb2-06a6bdcc7779",  
    "EventId": "EncryptedS3Bucket-CREATE_IN_PROGRESS-2021-08-04T23:22:59.410Z",  
    "StackName": "my-encrypted-bucket-stack",  
    "LogicalResourceId": "EncryptedS3Bucket",  
    "PhysicalResourceId": "encryptedbucket-us-west-2-ACCOUNT_ID",  
    "ResourceType": "AWS::S3::Bucket",  
    "Timestamp": "2021-08-04T23:22:59.410000+00:00",  
    "ResourceStatus": "CREATE_IN_PROGRESS",  
    "ResourceStatusReason": "Resource creation Initiated",  
    "ResourceProperties": "{\"BucketName\": \"encryptedbucket-us-  
west-2-071617338693\", \"BucketEncryption\": {\"ServerSideEncryptionConfiguration\":  
[ {\"BucketKeyEnabled\": \"true\", \"ServerSideEncryptionByDefault\": {\"SSEAlgorithm\":  
\"aws:kms\", \"KMSMasterKeyID\": \"ENCRYPTION_KEY_ARN\"} } ] } }",  
    "ClientRequestToken": "Console-CreateStack-39df35ac-ca00-  
b7f6-5661-4e917478d075"  
  },  
  {  
    "StackId": "arn:aws:cloudformation:us-west-2:ACCOUNT_ID:stack/my-encrypted-  
bucket-stack/82a97150-f57a-11eb-8eb2-06a6bdcc7779",  
    "EventId": "EncryptedS3Bucket-6516081f-c1f2-4bfe-a0f0-cefa28679994",  
    "StackName": "my-encrypted-bucket-stack",  
    "LogicalResourceId": "EncryptedS3Bucket",  
    "PhysicalResourceId": "",  
    "ResourceType": "AWS::S3::Bucket",  
    "Timestamp": "2021-08-04T23:22:58.349000+00:00",  
    "ResourceStatus": "CREATE_IN_PROGRESS",  
    "ResourceStatusReason": "Hook invocations complete. Resource creation  
initiated",  
    "ClientRequestToken": "Console-CreateStack-39df35ac-ca00-  
b7f6-5661-4e917478d075"  
  },  
  ...  
]  
}
```

Results: CloudFormation successfully created the stack by verifying that the `AWS::S3::Bucket` resource contained server-side encryption before provisioning the resource.

Subscribing to hook invocation events in Amazon EventBridge

Before running `create-stack`, you can create an Amazon EventBridge rule to subscribe to your hook invocation events. These rules won't poll directly, but you can set a target to receive the service events.

To create infrastructure to receive hook invocation events, provide the following:

- Something to receive EventBridge events. For example, an Amazon Simple Queue Service (Amazon SQS) queue and queue policy. For more information, see [Creating an Amazon SQS queue \(console\)](#) and [Configuring access policy \(console\)](#).
- An EventBridge rule. For more information, see [Create a rule in Amazon EventBridge](#).

To subscribe to hook invocation events in Amazon EventBridge

1. Create a CloudFormation template to invoke a hook event. The following example uses the template `EventBridgeInfra.yml`.

```
Resources:  
  HooksInvocationEventQueue:  
    Type: 'AWS::SQS::Queue'  
    DeletionPolicy: Delete  
    UpdateReplacePolicy: Delete
```

```
Properties:
  QueueName: HooksInvocationEventQueue
HooksInvocationEventQueuePolicy:
  Type: 'AWS::SQS::QueuePolicy'
  Properties:
    PolicyDocument:
      Id: HooksInvocationEventQueuePolicy
      Version: 2012-10-17
      Statement:
        - Sid: SendHooksEventToTheQueue
          Effect: Allow
          Principal:
            Service: events.amazonaws.com
          Action:
            - 'sqs:SendMessage'
          Resource: !GetAtt
            - HooksInvocationEventQueue
            - Arn
    Queues:
      - !Ref HooksInvocationEventQueue
HooksInovcationEventRule:
  Type: 'AWS::Events::Rule'
  Properties:
    Description: Rule to move acceptance tests events to the queue
    EventPattern:
      source:
        - aws.cloudformation
      detail-type:
        - CloudFormation Hook Invocation Progress
    Targets:
      - Arn: !GetAtt
          - HooksInvocationEventQueue
          - Arn
      Id: HooksInovcationEventQueue
```

2. Create a stack to receive hook invocation details and events in EventBridge. The following example specifies the template `EventBridgeInfra.yml`.

```
aws cloudformation create-stack \
  --stack-name event-bridge-infra \
  --template-body file://EventBridgeInfra.yml
```

3. (Optional) To view EventBridge events, run `create-stack` and the events will display in your Amazon SQS queue or another EventBridge target. To learn more about additional target types and policy configurations, see [Using resource-based policies for Amazon EventBridge](#).

Managing hooks

Once you've registered a hook, you can manage it through the CloudFormation registry, including versioning and account and region availability.

Updating a hook

Updating a hook allows revisions in the hook to be made available in the CloudFormation registry.

To update a hook, submit your revisions to the CloudFormation registry through the CloudFormation CLI [the section called "submit" \(p. 171\)](#) operation.

```
cfn submit
```

To specify the default version of your hook in your account, use the `set-type-default-version` command and specify the type, type name, and version ID.

