OpenShift Container Platform 4.9

Serverless

OpenShift Serverless installation, usage, and release notes

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Legal Notice

Abstract

This document provides information on how to use OpenShift Serverless in OpenShift Container Platform.

Table of Contents

CHAPTER 1. OPENSHIFT SERVERLESS RELEASE NOTES

This topic includes information about new features, changes, and known issues that pertain to the latest OpenShift Serverless release on OpenShift Container Platform.

For an overview of OpenShift Serverless functionality, see About OpenShift Serverless.

NOTE

OpenShift Serverless is based on the open source Knative project.

For details about the latest Knative component releases, see the Knative blog.

1.1. ABOUT API VERSIONS

The OpenShift Serverless Operator automatically upgrades older resources that use deprecated versions of APIs to use the latest version.

For example, if you have created resources on your cluster that use older versions of the **ApiServerSource** API, such as **v1beta1**, the OpenShift Serverless Operator automatically updates these resources to use the **v1** version of the API when this is available and the **v1beta1** version is deprecated.

After they have been deprecated, older versions of APIs might be removed in any upcoming release. Using deprecated versions of APIs does not cause resources to fail. However, if you try to use a version of an API that has been removed, it will cause resources to fail. Ensure that your manifests are updated to use the latest version to avoid issues.

1.2. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.19.0

OpenShift Serverless 1.19.0 is now available. New features, changes, and known issues that pertain to OpenShift Serverless on OpenShift Container Platform are included in this topic.

1.2.1. New features

- OpenShift Serverless now uses Knative Serving 0.25.
- OpenShift Serverless now uses Knative Eventing 0.25.
- OpenShift Serverless now uses Kourier 0.25.
- OpenShift Serverless now uses Knative **kn** CLI 0.25.
- OpenShift Serverless now uses Knative Kafka 0.25.
- The **kn func** CLI plug-in now uses **func** 0.19.
- The **KafkaBinding** API is deprecated in OpenShift Serverless 1.19.0 and will be removed in a future release.
- HTTPS redirection is now supported and can be configured either globally for a cluster or per each Knative service.

1.2.2. Fixed issues

- In previous releases, the Kafka channel dispatcher waited only for the local commit to succeed before responding, which might have caused lost events in the case of an Apache Kafka node failure. The Kafka channel dispatcher now waits for all in-sync replicas to commit before responding.

1.2.3. Known issues

- In **func** version 0.19, some runtimes might be unable to build a function by using podman. You might see an error message similar to the following:

```
ERROR: failed to image: error during connect: Get
"http://%2Fvar%2Frun%2Fdocker.sock/v1.40/info": EOF
```

  - The following workaround exists for this issue:

    a. Update the podman service by adding **--time=0** to the service **ExecStart** definition:

    Example service configuration

    ```
    ExecStart=/usr/bin/podman $LOGGING system service --time=0
    ```

    b. Restart the podman service by running the following commands:

    ```
    $ systemctl --user daemon-reload
    ```

    ```
    $ systemctl restart --user podman.socket
    ```

  - Alternatively, you can expose the podman API by using TCP:

    ```
    $ podman system service --time=0 tcp:127.0.0.1:5534 &
    export DOCKER_HOST=tcp://127.0.0.1:5534
    ```

1.3. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.18.0

OpenShift Serverless 1.18.0 is now available. New features, changes, and known issues that pertain to OpenShift Serverless on OpenShift Container Platform are included in this topic.

1.3.1. New features

- OpenShift Serverless now uses Knative Serving 0.24.0.
- OpenShift Serverless now uses Knative Eventing 0.24.0.
- OpenShift Serverless now uses Kourier 0.24.0.
- OpenShift Serverless now uses Knative **kn** CLI 0.24.0.
- OpenShift Serverless now uses Knative Kafka 0.24.7.
- The **kn func** CLI plug-in now uses **func** 0.18.0.
- In the upcoming OpenShift Serverless 1.19.0 release, the URL scheme of external routes will default to HTTPS for enhanced security.

If you do not want this change to apply for your workloads, you can override the default setting before upgrading to 1.19.0, by adding the following YAML to your **KnativeServing** custom resource (CR):

```
...
spec:
  config:
    network:
      defaultExternalScheme: "http"
...
```

If you want the change to apply in 1.18.0 already, add the following YAML:

```
...
spec:
  config:
    network:
      defaultExternalScheme: "https"
...
```

- In the upcoming OpenShift Serverless 1.19.0 release, the default service type by which the Kourier Gateway is exposed will be **ClusterIP** and not **LoadBalancer**.
  If you do not want this change to apply to your workloads, you can override the default setting before upgrading to 1.19.0, by adding the following YAML to your **KnativeServing** custom resource (CR):

```
...
spec:
  ingress:
    kourier:
      service-type: LoadBalancer
...
```

- You can now use **emptyDir** volumes with OpenShift Serverless. See the OpenShift Serverless documentation about Knative Serving for details.

- Rust templates are now available when you create a function using **kn func**.

1.3.2. Fixed issues

- The prior 1.4 version of Camel-K was not compatible with OpenShift Serverless 1.17.0. The issue in Camel-K has been fixed, and Camel-K version 1.4.1 can be used with OpenShift Serverless 1.17.0.

- Previously, if you created a new subscription for a Kafka channel, or a new Kafka source, a delay was possible in the Kafka data plane becoming ready to dispatch messages after the newly created subscription or sink reported a ready status.
  As a result, messages that were sent during the time when the data plane was not reporting a ready status, might not have been delivered to the subscriber or sink.

  In OpenShift Serverless 1.18.0, the issue is fixed and the initial messages are no longer lost. For more information about the issue, see Knowledgebase Article #6343981.

1.3.3. Known issues

- Older versions of the Knative **kn** CLI might use older versions of the Knative Serving and Knative Eventing APIs. For example, version 0.23.2 of the **kn** CLI uses the **v1alpha1** API version. On the other hand, newer releases of OpenShift Serverless might no longer support older API versions. For example, OpenShift Serverless 1.18.0 no longer supports version **v1alpha1** of the **kafkasources.sources.knative.dev** API.

  Consequently, using an older version of the Knative **kn** CLI with a newer OpenShift Serverless might produce an error because the **kn** cannot find the outdated API. For example, version 0.23.2 of the **kn** CLI does not work with OpenShift Serverless 1.18.0.

  To avoid issues, use the latest **kn** CLI version available for your OpenShift Serverless release. For OpenShift Serverless 1.18.0, use Knative **kn** CLI 0.24.0.

1.4. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.17.0

OpenShift Serverless 1.17.0 is now available. New features, changes, and known issues that pertain to OpenShift Serverless on OpenShift Container Platform are included in this topic.