```
aws cloudformation set-type-default-version \  
  --type HOOK \  
  --type-name MyCompany::Testing::MyTestHook \  
  --version-id 00000003
```

To retrieve information about the versions of a hook, use `list-type-versions`.

```
aws cloudformation list-type-versions \  
  --type HOOK \  
  --type-name "MyCompany::Testing::MyTestHook"
```

Deactivating a hook

Deactivating a hook prevents the hook from running your Amazon Web Services account.

TargetStacks set to NONE turns the hook off in your account, so it doesn't apply to stack operations. Use the `set-type-configuration` operation and specify TargetStacks as NONE to deactivate a hook.

The following example specifies the Amazon Web Services Region and the Amazon Resource Name (ARN) of the hook that's being deactivated.

```
aws cloudformation set-type-configuration \  
  --region us-west-2 \  
  --configuration "{\"CloudFormationConfiguration\":{\"HookConfiguration\":{\"TargetStacks\":"NONE\"},\"FailureMode\":\"FAIL\"},\"Properties\":{}}\" \  
  --type-arn HOOK_TYPE_ARN
```

Deregistering a hook

Deregistering a hook marks the extension or extension version as DEPRECATED in the CloudFormation registry, which removes it from active use. Once deprecated, the hook can't be used in a CloudFormation operation.

To deregister a hook, use the `deregister-type` operation and specify your hook ARN.

```
aws cloudformation deregister-type HOOK_TYPE_ARN
```

This command doesn't produce an output.

Publishing hooks for public use

Developing a public extension for CloudFormation

To develop a public third-party hook, develop your hook as a private extension. Then, in each Amazon Web Services Region in which you want to make the extension publicly available:

1. Register your hook as a private extension in the CloudFormation registry.
2. Test your hook to make sure it meets all necessary requirements for being published in the CloudFormation registry.
3. Publish your hook to the CloudFormation registry.

Note

Before you publish any extension in a given Region, you must first register as an extension publisher in that Region.

To do this in multiple Regions simultaneously, see [Publishing your extension in multiple Regions using StackSets \(p. 162\)](#).

After you've developed and registered your hook, you can make it publicly available to general CloudFormation users by *publishing* it to the CloudFormation registry, as a third-party public extension.

Public third-party hooks enable you to offer CloudFormation users to proactively inspect the configuration of Amazon resources before provisioning. As with private hooks, public hooks are treated the same as any hook published by Amazon within CloudFormation.

Hooks published to the registry are visible by all CloudFormation users in the Amazon Web Services Regions in which they're published. Users can then *activate* your extension in their account, which makes it available for use in their templates. For more information, see [Using public extensions in CloudFormation](#) in the *CloudFormation User Guide*.

Testing registered hooks

In order to publish your hook, it must pass all test requirements defined for it. The following is a list of requirements needed before publishing your hook as a third-party extension.

Each handler and target is tested twice. Once for `SUCCESS` and once for `FAILED`.

- For `SUCCESS` response case:
 - Status must be `SUCCESS`.
 - Must not return an error code.
 - Callback delay should be set to 0 seconds, if specified.
- For `FAILED` response case:
 - Status must be `FAILED`.
 - Must return an error code.
 - Must have a message in response.
 - Callback delay should be set to 0 seconds, if specified.
- For `IN_PROGRESS` response case:
 - Must not return an error code.
 - `Result` field must not be set in response.

Specifying input data for use in contract tests

By default, the CloudFormation performs contract tests using input properties generated from the patterns you define in your hook schema. However, most hooks are complex enough that the input properties for precreating or preupdating provisioning stacks requires an understanding of the resource being provisioned. To address this, you can specify the input the CloudFormation uses when performing its contract tests.

CloudFormation offers two ways for you to specify the input data for it to use when performing contract tests:

- Overrides file

Using an `overrides` file provides a light-weight way of specifying input data for certain specific properties for the CloudFormation to use during `preCreate`, `preUpdate` and `preDelete` operations testing.

- Input files

You can also use multiple `input` files to specify contract test input data if:

- You want or need to specify different input data for create, update, and delete operations, or invalid data with which to test.
- You want to specify multiple different input data sets.

Specifying input data using an override file

The following is an example of Amazon S3 hook's input data using the overrides file.

```
{
  "CREATE_PRE_PROVISION": {
    "AWS::S3::Bucket": {
      "resourceProperties": {
        "/BucketName": "encryptedbucket-us-west-2-contractor",
        "/BucketEncryption/ServerSideEncryptionConfiguration": [
          {
            "BucketKeyEnabled": true,
            "ServerSideEncryptionByDefault": {
              "KMSMasterKeyID": "KMS-KEY-ARN",
              "SSEAlgorithm": "aws:kms"
            }
          }
        ]
      }
    },
    "AWS::SQS::Queue": {
      "resourceProperties": {
        "/QueueName": "MyQueueContract",
        "/KmsMasterKeyId": "hellocontract"
      }
    }
  },
  "UPDATE_PRE_PROVISION": {
    "AWS::S3::Bucket": {
      "resourceProperties": {
        "/BucketName": "encryptedbucket-us-west-2-contractor",
        "/BucketEncryption/ServerSideEncryptionConfiguration": [
          {
            "BucketKeyEnabled": true,
            "ServerSideEncryptionByDefault": {
              "KMSMasterKeyID": "KMS-KEY-ARN",
              "SSEAlgorithm": "aws:kms"
            }
          }
        ]
      }
    },
    "previousResourceProperties": {
      "/BucketName": "encryptedbucket-us-west-2-contractor",
      "/BucketEncryption/ServerSideEncryptionConfiguration": [
        {
          "BucketKeyEnabled": true,
          "ServerSideEncryptionByDefault": {
            "KMSMasterKeyID": "KMS-KEY-ARN",
            "SSEAlgorithm": "aws:kms"
          }
        }
      ]
    }
  },
  "INVALID_UPDATE_PRE_PROVISION": {
    "AWS::S3::Bucket": {
      "resourceProperties": {
        "/BucketName": "encryptedbucket-us-west-2-contractor",
```