1.4.1. New features

- OpenShift Serverless now uses Knative Serving 0.23.0.
- OpenShift Serverless now uses Knative Eventing 0.23.0.
- OpenShift Serverless now uses Kourier 0.23.0.
- OpenShift Serverless now uses Knative **kn** CLI 0.23.0.
- OpenShift Serverless now uses Knative Kafka 0.23.0.
- The **kn func** CLI plug-in now uses **func** 0.17.0.
- In the upcoming OpenShift Serverless 1.19.0 release, the URL scheme of external routes will default to HTTPS for enhanced security.
  If you do not want this change to apply for your workloads, you can override the default setting before upgrading to 1.19.0, by adding the following YAML to your **KnativeServing** custom resource (CR):

```
...
spec:
  config:
    network:
      defaultExternalScheme: "http"
...
```

- mTLS functionality is now Generally Available (GA).
- TypeScript templates are now available when you create a function using **kn func**.
- Changes to API versions in Knative Eventing 0.23.0:
  - The **v1alpha1** version of the **KafkaChannel** API, which was deprecated in OpenShift Serverless version 1.14.0, has been removed. If the **ChannelTemplateSpec** parameters of your config maps contain references to this older version, you must update this part of the spec to use the correct API version.

1.4.2. Known issues

- If you try to use an older version of the Knative **kn** CLI with a newer OpenShift Serverless release, the API is not found and an error occurs.
  For example, if you use the 1.16.0 release of the **kn** CLI, which uses version 0.22.0, with the 1.17.0 OpenShift Serverless release, which uses the 0.23.0 versions of the Knative Serving and Knative Eventing APIs, the CLI does not work because it continues to look for the outdated 0.22.0 API versions.

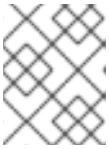
  Ensure that you are using the latest **kn** CLI version for your OpenShift Serverless release to avoid issues.

- Kafka channel metrics are not monitored or shown in the corresponding web console dashboard in this release. This is due to a breaking change in the Kafka dispatcher reconciling process.

- If you create a new subscription for a Kafka channel, or a new Kafka source, there might be a delay in the Kafka data plane becoming ready to dispatch messages after the newly created subscription or sink reports a ready status.
  As a result, messages that are sent during the time when the data plane is not reporting a ready status might not be delivered to the subscriber or sink.

  For more information about this issue and possible workarounds, see Knowledge Article #6343981.

- The Camel-K 1.4 release is not compatible with OpenShift Serverless version 1.17.0. This is because Camel-K 1.4 uses APIs that were removed in Knative version 0.23.0. There is currently no workaround available for this issue. If you need to use Camel-K 1.4 with OpenShift Serverless, do not upgrade to OpenShift Serverless version 1.17.0.



NOTE

The issue has been fixed, and Camel-K version 1.4.1 is compatible with OpenShift Serverless 1.17.0.

1.5. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.16.0

OpenShift Serverless 1.16.0 is now available. New features, changes, and known issues that pertain to OpenShift Serverless on OpenShift Container Platform are included in this topic.

1.5.1. New features

- OpenShift Serverless now uses Knative Serving 0.22.0.
- OpenShift Serverless now uses Knative Eventing 0.22.0.
- OpenShift Serverless now uses Kourier 0.22.0.
- OpenShift Serverless now uses Knative **kn** CLI 0.22.0.
- OpenShift Serverless now uses Knative Kafka 0.22.0.
- The **kn func** CLI plug-in now uses **func** 0.16.0.
- The **kn func emit** command has been added to the functions **kn** plug-in. You can use this command to send events to test locally deployed functions.

1.5.2. Known issues

- You must upgrade OpenShift Container Platform to version 4.6.30, 4.7.11, or higher before upgrading to OpenShift Serverless 1.16.0.
- The AMQ Streams Operator might prevent the installation or upgrade of the OpenShift Serverless Operator. If this happens, the following error is thrown by Operator Lifecycle Manager (OLM):

  ```
  WARNING: found multiple channel heads: [amqstreams.v1.7.2 amqstreams.v1.6.2], please check the `replaces`/`skipRange` fields of the operator bundles.
  ```

  You can fix this issue by uninstalling the AMQ Streams Operator before installing or upgrading the OpenShift Serverless Operator. You can then reinstall the AMQ Streams Operator.
- If Service Mesh is enabled with mTLS, metrics for Knative Serving are disabled by default because Service Mesh prevents Prometheus from scraping metrics. For instructions on enabling Knative Serving metrics for use with Service Mesh and mTLS, see the "Integrating Service Mesh with OpenShift Serverless" section of the Serverless documentation.
- If you deploy Service Mesh CRs with the Istio ingress enabled, you might see the following warning in the **istio-ingressgateway** pod:

  ```
  2021-05-02T12:56:17.700398Z warning envoy config [external/envoy/source/common/config/grpc_subscription_impl.cc:101] gRPC config for type.googleapis.com/envoy.api.v2.Listener rejected: Error adding/updating listener(s) 0.0.0.0_8081: duplicate listener 0.0.0.0_8081 found
  ```

  Your Knative services might also not be accessible.

  You can use the following workaround to fix this issue by recreating the **knative-local-gateway** service:

  a. Delete the existing **knative-local-gateway** service in the **istio-system** namespace:

  ```
  $ oc delete services -n istio-system knative-local-gateway
  ```

  b. Create and apply a **knative-local-gateway** service that contains the following YAML:

  ```
  apiVersion: v1
  kind: Service
  metadata:
   name: knative-local-gateway
   namespace: istio-system
   labels:
     experimental.istio.io/disable-gateway-port-translation: "true"
  spec:
   type: ClusterIP
   selector:
     istio: ingressgateway
   ports:
     - name: http2
       port: 80
       targetPort: 8081
  ```

- If you have 1000 Knative services on a cluster, and then perform a reinstall or upgrade of Knative Serving, there is a delay when you create the first new service after the **KnativeServing** custom resource (CR) becomes **Ready**.
  The **3scale-kourier-control** service reconciles all previously existing Knative services before processing the creation of a new service, which causes the new service to spend approximately 800 seconds in an **IngressNotConfigured** or **Unknown** state before the state updates to **Ready**.

- If you create a new subscription for a Kafka channel, or a new Kafka source, there might be a delay in the Kafka data plane becoming ready to dispatch messages after the newly created subscription or sink reports a ready status.
  As a result, messages that are sent during the time when the data plane is not reporting a ready status might not be delivered to the subscriber or sink.

  For more information about this issue and possible workarounds, see Knowledge Article #6343981.

CHAPTER 2. DISCOVER

2.1. ABOUT OPENSHIFT SERVERLESS

OpenShift Serverless simplifies the process of delivering code from development into production by reducing the need for infrastructure set up or back-end development by developers.

Developers on OpenShift Serverless can use the provided Kubernetes native APIs (Knative Serving and Eventing), as well as familiar languages and frameworks, to deploy applications and container workloads.

OpenShift Serverless is based on the open source Knative project, which provides portability and consistency for hybrid and multi-cloud environments by enabling an enterprise-grade serverless platform.

2.1.1. Supported configurations

The set of supported features, configurations, and integrations for OpenShift Serverless, current and past versions, are available at the Supported Configurations page.

2.1.2. Knative Serving

Knative Serving on OpenShift Container Platform enables developers to write cloud-native applications using serverless architecture.

Knative Serving supports deploying and managing cloud-native applications. It provides a set of objects as Kubernetes custom resource definitions (CRDs) that define and control the behavior of serverless workloads on an OpenShift Container Platform cluster.

Developers use these CRDs to create custom resource (CR) instances that can be used as building blocks to address complex use cases. For example:

- Rapidly deploying serverless containers.
- Automatically scaling pods.

2.1.3. Knative Eventing

Knative Eventing on OpenShift Container Platform enables developers to use an event-driven architecture with serverless applications.