```
    "/BucketEncryption/ServerSideEncryptionConfiguration": [
      {
        "BucketKeyEnabled": true,
        "ServerSideEncryptionByDefault": {
          "KMSEncryptionContext": "KMS-KEY-ARN",
          "SSEAlgorithm": "AES256"
        }
      }
    ]
  },
  "previousResourceProperties": {
    "/BucketName": "encryptedbucket-us-west-2-contractor",
    "/BucketEncryption/ServerSideEncryptionConfiguration": [
      {
        "BucketKeyEnabled": true,
        "ServerSideEncryptionByDefault": {
          "KMSEncryptionContext": "KMS-KEY-ARN",
          "SSEAlgorithm": "aws:kms"
        }
      }
    ]
  }
},
"INVALID": {
  "AWS::SQS::Queue": {
    "resourceProperties": {
      "/QueueName": "MyQueueContract",
      "/KmsMasterKeyId": "KMS-KEY-ARN"
    }
  }
}
}
```

Specifying input data using input files

Use input files to specify different kinds of input data for the CloudFormation to use: `preCreate` input, `preUpdate` input, and `invalid` input. Each kind of data is specified in a separate file. You can also specify multiple sets of input data for contract tests.

To specify input files for the CloudFormation to use in contract testing, add an `inputs` folder to the root directory of your hooks project. Then add your input files.

Specify which kind of input data a file contains by using the following naming conventions, where `n` is an integer:

- `inputs_n_pre_create.json`: Use files with `preCreate` handlers for specifying inputs for creating the resource.
- `inputs_n_pre_update.json`: Use files with `preUpdate` handlers for specifying inputs for updating the resource.
- `inputs_n_pre_delete.json`: Use files with `preDelete` handlers for specifying inputs for deleting the resource.
- `inputs_n_invalid.json`: For specifying invalid inputs to test.

To specify multiple sets of input data for contract tests, increment the integer in the file names to order your input data sets. For example, your first set of input files should be named `inputs_1_pre_create.json`, `inputs_1_pre_update.json`, and `inputs_1_pre_invalid.json`. Your next set would be named `inputs_2_pre_create.json`, `inputs_2_pre_update.json`, and `inputs_2_pre_invalid.json`, and so on.

Each input file is a JSON file containing only the resource properties to be used in testing.

The following is an example directory for inputs for Amazon S3 specifying input data using input files.

`inputs_1_pre_create.json`

The following is an example of the `inputs_1_pre_create.json` contract test.

```
{
  "AWS::S3::Bucket": {
    "resourceProperties": {
      "AccessControl": "BucketOwnerFullControl",
      "AnalyticsConfigurations": [],
      "BucketEncryption": {
        "ServerSideEncryptionConfiguration": [
          {
            "BucketKeyEnabled": true,
            "ServerSideEncryptionByDefault": {
              "KMSMasterKeyID": "KMS-KEY-ARN",
              "SSEAlgorithm": "aws:kms"
            }
          }
        ]
      },
      "BucketName": "encryptedbucket-us-west-2"
    }
  },
  "AWS::SQS::Queue": {
    "resourceProperties": {
      "QueueName": "MyQueue",
      "KmsMasterKeyId": "KMS-KEY-ARN"
    }
  }
}
```

`inputs_1_pre_update.json`

The following is an example of the `inputs_1_pre_update.json` contract test.

```
{
  "AWS::S3::Bucket": {
    "resourceProperties": {
      "BucketEncryption": {
        "ServerSideEncryptionConfiguration": [
          {
            "BucketKeyEnabled": true,
            "ServerSideEncryptionByDefault": {
              "KMSMasterKeyID": "KMS-KEY-ARN",
              "SSEAlgorithm": "aws:kms"
            }
          }
        ]
      },
      "BucketName": "encryptedbucket-us-west-2"
    },
    "previousResourceProperties": {
      "BucketEncryption": {
        "ServerSideEncryptionConfiguration": [
          {
            "BucketKeyEnabled": true,
            "ServerSideEncryptionByDefault": {
              "KMSMasterKeyID": "KMS-KEY-ARN",
              "SSEAlgorithm": "aws:kms"
            }
          }
        ]
      }
    }
  }
}
```

```
    },  
    "BucketName": "encryptedbucket-us-west-2"  
  }  
}  
}
```

inputs_1_invalid.json

The following is an example of the inputs_1_invalid.json contract test.