An event-driven architecture is based on the concept of decoupled relationships between event producers and event consumers. Event producers create events, and event *sinks*, or consumers, receive events.

Knative Eventing uses standard HTTP POST requests to send and receive events between event producers and sinks. These events conform to the CloudEvents specifications, which enables creating, parsing, sending, and receiving events in any programming language.

Knative Eventing supports the following use cases:

Publish an event without creating a consumer

You can send events to a broker as an HTTP POST, and use binding to decouple the destination configuration from your application that produces events.

Consume an event without creating a publisher

You can use a trigger to consume events from a broker based on event attributes. The application receives events as an HTTP POST.

2.1.4. Additional resources

- For more information about CRDs, see Extending the Kubernetes API with custom resource definitions.
- For more information about CRs, see Managing resources from custom resource definitions .

2.2. ABOUT OPENSHIFT SERVERLESS FUNCTIONS

IMPORTANT

OpenShift Serverless Functions is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see https://access.redhat.com/support/offerings/techpreview/.

OpenShift Serverless Functions enables developers to create and deploy stateless, event-driven functions as a Knative service on OpenShift Container Platform.

The **kn func** CLI is provided as a plug-in for the Knative **kn** CLI. OpenShift Serverless Functions uses the CNCF Buildpack API to create container images. After a container image has been created, you can use the **kn func** CLI to deploy the container image as a Knative service on the cluster.

2.2.1. Supported runtimes

OpenShift Serverless Functions provides templates that can be used to create basic functions for the following runtimes:

- Node.js
- Python
- Golang
- Quarkus
- TypeScript

2.2.2. Next steps

- See Getting started with functions.

2.3. KNATIVE SERVING COMPONENTS

Service

The **service.serving.knative.dev** CRD automatically manages the life cycle of your workload to ensure that the application is deployed and reachable through the network. It creates a route, a configuration, and a new revision for each change to a user created service, or custom resource. Most developer interactions in Knative are carried out by modifying services.

Revision

The **revision.serving.knative.dev** CRD is a point-in-time snapshot of the code and configuration for each modification made to the workload. Revisions are immutable objects and can be retained for as long as necessary.

Route

The **route.serving.knative.dev** CRD maps a network endpoint to one or more revisions. You can manage the traffic in several ways, including fractional traffic and named routes.

Configuration

The **configuration.serving.knative.dev** CRD maintains the desired state for your deployment. It provides a clean separation between code and configuration. Modifying a configuration creates a new revision.

2.4. KNATIVE EVENTING COMPONENTS

To enable delivery to multiple types of sinks, Knative Eventing defines the following generic interfaces that can be implemented by multiple Kubernetes resources:

Addressable resources

Able to receive and acknowledge an event delivered over HTTP to an address defined in the **status.address.url** field of the event. The Kubernetes **Service** resource also satisfies the addressable interface.

Callable resources

Able to receive an event delivered over HTTP and transform it, returning **0** or **1** new events in the HTTP response payload. These returned events may be further processed in the same way that events from an external event source are processed.

You can propagate an event from an event source to multiple event sinks by using:

- channels and subscriptions, or
- brokers and triggers.

2.5. EVENT SOURCES

A Knative *event source* can be any Kubernetes object that generates or imports cloud events, and relays those events to another endpoint, known as a *sink*. Sourcing events is critical to developing a distributed system that reacts to events.

You can create and manage Knative event sources by using the **Developer** perspective in the OpenShift Container Platform web console, the **kn** CLI, or by applying YAML files.

Currently, OpenShift Serverless supports the following event source types:

API server source

Brings Kubernetes API server events into Knative. The API server source sends a new event each time a Kubernetes resource is created, updated or deleted.

Ping source

Produces events with a fixed payload on a specified cron schedule.

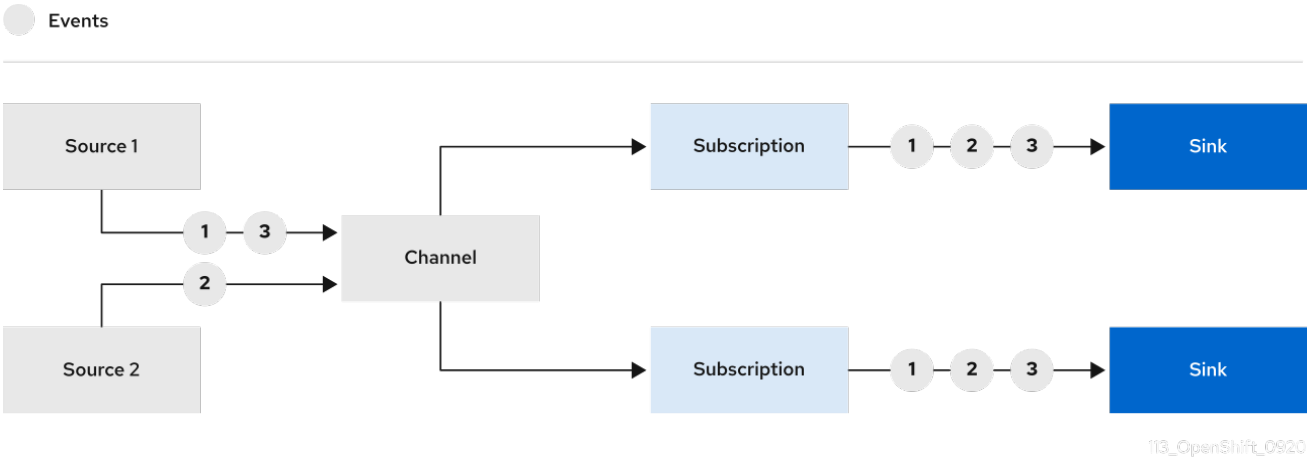
Kafka event source

Connects a Kafka cluster to a sink as an event source.

You can also create a custom event source.

2.6. CHANNELS

Channels are custom resources that define a single event-forwarding and persistence layer.



After events have been sent to a channel from an event source or producer, these events can be sent to multiple Knative services, or other sinks, by using a subscription.

InMemoryChannel and **KafkaChannel** channel implementations can be used with OpenShift Serverless for development use.

The following are limitations of **InMemoryChannel** type channels:

- No event persistence is available. If a pod goes down, events on that pod are lost.
- **InMemoryChannel** channels do not implement event ordering, so two events that are received in the channel at the same time can be delivered to a subscriber in any order.
- If a subscriber rejects an event, there are no re-delivery attempts by default. You can configure re-delivery attempts by modifying the **delivery** spec in the **Subscription** object.

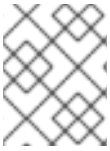
2.6.1. Next steps

- If you are a cluster administrator, you can configure default settings for channels. See Configuring channel defaults.
- See Creating and deleting channels.

CHAPTER 3. INSTALL

3.1. INSTALLING THE OPENSHIFT SERVERLESS OPERATOR

This guide walks cluster administrators through installing the OpenShift Serverless Operator to an OpenShift Container Platform cluster.

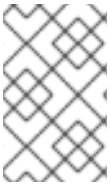


NOTE

OpenShift Serverless is supported for installation in a restricted network environment. For more information, see Using Operator Lifecycle Manager on restricted networks .