```
{  
  "AWS::S3::Bucket": {  
    "resourceProperties": {  
      "AccessControl": "BucketOwnerFullControl",  
      "AnalyticsConfigurations": [],  
      "BucketEncryption": {  
        "ServerSideEncryptionConfiguration": [  
          {  
            "ServerSideEncryptionByDefault": {  
              "SSEAlgorithm": "AES256"  
            }  
          }  
        ]  
      },  
      "BucketName": "encryptedbucket-us-west-2"  
    }  
  },  
  "AWS::SQS::Queue": {  
    "resourceProperties": {  
      "NotValid": "The property of this resource is not valid."  
    }  
  }  
}
```

inputs_1_invalid_pre_update.json

The following is an example of the inputs_1_invalid_pre_update.json contract test.

```
{  
  "AWS::S3::Bucket": {  
    "resourceProperties": {  
      "BucketEncryption": {  
        "ServerSideEncryptionConfiguration": [  
          {  
            "BucketKeyEnabled": true,  
            "ServerSideEncryptionByDefault": {  
              "KMSEncryption": {  
                "KMSMasterKeyID": "KMS-KEY-ARN",  
                "SSEAlgorithm": "AES256"  
              }  
            }  
          }  
        ]  
      },  
      "BucketName": "encryptedbucket-us-west-2"  
    }  
  },  
  "previousResourceProperties": {  
    "BucketEncryption": {  
      "ServerSideEncryptionConfiguration": [  
        {  
          "BucketKeyEnabled": true,  
          "ServerSideEncryptionByDefault": {  
            "KMSEncryption": {  
              "KMSMasterKeyID": "KMS-KEY-ARN",  
              "SSEAlgorithm": "aws:kms"  
            }  
          }  
        }  
      ]  
    }  
  }  
}
```



```
    }  
  ],  
  },  
  "BucketName": "encryptedbucket-us-west-2"  
}  
}
```

For more information, see [Testing your public extension before publishing](#).

Registering extensions for use in the CloudFormation registry

Once you've completed developing your extension, you'll need to *register* it with CloudFormation to make it available for use in the CloudFormation registry. From the CloudFormation CLI, use the [submit](#) (p. 171) command to register your extension with CloudFormation. You can also register your resource directly using the [register-type](#) operation.

For detailed information about registering private extensions, see [Using private extensions](#) in the *Amazon CloudFormation User Guide*.

Registering extensions using the `submit` command

In general, the `submit` command does the following:

- Validates the extension schema.
- Packages up the extension project files and uploads them to CloudFormation.
 - This includes any source code, such as resource handlers for resource type extensions.
 - Extension source code, such as resource handlers runs within the CloudFormation service account.
- Runs the unit and contract tests defined in the extension project.
- For resource type extensions, determines which handlers have been specified for the resource, to determine how CloudFormation provisions the resource.
- Returns a *registration token* that you can use with the [describe-type-registration](#) operation to track the status of the registration request.

To validate and package your extension project, but not register it with CloudFormation, use the `--dry-run` option for the `submit` command.

You must register your extension in each Amazon Web Services Region in which you want to use it.

Use the [list-types](#) operation for summary information about types that have been registered with CloudFormation, and the [describe-type](#) operation for detailed information about specific registered resource type or resource type version.

To enable activated hooks

After you've registered and enabled your hook, you must set the `TargetStacks` to `ALL` in the `HookConfiguration` section. For example, the following command uses the `set-type-configuration` operation and lists the `TargetStacks` as `ALL`. You may specify the `FailureMode` as `FAIL` or `WARN` and add additional properties.