3.1.1. Defining cluster size requirements for an OpenShift Serverless installation

To install and use OpenShift Serverless, the OpenShift Container Platform cluster must be sized correctly.



NOTE

The following requirements relate only to the pool of worker machines of the OpenShift Container Platform cluster. Control plane nodes are not used for general scheduling and are omitted from the requirements.

The total size requirements to run OpenShift Serverless are dependent on the applications deployed. By default, each pod requests approximately 400m of CPU, so the minimum requirements are based on this value. Lowering the actual CPU request of applications can increase the number of possible replicas.

If you have high availability (HA) enabled on your cluster, this requires between 0.5 - 1.5 cores and between 200MB - 2GB of memory for each replica of the Knative Serving control plane.

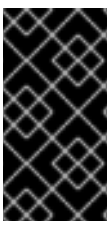
HA is enabled for some Knative Serving components by default. You can disable HA by following the documentation on Configuring high availability replicas on OpenShift Serverless .

3.1.2. Scaling your cluster using machine sets

You can use the OpenShift Container Platform **MachineSet** API to manually scale your cluster up to the desired size. The minimum requirements usually mean that you must scale up one of the default machine sets by two additional machines. See Manually scaling a machine set .

3.1.3. Installing the OpenShift Serverless Operator

This procedure describes how to install and subscribe to the OpenShift Serverless Operator from the OperatorHub using the OpenShift Container Platform web console.



IMPORTANT

Before upgrading to the latest Serverless release, you must remove the community Knative Eventing Operator if you have previously installed it. Having the Knative Eventing Operator installed prevents you from being able to install the latest version of Knative Eventing using the OpenShift Serverless Operator.

Procedure

1. In the OpenShift Container Platform web console, navigate to the **Operators → OperatorHub** page.
2. Scroll, or type the keyword **Serverless** into the **Filter by keyword** box to find the OpenShift Serverless Operator.
3. Review the information about the Operator and click **Install**.
4. On the **Install Operator** page:
    a. The **Installation Mode** is **All namespaces on the cluster (default)** This mode installs the Operator in the default **openshift-serverless** namespace to watch and be made available to all namespaces in the cluster.
    b. The **Installed Namespace** will be **openshift-serverless**.
    c. Select the **stable** channel as the **Update Channel**. The **stable** channel will enable installation of the latest stable release of the OpenShift Serverless Operator.
    d. Select **Automatic** or **Manual** approval strategy.
5. Click **Install** to make the Operator available to the selected namespaces on this OpenShift Container Platform cluster.
6. From the **Catalog → Operator Management** page, you can monitor the OpenShift Serverless Operator subscription's installation and upgrade progress.
    a. If you selected a **Manual** approval strategy, the subscription's upgrade status will remain **Upgrading** until you review and approve its install plan. After approving on the **Install Plan** page, the subscription upgrade status moves to **Up to date**.
    b. If you selected an **Automatic** approval strategy, the upgrade status should resolve to **Up to date** without intervention.

Verification

After the Subscription's upgrade status is **Up to date**, select **Catalog → Installed Operators** to verify that the OpenShift Serverless Operator eventually shows up and its **Status** ultimately resolves to **InstallSucceeded** in the relevant namespace.

If it does not:

1. Switch to the **Catalog → Operator Management** page and inspect the **Operator Subscriptions** and **Install Plans** tabs for any failure or errors under **Status**.
2. Check the logs in any pods in the **openshift-serverless** project on the **Workloads → Pods** page that are reporting issues to troubleshoot further.

3.1.4. Next steps

- After the OpenShift Serverless Operator is installed, you can install the Knative Serving component. See the documentation on Installing Knative Serving.
- After the OpenShift Serverless Operator is installed, you can install the Knative Eventing component. See the documentation on Installing Knative Eventing.

3.2. INSTALLING KNATIVE SERVING

After you have installed the OpenShift Serverless Operator, you can install Knative Serving.

This guide provides information about installing Knative Serving using the default settings. However, you can configure more advanced settings in the **KnativeServing** custom resource definition (CRD). For more information about configuration options for the **KnativeServing** CRD, see Knative Serving advanced configuration options.

3.2.1. Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- You have installed the OpenShift Serverless Operator.

3.2.2. Installing Knative Serving using the web console

Procedure

1. In the **Administrator** perspective of the OpenShift Container Platform web console, navigate to **Operators → Installed Operators**.
2. Check that the **Project** dropdown at the top of the page is set to **Project: knative-serving**.
3. Click **Knative Serving** in the list of **Provided APIs** for the OpenShift Serverless Operator to go to the **Knative Serving** tab.
4. Click **Create Knative Serving**
5. In the **Create Knative Serving** page, you can install Knative Serving using the default settings by clicking **Create**.
   You can also modify settings for the Knative Serving installation by editing the **KnativeServing** object using either the form provided, or by editing the YAML.
   - Using the form is recommended for simpler configurations that do not require full control of **KnativeServing** object creation.
   - Editing the YAML is recommended for more complex configurations that require full control of **KnativeServing** object creation. You can access the YAML by clicking the **edit YAML** link in the top right of the **Create Knative Serving** page.
     After you complete the form, or have finished modifying the YAML, click **Create**.

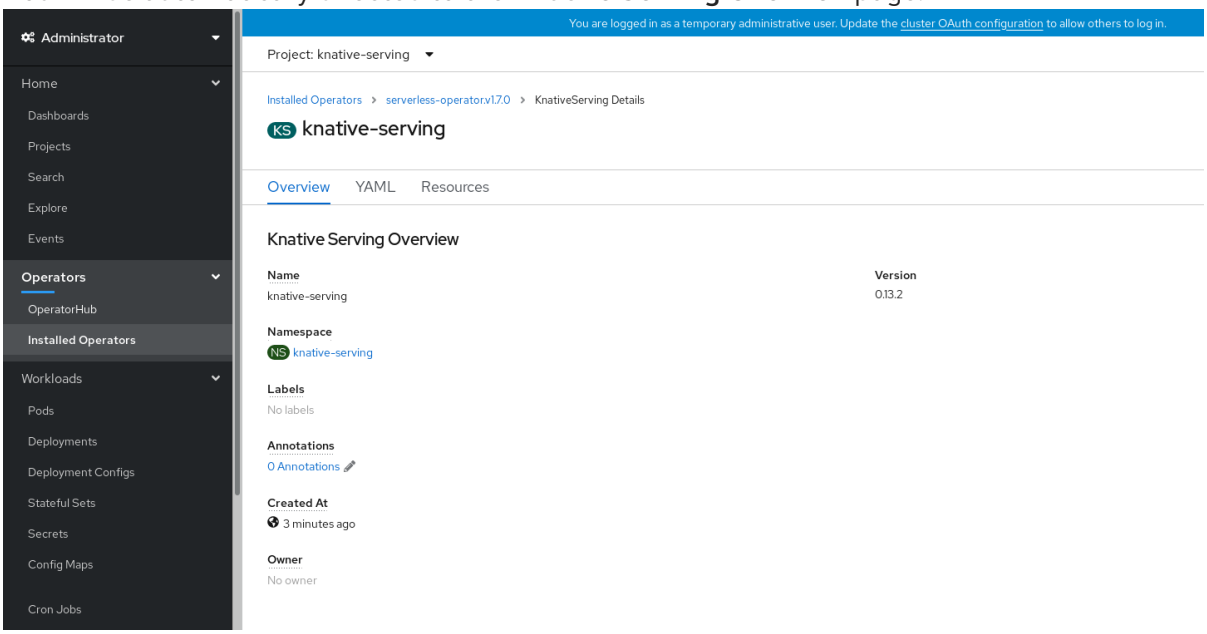
     NOTE

     For more information about configuration options for the KnativeServing custom resource definition, see the documentation on *Advanced installation configuration options*.
6. After you have installed Knative Serving, the **KnativeServing** object is created, and you are automically directed to the **Knative Serving** tab. You will see the **knative-serving** custom resource in the list of resources.