```
aws cloudformation --region us-west-2 set-type-configuration \
  --configuration "{\"CloudFormationConfiguration\":{\"HookConfiguration\":{\"TargetStacks
  \":\"ALL\", \"FailureMode\": \"FAIL\", \"Properties\":{}}}}" \
  --type-arn $HOOK_TYPE_ARN
```

Resource type provisioning

During registration, CloudFormation examines which resource handlers have been implemented for the resource. The handlers implemented determine what provisioning actions CloudFormation takes with respect to the resource during various stack operations.

- If the resource type doesn't contain `create`, `read`, and `delete` handlers, CloudFormation can't actually provision the resource.
- If the resource type doesn't contain an `update` handler, CloudFormation can't update the resource during stack update operations, and will instead replace it.

Extension versions and scope

When you register an extension, you are actually registering a specific *version* of that extension. You can register multiple versions of an extension, and specify which version you want to use. Use the [SetTypeDefaultVersion](#) action to specify the default version of an extension. The default version of an extension will be used in CloudFormation operations.

Any extension you register is only visible and usable within the account(s) in which you register it.

Deregistering extensions and extension versions

To remove an extension or extension version from active use in CloudFormation, you must *deregister* it using the [DeregisterType](#) action. If an extension or extension version is deregistered, it can no longer be used in CloudFormation operations.

You can deregister a specific extension version, or the extension as a whole. To deregister an extension, you must individually deregister all registered versions of that extension. If an extension has only a single registered version, deregistering that version results in the extension itself being deregistered. You can't deregister the default version of an extension, unless it's the only registered version of that extension, in which case the extension itself is deregistered as well.

Deregistering an extension or extension version deregisters it in all Amazon Web Services Regions.

You can't deregister an extension using the CloudFormation console.

Publishing extensions to make them available for public use

After you've developed and registered a private extension, you can make it publicly available to general CloudFormation users by *publishing* it to the CloudFormation registry, as a third-party public extension.

Public third-party extensions enable you to offer CloudFormation users ways to model, provision, and configure environments containing Amazon and third-party resources. As with private extensions, public extensions are treated the same as any resource published by Amazon within CloudFormation; users can use CloudFormation capabilities to create, provision, and manage the extensions you provide in a safe and repeatable manner, just as they would any Amazon resource. This includes CloudFormation management capabilities such as change sets, drift detection, and resource import.

Extensions published to the registry are visible by all CloudFormation users in the Regions in which they're published. Users can then *activate* your extension in their account, which makes it available for use in their templates. For more information, see [Using public extensions in CloudFormation](#) in the *CloudFormation User Guide*.

Note

If your public extension implements event handlers, users of the extension may incur charges to their account. For example, suppose your public extension is a resource type with create, read, update, list, and delete handlers. Users using your extension in their stacks would incur charges when your handler code executes during the various resource create, read, update, list, and delete stack operations. This is in addition to any charges incurred for the resources themselves running.

For more information, see [Amazon CloudFormation pricing](#).

Developing a public extension for CloudFormation

To develop a public third-party extension, develop your extension as a private extension. Then, in each Region in which you want to make the extension publicly available:

1. [Register your extension](#) as a private extension in the CloudFormation registry.
2. [Test your extension](#) to make sure it meets all necessary requirements for being published in the CloudFormation registry.
3. [Publish your extension](#) to the CloudFormation registry.

Note

Before you publish any extension in a given Region, you must first register as an extension publisher in that Region.

To complete this in multiple Regions simultaneously, see [Publishing your extension in multiple Regions using StackSets](#) (p. 162).

Prerequisite: Registering your account to publish CloudFormation extensions

To publish third-party extensions, register your extension publisher with CloudFormation. To do so, you must have an account with one of the following services. CloudFormation uses these services to verify your public identity as a publisher:

- [Amazon Marketplace](#)
- [Bitbucket](#)
- [GitHub](#)

Note

CloudFormation doesn't currently support GitHub Enterprise Cloud or GitHub Enterprise Server accounts for identity verification.

If you use your Bitbucket or GitHub account, you must create a connection between that account and the Amazon account which you want to register as a publisher. For more information, see the following topics in the *Developer Tools Console User Guide*:

- [Create a connection to Bitbucket](#)
- [Create a connection to GitHub](#)

Use [RegisterPublisher](#) to register your account to publish extensions. As part of registering as a publisher, you must accept the [Terms and Conditions](#) for extension publishers. If you use a Bitbucket or GitHub account for identity verification, you'll need to supply CloudFormation the Amazon Resource Name (ARN) for your connection to that account.

In addition, you'll need the following permissions:

- `codestar-connections:GetConnection`
- `codestar-connections:UseConnection`

For more information, see [Amazon CodeStar Connections permissions reference](#) in the *Developer Tools console User Guide*.

When you register, CloudFormation assigns your account a publisher ID under which your extensions will be published. This publisher ID applies across all Amazon Web Services Regions.

Testing your public extension before publishing

To publish your public extension, it must pass all test requirements defined for it:

- For resource types, this includes passing all contracts tests defined for the type. For more information about testing resource types, see [Testing resource types using contract tests](#).
- For modules, this includes determining if the module's model meets all necessary requirements. For information about publication requirements for modules, see [Requirements for publishing a public module](#).
- For hooks, this includes determining if the hook meets all the necessary requirements. For information about publication requirements for hooks, see [Testing registered hooks](#).

Use [TestType](#) to have CloudFormation perform the required tests on an extension. After running the test, CloudFormation assigns a test status to the extension. An extension must have a test status of `PASSED` in a given Region before it can be published there.

If you don't specify a version, CloudFormation uses the default version of the extension in your account and Region for testing.

Because testing may take some time, `TestType` is an asynchronous operation. Once you've initiated testing on an extension using `TestType`, you can use [DescribeType](#) to monitor the current test status and test status description for the extension.

The tests that CloudFormation runs against your extension are non-exhaustive and generic, which means that you should also thoroughly test your extension to ensure that it performs as expected. Using your privately registered extension in stack templates is the CloudFormation equivalent of testing your extension in a sandbox environment. Publishing your extension doesn't change any provisioning behavior of your extension; it only makes it available to all customers in the Region in which the extension is published.

Publishing your public extension to the CloudFormation registry

After your extension has passed all necessary test requirements, you can publish it to make it publicly available for use through the CloudFormation registry. Publishing your extension makes it available in all Amazon Web Services accounts in the Region. Use `PublishType` to publish your extension in each desired Region.

Versioning your public extension

When publishing your extension, you can specify a public version number. This is separate and distinct from the private extension version that CloudFormation assigns to a private extension when you register it. If you don't specify a version number, CloudFormation increments the version number by one minor version release.

Use the following format, and adhere to semantic versioning when assigning a version number to your extension:

`MAJOR.MINOR.PATCH`

For more information, see [Semantic Versioning 2.0.0](#).

Versioning and updating activated public extensions

When a user activates a public extension for use in their account, they have the option to have CloudFormation automatically update to using a new minor version whenever one is released by the extension publisher. This only applies to *minor* version changes, including patches. For major version changes, users are required to manually update to a new major version of an extension.

Increment to a new major version if the new version possibly contains breaking changes.

Open-sourcing your public extension project

It's considered a best practice to open-source your public extensions.

Publishing your extension in multiple Regions using Amazon CloudFormation StackSets

Because CloudFormation is a regional service, you must repeat each required step to publish your extension to the public registry in all Regions you would like your extension to be available in. However, with the use of CloudFormation resources, you can use Amazon CloudFormation StackSets to publish your extensions globally in fewer steps.

For more information about Amazon CloudFormation StackSets, see [Working with Amazon CloudFormation StackSets](#) in the *Amazon CloudFormation User Guide*.

Important

While Amazon CloudFormation is available in many Regions worldwide, our public registry is not supported in China (cn-north-1 and cn-northwest-1) or GovCloud (us-gov-east-1 and us-gov-west-1) Regions. Any stack instances created using StackSets should only target the supported Regions.

Prerequisites for using Amazon CloudFormation StackSets

Before using StackSets, you must complete prerequisites depending on which management policy you want to use for your stack sets.

- Stack sets with self-managed permissions require that you create IAM roles in the necessary admin and target accounts. If you intend to publish a type across multiple Regions from the same publisher account, you should create the roles in the same account.
- Stack sets with service-managed permissions make use of Amazon Organizations and thus require that you enable trusted access to Amazon Organizations.

For detailed instructions to set up the required permissions, see [Prerequisites for stack set operations](#).

Using StackSets to publish in multiple Regions for the first time

The example templates in this section publish extensions for the first time to the public registry. They contain the following CloudFormation resource types to mimic the workflow of publishing an extension in a single Region:

- `AWS::CloudFormation::ResourceVersion` or `AWS::CloudFormation::ModuleVersion` – Registers a new version for a private type.
- `AWS::CloudFormation::ResourceDefaultVersion` or `AWS::CloudFormation::ModuleDefaultVersion` – Sets the new version to the type's default version. The default version is used for publishing.
- `AWS::CloudFormation::Publisher` – Registers the calling account as a publisher with Amazon Marketplace. This functionality is idempotent, meaning that once you've registered as a publisher, this resource doesn't get updated.
- `AWS::CloudFormation::PublicTypeVersion` – Tests the new version and publishes it to the public registry.

For more details about each type, including settings you can modify, see the [Amazon CloudFormation resource type reference](#) in the *Amazon CloudFormation User Guide*.

Note

The same publishing restrictions apply when you use StackSets to publish extensions globally, including agreeing to the [Terms and Conditions for Amazon CloudFormation Registry Publishers](#) before registering as a publisher and ensuring your extension passes all test requirements before successfully publishing.

The following example template publishes a resource type across Regions with StackSets.