Verification

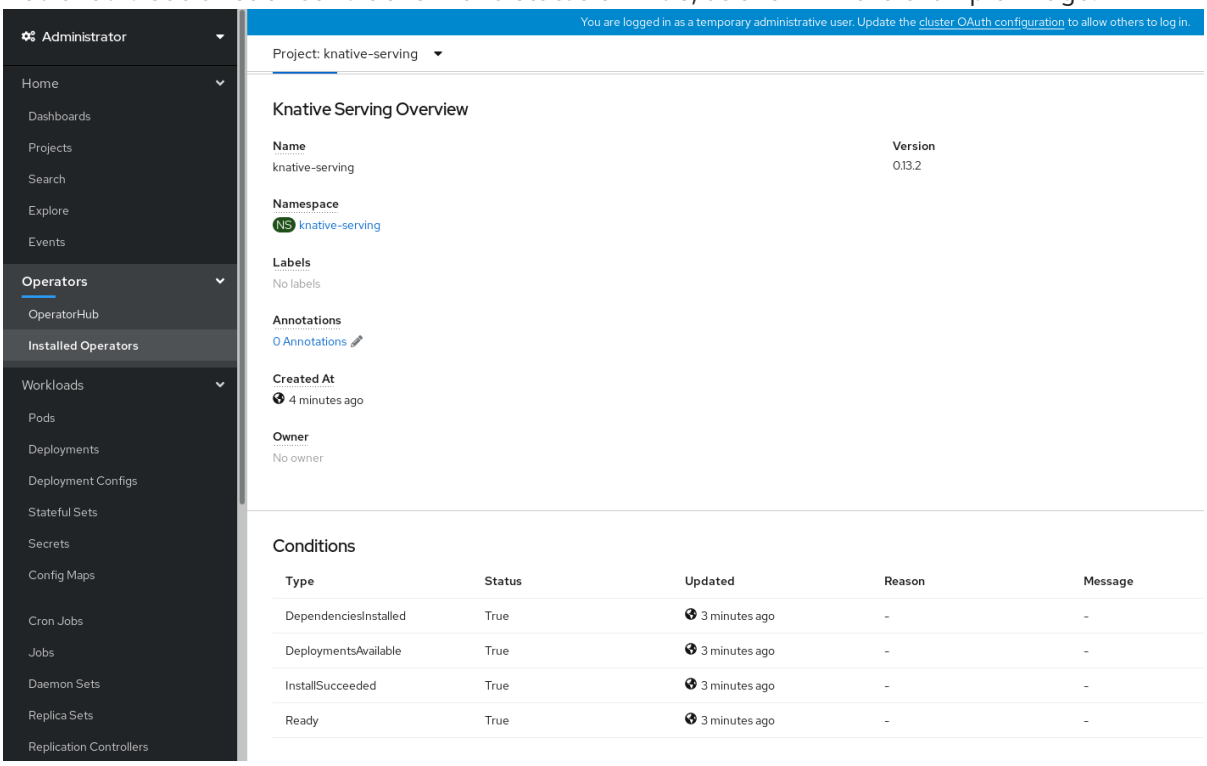
1. Click on **knative-serving** custom resource in the **Knative Serving** tab.

2. You will be automatically directed to the **Knative Serving Overview** page.



3. Scroll down to look at the list of **Conditions**.

4. You should see a list of conditions with a status of **True**, as shown in the example image.



NOTE

It may take a few seconds for the Knative Serving resources to be created. You can check their status in the **Resources** tab.

5. If the conditions have a status of **Unknown** or **False**, wait a few moments and then check again after you have confirmed that the resources have been created.

3.2.3. Installing Knative Serving using YAML

Procedure

1. Create a file named **serving.yaml** and copy the following example YAML into it:

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
```

2. Apply the **serving.yaml** file:

```
$ oc apply -f serving.yaml
```

Verification

1. To verify the installation is complete, enter the following command:

```
$ oc get knativeserving.operator.knative.dev/knative-serving -n knative-serving --
template='{{range .status.conditions}}{{printf "%s=%s\n" .type .status}}{{end}}'
```

Example output

```
DependenciesInstalled=True
DeploymentsAvailable=True
InstallSucceeded=True
Ready=True
```

NOTE

It may take a few seconds for the Knative Serving resources to be created.

If the conditions have a status of **Unknown** or **False**, wait a few moments and then check again after you have confirmed that the resources have been created.

2. Check that the Knative Serving resources have been created:

```
$ oc get pods -n knative-serving
```

Example output

```
NAME                                     READY   STATUS      RESTARTS   AGE
activator-67ddf8c9d7-p7rm5               2/2     Running     0          4m
activator-67ddf8c9d7-q84fz               2/2     Running     0          4m
autoscaler-5d87bc6dbf-6nqc6              2/2     Running     0          3m59s
autoscaler-5d87bc6dbf-h64rl              2/2     Running     0          3m59s
autoscaler-hpa-77f85f5cc4-lrts7          2/2     Running     0          3m57s
autoscaler-hpa-77f85f5cc4-zx7hl          2/2     Running     0          3m56s
controller-5cfc7cb8db-nlccl              2/2     Running     0          3m50s
controller-5cfc7cb8db-rmv7r              2/2     Running     0          3m18s
domain-mapping-86d84bb6b4-r746m          2/2     Running     0          3m58s
domain-mapping-86d84bb6b4-v7nh8          2/2     Running     0          3m58s
domainmapping-webhook-769d679d45-bkcnj   2/2     Running     0          3m58s
```

```
domainmapping-webhook-769d679d45-fff68                    2/2     Running     0          3m58s
storage-version-migration-serving-serving-0.26.0--1-6qlkb  0/1     Completed   0          3m56s
webhook-5fb774f8d8-6bqrt                                  2/2     Running     0          3m57s
webhook-5fb774f8d8-b8lt5                                  2/2     Running     0          3m57s
```

3. Check that the necessary networking components have been installed to the automatically created **knative-serving-ingress** namespace:

```
$ oc get pods -n knative-serving-ingress
```

Example output

```
NAME                                    READY   STATUS    RESTARTS   AGE
net-kourier-controller-7d4b6c5d95-62mkf   1/1     Running   0          76s
net-kourier-controller-7d4b6c5d95-qmgm2   1/1     Running   0          76s
3scale-kourier-gateway-6688b49568-987qz   1/1     Running   0          75s
3scale-kourier-gateway-6688b49568-b5tnp   1/1     Running   0          75s
```

3.2.4. Knative Serving advanced configuration options

This section provides information about advanced configuration options for Knative Serving.

3.2.4.1. Controller custom certs

If your registry uses a self-signed certificate, you must enable tag-to-digest resolution by creating a config map or secret. To enable tag-to-digest resolution, the Knative Serving controller requires access to the container registry.

The following example **KnativeServing** custom resource configuration uses a certificate in a config map named **certs** in the **knative-serving** namespace. This example triggers the OpenShift Serverless Operator to:

1. Create and mount a volume containing the certificate in the controller.
2. Set the required environment variable properly.

Example YAML

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
spec:
  controller-custom-certs:
    name: config-service-ca
    type: ConfigMap (1)
```

(1) The supported types are **ConfigMap** and **Secret**.

If no controller custom cert is specified, this setting defaults to use the **config-service-ca** config map.

After tag-to-digest resolution is enabled, the OpenShift Serverless Operator automatically configures Knative Serving controller access to the registry.

IMPORTANT

The config map or secret must reside in the same namespace as the Knative Serving custom resource definition (CRD).

3.2.4.2. High availability

High availability, which can be configured using the **spec.high-availability** field, defaults to **2** replicas per controller if no number of replicas is specified by a user during the Knative Serving installation.

You can set this to **1** to disable high availability, or add more replicas by setting a higher integer.

Example YAML

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
spec:
  high-availability:
    replicas: 2
```

3.2.5. Next steps

- For cloud events functionality on OpenShift Serverless, you can install the Knative Eventing component. See the documentation on Installing Knative Eventing .

3.3. INSTALLING KNATIVE EVENTING

After you install the OpenShift Serverless Operator, you can install Knative Eventing by following the procedures described in this guide.

This guide provides information about installing Knative Eventing using the default settings.

3.3.1. Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- You have installed OpenShift Serverless Operator.

3.3.2. Installing Knative Eventing using the web console

Procedure

1. In the **Administrator** perspective of the OpenShift Container Platform web console, navigate to **Operators → Installed Operators**.
2. Check that the **Project** dropdown at the top of the page is set to **Project: knative-eventing**.

3. Click **Knative Eventing** in the list of **Provided APIs** for the OpenShift Serverless Operator to go to the **Knative Eventing** tab.

4. Click **Create Knative Eventing**

5. In the **Create Knative Eventing** page, you can choose to configure the **KnativeEventing** object by using either the default form provided, or by editing the YAML.

   - Using the form is recommended for simpler configurations that do not require full control of **KnativeEventing** object creation.
     Optional. If you are configuring the **KnativeEventing** object using the form, make any changes that you want to implement for your Knative Eventing deployment.

6. Click **Create**.

   - Editing the YAML is recommended for more complex configurations that require full control of **KnativeEventing** object creation. You can access the YAML by clicking the **edit YAML** link in the top right of the **Create Knative Eventing** page.
     Optional. If you are configuring the **KnativeEventing** object by editing the YAML, make any changes to the YAML that you want to implement for your Knative Eventing deployment.

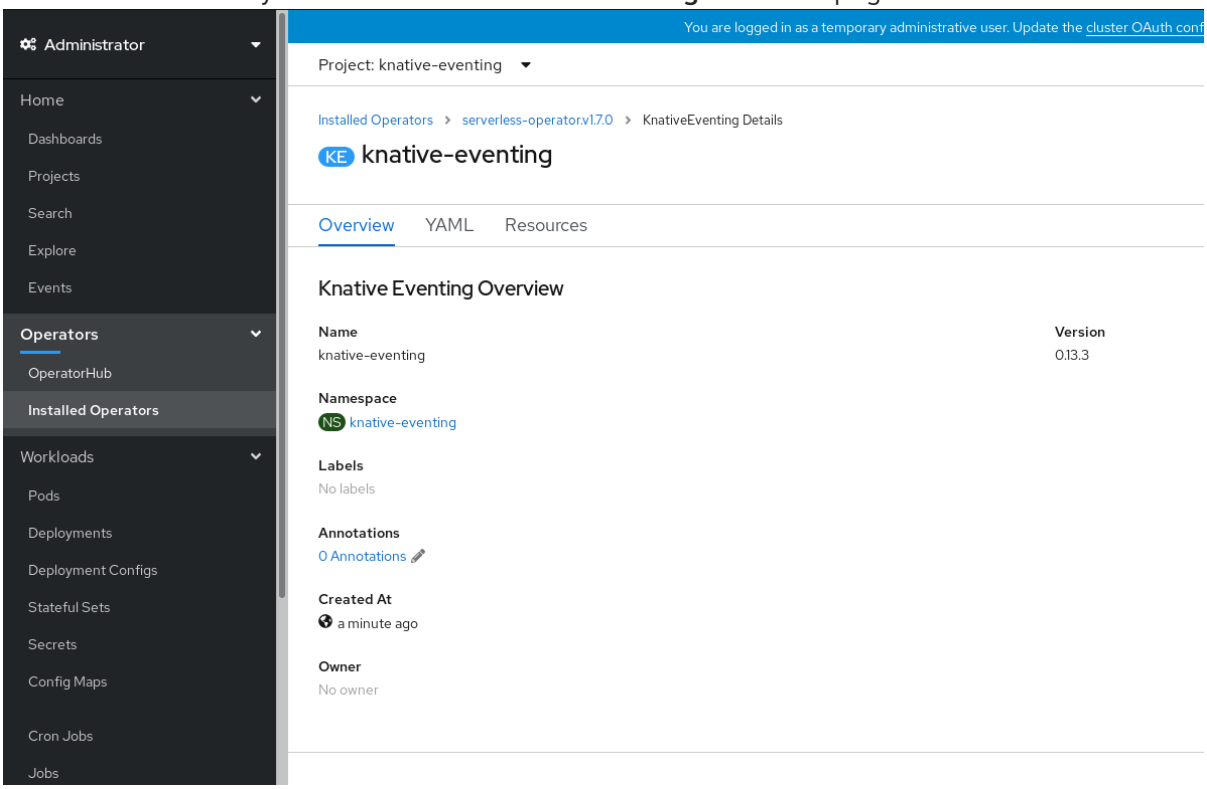
7. Click **Create**.

8. After you have installed Knative Eventing, the **KnativeEventing** object is created, and you are automically directed to the **Knative Eventing** tab. You will see the **knative-eventing** custom resource in the list of resources.

Verification

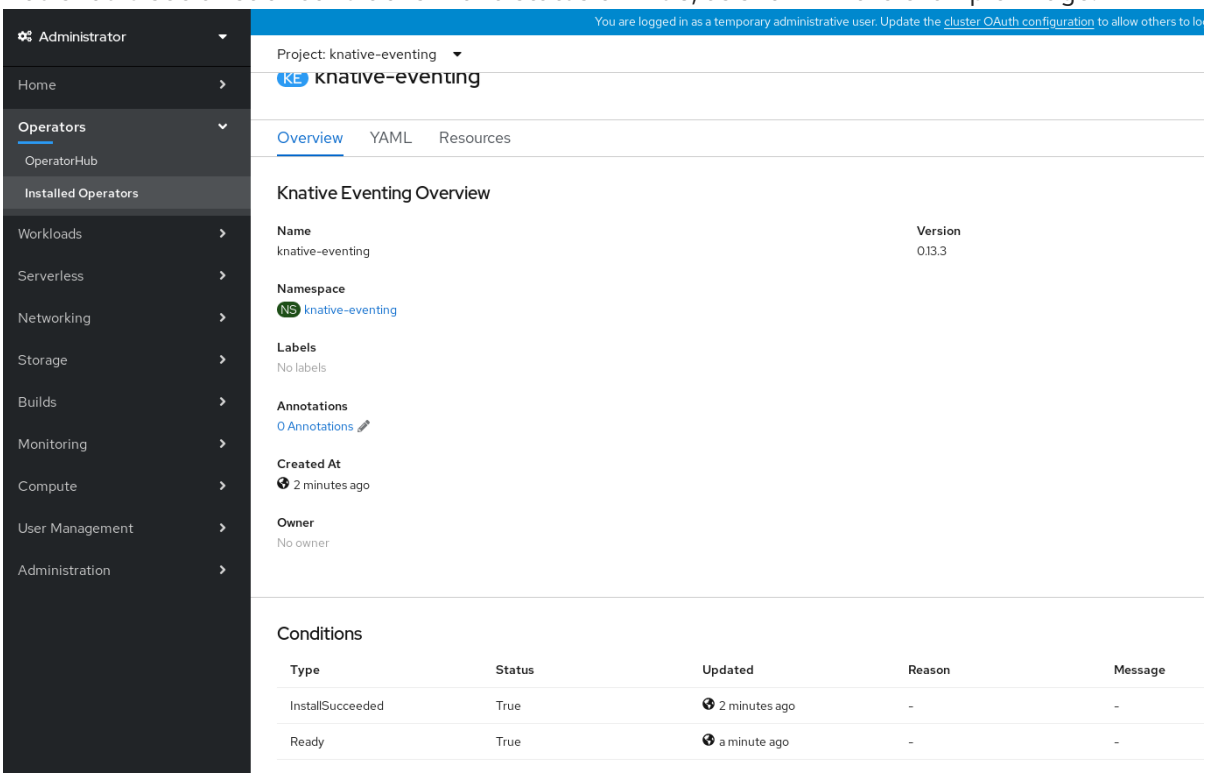
1. Click on the **knative-eventing** custom resource in the **Knative Eventing** tab.

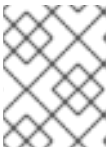
2. You are automatically directed to the **Knative Eventing Overview** page.



3. Scroll down to look at the list of **Conditions**.

4. You should see a list of conditions with a status of **True**, as shown in the example image.





NOTE

It may take a few seconds for the Knative Eventing resources to be created. You can check their status in the **Resources** tab.

5. If the conditions have a status of **Unknown** or **False**, wait a few moments and then check again after you have confirmed that the resources have been created.

3.3.3. Installing Knative Eventing using YAML

Procedure

1. Create a file named **eventing.yaml**.
2. Copy the following sample YAML into **eventing.yaml**:

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeEventing
metadata:
    name: knative-eventing
    namespace: knative-eventing
```