```
AWS::TemplateFormatVersion: "2010-09-09"
```

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Using StackSets to publish in
multiple Regions for the first time

```
Description: Registers and sets a new default resource version, registers the account as a
publisher, and publishes the resource to the public registry.
Parameters:
  SchemaPackageURL:
    Description: URL to S3::Bucket that contains the resource project package
    Type: String
Resources:
  PrivateResourceVersion:
    Type: AWS::CloudFormation::ResourceVersion
    Properties:
      SchemaHandlerPackage: !Ref SchemaPackageURL
      TypeName: MyOrg::MyService::MyType
  ResourceDefaultVersion:
    Type: AWS::CloudFormation::ResourceDefaultVersion
    DependsOn: PrivateResourceVersion
    Properties:
      TypeVersionArn: !Ref PrivateResourceVersion
  Publisher:
    Type: AWS::CloudFormation::Publisher
    DependsOn: ResourceDefaultVersion
    Properties:
      AcceptTermsAndConditions: true
  PublishedResource:
    Type: AWS::CloudFormation::PublicTypeVersion
    DependsOn: Publisher
    Properties:
      Type: RESOURCE
      TypeName: MyOrg::MyService::MyType
```

The following example template publishes a module across Regions with StackSets.

```
AWSTemplateFormatVersion: "2010-09-09"
Description: Registers and sets a new default module version, registers the account as a
publisher, and publishes the module to the public registry with the given public version.
Parameters:
  VersionToPublish:
    Description: Version number for published version, e.g. 1.2.3
    Type: String
    Default: AWS::NoValue
  FirstTimePublishing:
    Description: Indicate if this is the first time publishing this extension in the
targeted region.
    Type: String
    AllowedValues:
      - true
      - false
  SchemaPackageURL:
    Description: URL to S3::Bucket that contains the resource project package
    Type: String
Conditions:
  IsFirstTimePublishing: !Equals
  - !Ref FirstTimePublishing
  - true
Resources:
  PrivateModuleVersion:
    Type: AWS::CloudFormation::ModuleVersion
    Properties:
      ModulePackage: !Ref SchemaPackageURL
      ModuleName: MyOrg::MyService::MyType::MODULE
  ModuleDefaultVersion:
    Type: AWS::CloudFormation::ModuleDefaultVersion
    DependsOn: PrivateModuleVersion
    Properties:
      Arn: !Ref PrivateModuleVersion
  Publisher:
```