3. Optional. Make any changes to the YAML that you want to implement for your Knative Eventing deployment.
4. Apply the **eventing.yaml** file by entering:

```
$ oc apply -f eventing.yaml
```

Verification

1. Verify the installation is complete by entering the following command and observing the output:

```
$ oc get knativeeventing.operator.knative.dev/knative-eventing \
  -n knative-eventing \
  --template='{{range .status.conditions}}{{printf "%s=%s\n" .type .status}}{{end}}'
```

Example output

```
InstallSucceeded=True
Ready=True
```

NOTE

It may take a few seconds for the Knative Eventing resources to be created.

2. If the conditions have a status of **Unknown** or **False**, wait a few moments and then check again after you have confirmed that the resources have been created.

3. Check that the Knative Eventing resources have been created by entering:

```
$ oc get pods -n knative-eventing
```

Example output

```
NAME                                  READY   STATUS    RESTARTS   AGE
broker-controller-58765d9d49-g9zp6    1/1     Running   0          7m21s
eventing-controller-65fdd66b54-jw7bh  1/1     Running   0          7m31s
eventing-webhook-57fd74b5bd-kvhlz     1/1     Running   0          7m31s
imc-controller-5b75d458fc-ptvm2       1/1     Running   0          7m19s
imc-dispatcher-64f6d5fccb-kkc4c       1/1     Running   0          7m18s
```

3.4. REMOVING OPENSHIFT SERVERLESS

This guide provides details of how to remove the OpenShift Serverless Operator and other OpenShift Serverless components.

NOTE

Before you can remove the OpenShift Serverless Operator, you must remove Knative Serving and Knative Eventing.

3.4.1. Uninstalling Knative Serving

To uninstall Knative Serving, you must remove its custom resource and delete the **knative-serving** namespace.

Procedure

1. Delete the **knative-serving** custom resource:

```
$ oc delete knativeservings.operator.knative.dev knative-serving -n knative-serving
```

2. After the command has completed and all pods have been removed from the **knative-serving** namespace, delete the namespace:

```
$ oc delete namespace knative-serving
```

3.4.2. Uninstalling Knative Eventing

To uninstall Knative Eventing, you must remove its custom resource and delete the **knative-eventing** namespace.

Procedure

1. Delete the **knative-eventing** custom resource:

```
$ oc delete knativeeventings.operator.knative.dev knative-eventing -n knative-eventing
```

2. After the command has completed and all pods have been removed from the **knative-eventing** namespace, delete the namespace:

```
$ oc delete namespace knative-eventing
```

3.4.3. Removing the OpenShift Serverless Operator

You can remove the OpenShift Serverless Operator from the host cluster by following the documentation on Deleting Operators from a cluster .

3.4.4. Deleting OpenShift Serverless custom resource definitions

After uninstalling the OpenShift Serverless, the Operator and API custom resource definitions (CRDs) remain on the cluster. You can use the following procedure to remove the remaining CRDs.

IMPORTANT

Removing the Operator and API CRDs also removes all resources that were defined using them, including Knative services.

Prerequisites

- You uninstalled Knative Serving and removed the OpenShift Serverless Operator.

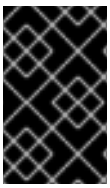
Procedure

- To delete the remaining OpenShift Serverless CRDs, enter the following command:

```
$ oc get crd -oname | grep 'knative.dev' | xargs oc delete
```

CHAPTER 4. UPDATE

If you have installed a previous version of OpenShift Serverless, you can follow the instructions in this guide to update to the latest version.



IMPORTANT

If you have previously installed the community Knative Eventing Operator, you must remove this Operator before you are able to install the latest version of Knative Eventing by using the OpenShift Serverless Operator.

4.1. UPGRADING THE SUBSCRIPTION CHANNEL

Prerequisites

- You have installed a previous version of OpenShift Serverless Operator, and have selected Automatic updates during the installation process.

NOTE

If you have selected Manual updates, you will need to complete additional steps after updating the channel as described in this guide. The Subscription's upgrade status will remain **Upgrading** until you review and approve its Install Plan. Information about the Install Plan can be found in the OpenShift Container Platform Operators documentation.

- You have logged in to the OpenShift Container Platform web console.

Procedure

1. Select the **openshift-operators** namespace in the OpenShift Container Platform web console.
2. Navigate to the **Operators → Installed Operators** page.
3. Select the **OpenShift Serverless Operator Operator**.
4. Click **Subscription → Channel**.
5. In the **Change Subscription Update Channel** window, select **stable**, and then click **Save**.
6. Wait until all pods have been upgraded in the **knative-serving** namespace and the **KnativeServing** custom resource reports the latest Knative Serving version.