```
Type: AWS::CloudFormation::Publisher
DependsOn: ModuleDefaultVersion
Properties:
  AcceptTermsAndConditions: true
PublishedModule:
  Type: AWS::CloudFormation::PublicTypeVersion
  DependsOn: Publisher
  Properties:
    Type: MODULE
    TypeName: MyOrg::MyService::MyType::MODULE
    PublicVersionNumber:
      Fn::If:
        - IsFirstTimePublishing
        - Ref: AWS::NoValue
        - Ref: VersionToPublish
```

Note that for `AWS::CloudFormation::PublicTypeVersion` resources, `PublicVersionNumber` can't be specified upon creation. CloudFormation automatically publishes the first version of the extension with version number 1.0.0.

As a publisher, you can choose to provide version numbers for new versions. The second template above requires you to input whether it's your first time publishing the extension. You can subsequently modify this by overriding parameters when updating the stack set.

If you instead choose to omit the `PublicVersionNumber` property (as shown in the first template above), all publishing updates increment the minor version by 1. For example, version 1.0.0 increments to version 1.1.0. To publish a new patch or major version, you must explicitly specify a new version number.

Once your template is created and validated, you can create a stack set and new stack instances for each Region you want to publish your extension in. For more information about how to use Amazon CloudFormation StackSets in the Amazon CLI and Amazon Web Services Management Console, see [Create a stack set](#) in the *Amazon CloudFormation User Guide*.

Using StackSets to update already published extensions

Amazon CloudFormation StackSets allows you to customize each stack instance, meaning that you can use the same stack set to continuously update and maintain your published extensions. If you've already published extensions to the public registry and want to use StackSets to manage all future updates, you can bring them directly into the stack set *without* publishing a new version.

- If the extensions were registered, tested, and published using CloudFormation APIs, they first need to be imported into stacks. For information about using resource import, see [Bringing existing resources into CloudFormation management](#).
- If the extensions were managed in individual stacks or you've successfully imported them into stacks, the stacks need to be imported into the stack set. For instructions, see [Importing a stack into Amazon CloudFormation StackSets](#).

You can use the following StackSets actions to update your published extensions:

- [Adding stack instances](#) to your stack set publishes your extensions in additional Regions. If you add a stack instance in a Region you've already independently published to (not using StackSets), this brings the published extension into the stack set's management.
- [Overriding parameters on existing stack instances](#) allows you to update and publish new versions for your already published extensions at an individual level. This can be used when you want to specify new version numbers when performing updates.

- [Updating your stack set](#) can be used to modify the existing template, add new stack instances, modify parameters, and perform other edits. You can do this if you choose not to specify version numbers in your template, but later decide you want to provide them.

For more information about how to use Amazon CloudFormation StackSets, see [Working with Amazon CloudFormation StackSets](#) in the *Amazon CloudFormation User Guide*.

CloudFormation CLI command reference

The following commands are available through the CloudFormation Command Line Interface (CLI).

Topics

- [Global parameters \(p. 167\)](#)
- [init \(p. 167\)](#)
- [generate \(p. 168\)](#)
- [validate \(p. 168\)](#)
- [invoke \(p. 169\)](#)
- [test \(p. 170\)](#)
- [submit \(p. 171\)](#)

Global parameters

The following parameters can be used with any CloudFormation CLI command.

`-h, --help`

Shows the help message and exits.

`-v, --verbose`

Increase the output verbosity and can specify multiple times.

init

Description

The `init` command launches a wizard that walks you through setting up your project. Once your project is specified, the command generates a new extension project with stub source files.

While the specific folder structure and files generated varies project and by language, in general the project includes the following:

- Schema file.
- Handler function source files.
- Unit test files.
- Build files for the specified language.

By default, `init` generates the extension project in the current directory.

Synopsis

```
cfn init  
[--force]
```

Options

`--force`

Force project files to be overwritten.

Output

The `init` command launches a wizard that walks you through setting up the project, including specifying the extension name.

```
Initializing new project  
Do you want to develop a new resource(r) or a module(m) or a hook(h)?
```

generate

Description

The `generate` command generates code based on the project and appropriate extension type schema.

Synopsis

```
cfn generate
```

Examples

The following command submits the resource to the registry in your CloudFormation account.

```
cfn generate && cfn submit --set-default --region us-east-1
```

Output

```
Generated files for <type_name>
```

validate

Description

Validates a project's specification against the appropriate extension schema.

Synopsis

```
cfn validate
```

Examples

The following command validates the extension type project.

```
cfn validate
```

invoke

Description

Performs contract tests on the specified handler of an extension type.

Synopsis

```
cfn invoke  
[--endpoint <value>]  
[--function-name <value>]  
[--region <value>]  
[--max-reinvoke <value>]  
action  
request
```

Options

`--endpoint <value>`

The endpoint at which the type can be invoked. Alternately, you can also specify an actual Lambda endpoint and function name in your Amazon Web Services account.

Default: `http://127.0.0.1:3001`

`--function-name <value>`

The logical Lambda function name in the Amazon SAM template. Alternately, you can also specify an actual Lambda endpoint and function name in your Amazon Web Services account.

Default: `TypeFunction`

`--region <value>`

The region to configure the client to interact with.

Default: `us-east-1`

`--max-reinvoke <value>`

Maximum number of `IN_PROGRESS` re-invoations allowed before exiting. If not specified, will continue to re-invoke until terminal status is reached.

action

Which single handler to invoke.

Values: CREATE | READ | UPDATE | DELETE | LIST

request

File path to a JSON file containing the request with which to invoke the function.

test

Description

Performs contract tests on the handlers of an extension type.

Synopsis

```
cfn test
[--endpoint <value>]
[--function-name <value>]
[--region <value>]
[--role-arn <value>]
[-- -k <value>]
[-- --tb=<value>]
[--enforce-timeout <value>]
```

Options

--endpoint <value>

The endpoint at which the type can be invoked. Alternately, you can also specify an actual Lambda endpoint and function name in your Amazon Web Services account.

Default: `http://127.0.0.1:3001`

--function-name <value>

The logical Lambda function name in the Amazon SAM template. Alternately, you can also specify an actual Lambda endpoint and function name in your Amazon Web Services account.

Default: `TestEntrypoint`

--region <value>

The region to use for temporary credentials.

Default: `us-east-1`

--role-arn <value>

The Amazon Resource Name (ARN) of the IAM execution role for the contract tests to assume and use when performing operations.

If you don't specify an execution role, the contract tests use the environment credentials or the credentials specified in the [Boto 3 credentials chain](#).

-- -k <value>

Runs a single unit test. For more information, see [Using `-k expr` to select tests based on their name](#) from the `pytest` documentation.

```
-- --tb=<value>
```

Default: auto

The following are valid values for the traceback. For more information, see [Modifying Python traceback printing](#) from the `pytest` documentation.

- *auto* – long tracebacks for the first and last entry, but `short` tracebacks for all other entries.
- *long* – exhaustive and informative traceback formatting.
- *short* – shorter traceback format.
- *line* – only one line per failure.
- *native* – standard library formatting.
- *no* – no traceback.

```
--enforce-timeout <value>
```

Sets the read and list timeout to 60 seconds and the create, update, and delete handler timeouts to 120 seconds.

Examples

The following command performs contract tests on the handlers of the extension type.

```
cfn test
```

The following command runs one contract test at a time.

```
cfn test -- -k test-name
```

The following command increases the timeout time when running contract tests.

```
cfn test --enforce-timeout 60
```

The following command combines the contract test and timeout time.

```
cfn test --enforce-timeout 60 -- -k test-name
```

The following command starts a Lambda service and uses the test command to perform contract tests.

```
sam local start-lambda  
cfn test -v --enforce-timeout 90
```

submit

Description

Registers the extension with CloudFormation, in the specified region. Registering an extension makes it available for use in CloudFormation operations.

Registering includes:

- Validating the resource schema.
- Packaging up the resource project files and uploading them to CloudFormation.

This includes the source code for your resource handlers. These resource handlers run within the CloudFormation account.

- Determining which handlers have been specified for the resource, and running the appropriate contract tests.
- Uploading the resource handlers as functions that CloudFormation calls at the appropriate times in a resource's lifecycle.
- Returning a *registration token* that you can use with the [DescribeTypeRegistration](#) action to track the status of the registration request.

Note

The user registering the extension must be able to access the schema handler package in the Amazon S3 bucket. That is, the user needs to have [GetObject](#) permissions for the schema handler package. For more information, see [Actions, Resources, and Condition Keys for Amazon S3](#) in the *Amazon Identity and Access Management User Guide*.

Synopsis

```
cfn submit
[--dry-run]
[--endpoint-url <value>]
[--region <value>]
[--role-arn <value>]
[--no-role]
[--set-default]
```

Options

`--dry-run`

Validate the schema and package up the project files, but doesn't register the extension with CloudFormation.

`--endpoint-url <value>`

The CloudFormation endpoint to use.

`--region <value>`

The Amazon Web Services Region in which to register the extension. If no region is specified, the extension is registered in the default region.

`--role-arn <value>`

A specific IAM role to use when invoking handler operations.

If you don't specify an IAM role, the CloudFormation CLI attempts to create or update an execution role based on the execution role template derived from the extension type's schema, and then passes this execution role to CloudFormation. For more information, see [Accessing Amazon APIs from a Resource Type](#).

You can't specify both `--role-arn` and `--no-role` arguments.

`--no-role`

Prevent the CloudFormation CLI from passing an execution role to CloudFormation.

If your resource type calls Amazon APIs in any of its handlers, you must either specify a role Amazon Resource Name (ARN), or have the CloudFormation CLI create or update an execution role and pass that execution role to CloudFormation. For more information, see [Accessing Amazon APIs from a Resource Type](#).

You can't specify both `--role-arn` and `--no-role` arguments.

`--set-default`

Upon successful registration of the type version, sets the current type version as the default version.

Examples

The following command builds and packages your extension project without registering it.

```
cfn submit --dry-run
```

The following command registers your extension.

```
cfn submit --set-default
```

The following command registers your extension in the us-west-2 region.

```
cfn submit --region us-west-2
```

Output

Extension registration is an asynchronous operation. You can use the supplied registration token to track the progress of your extension registration request using the [DescribeTypeRegistration](#) operation of the CloudFormation API.

```
{'ProgressStatus': 'COMPLETE'}
```

Document history for the CloudFormation Command Line Interface user guide

The following table describes the documentation for this release of the CloudFormation Command Line Interface.

- **Latest documentation update:** February 10, 2022.

| update-history-change | update-history-description | update-history-date |
|---|--|---------------------|
| Hooks availability (p. 174) | Hooks proactively inspect the configuration of your Amazon resources before provisioning. For more information, see Developing hooks . | February 10, 2022 |
| Drift detection (p. 174) | Amazon CloudFormation supports drift detection operations on an expanded list of Amazon resources, in addition to private resources that are defined as provisionable. | October 1, 2021 |
| Public extensions (p. 174) | Use public extensions provided by third-party publishers, just as you would extensions from Amazon. | June 21, 2021 |
| General availability (p. 174) | Initial publication of the CloudFormation Command Line Interface documentation. | November 14, 2019 |

Amazon glossary

For the latest Amazon terminology, see the [Amazon glossary](#) in the *Amazon General Reference*.