Verification

To verify that the upgrade has been successful, you can check the status of pods in the **knative-serving** namespace, and the version of the **KnativeServing** custom resource.

1. Check the status of the pods:

```
$ oc get knativeserving.operator.knative.dev knative-serving -n knative-serving -
o=jsonpath='{.status.conditions[?(@.type=="Ready")].status}'
```

This command should return a status of **True**.

2. Check the version of the **KnativeServing** custom resource:

```
$ oc get knativeserving.operator.knative.dev knative-serving -n knative-serving -
o=jsonpath='{.status.version}'
```

This command should return the latest version of Knative Serving. You can check the latest version in the OpenShift Serverless Operator release notes.

CHAPTER 5. DEVELOP

5.1. SERVERLESS APPLICATIONS

To deploy a serverless application using OpenShift Serverless, you must create a *Knative service*. Knative services are Kubernetes services, defined by a route and a configuration, and contained in a YAML file.

Example Knative service YAML

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: hello 1
  namespace: default 2
spec:
  template:
    spec:
      containers:
        - image: docker.io/openshift/hello-openshift 3
          env:
            - name: RESPONSE 4
              value: "Hello Serverless!"
```

1. The name of the application.
2. The namespace the application uses.
3. The image of the application.
4. The environment variable printed out by the sample application.

5.1.1. Creating serverless applications

You can create a serverless application by using one of the following methods:

- Create a Knative service from the OpenShift Container Platform web console. See the documentation about Creating applications using the Developer perspective .
- Create a Knative service using the **kn** CLI.
- Create and apply a YAML file.

5.1.1.1. Creating serverless applications by using the Knative CLI

The following procedure describes how you can create a basic serverless application using the **kn** CLI.

Prerequisites

- OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have installed the **kn** CLI.

Procedure

- Create a Knative service:

```
$ kn service create <service-name> --image <image> --env <key=value>
```

Example command

```
$ kn service create event-display \
    --image quay.io/openshift-knative/knative-eventing-sources-event-display:latest
```

Example output

```
Creating service 'event-display' in namespace 'default':

  0.271s The Route is still working to reflect the latest desired specification.
  0.580s Configuration "event-display" is waiting for a Revision to become ready.
  3.857s ...
  3.861s Ingress has not yet been reconciled.
  4.270s Ready to serve.

Service 'event-display' created with latest revision 'event-display-bxshg-1' and URL:
http://event-display-default.apps-crc.testing
```

5.1.1.1.1. Knative client multi-container support

You can use the **kn container add** command to print YAML container spec to standard output. This command is useful for multi-container use cases because it can be used along with other standard **kn** flags to create definitions. The **kn container add** command accepts all container-related flags that are supported for use with the **kn service create** command. The **kn container add** command can also be chained by using UNIX pipes (|) to create multiple container definitions at once.

5.1.1.1.1.1. Example commands

- Add a container from an image and print it to standard output:

```
$ kn container add <container_name> --image <image_uri>
```

Example command

```
$ kn container add sidecar --image docker.io/example/sidecar
```

Example output

```
containers:
- image: docker.io/example/sidecar
  name: sidecar
  resources: {}
```

- Chain two **kn container add** commands together, and then pass them to a **kn service create** command to create a Knative service with two containers:

```
$ kn container add <first_container_name> --image <image_uri> | \
kn container add <second_container_name> --image <image_uri> | \
kn service create <service_name> --image <image_uri> --extra-containers -
```

--extra-containers - specifies a special case where **kn** reads the pipe input instead of a YAML file.

Example command

```
$ kn container add sidecar --image docker.io/example/sidecar:first | \
kn container add second --image docker.io/example/sidecar:second | \
kn service create my-service --image docker.io/example/my-app:latest --extra-containers -
```

The **--extra-containers** flag can also accept a path to a YAML file:

```
$ kn service create <service_name> --image <image_uri> --extra-containers <filename>
```

Example command

```
$ kn service create my-service --image docker.io/example/my-app:latest --extra-containers
my-extra-containers.yaml
```

5.1.1.2. Creating serverless applications using YAML

To create a serverless application by using YAML, you must create a YAML file that defines a **Service** object, then apply it by using **oc apply**.

Procedure

1. Create a YAML file containing the following sample code:

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: event-delivery
  namespace: default
spec:
  template:
    spec:
      containers:
        - image: quay.io/openshift-knative/knative-eventing-sources-event-display:latest
          env:
            - name: RESPONSE
              value: "Hello Serverless!"
```

2. Navigate to the directory where the YAML file is contained, and deploy the application by applying the YAML file:

```
$ oc apply -f <filename>
```

After the service is created and the application is deployed, Knative creates an immutable revision for this version of the application. Knative also performs network programming to create a route, ingress,

service, and load balancer for your application and automatically scales your pods up and down based on traffic, including inactive pods.

5.1.2. Updating serverless applications by using the Knative CLI

You can use the **kn service update** command for interactive sessions on the command line as you build up a service incrementally. In contrast to the **kn service apply** command, when using the **kn service update** command you only have to specify the changes that you want to update, rather than the full configuration for the Knative service.

Example commands

- Update a service by adding a new environment variable:

```
$ kn service update <service_name> --env <key>=<value>
```

- Update a service by adding a new port:

```
$ kn service update <service_name> --port 80
```

- Update a service by adding new request and limit parameters:

```
$ kn service update <service_name> --request cpu=500m --limit memory=1024Mi --limit
cpu=1000m
```

- Assign the **latest** tag to a revision:

```
$ kn service update <service_name> --tag <revision_name>=latest
```

- Update a tag from **testing** to **staging** for the latest **READY** revision of a service:

```
$ kn service update <service_name> --untag testing --tag @latest=staging
```

- Add the **test** tag to a revision that receives 10% of traffic, and send the rest of the traffic to the latest **READY** revision of a service:

```
$ kn service update <service_name> --tag <revision_name>=test --traffic test=10,@latest=90
```

5.1.3. Applying service declarations

You can declaratively configure a Knative service by using the **kn service apply** command. If the service does not exist it is created, otherwise the existing service is updated with the options that have been changed.

The **kn service apply** command is especially useful for shell scripts or in a continuous integration pipeline, where users typically want to fully specify the state of the service in a single command to declare the target state.

When using **kn service apply** you must provide the full configuration for the Knative service. This is different from the **kn service update** command, which only requires you to specify in the command the options that you want to update.

Example commands

- Create a service:

```
$ kn service apply <service_name> --image <image>
```

- Add an environment variable to a service:

```
$ kn service apply <service_name> --image <image> --env <key>=<value>
```

- Read the service declaration from a JSON or YAML file:

```
$ kn service apply <service_name> -f <filename>
```

5.1.4. Describing serverless applications by using the Knative CLI

You can describe a Knative service by using the **kn service describe** command.

Example commands

- Describe a service:

```
$ kn service describe --verbose <service_name>
```

The **--verbose** flag is optional but can be included to provide a more detailed description. The difference between a regular and verbose output is shown in the following examples:

Example output without --verbose flag

```
Name:       hello
Namespace:  default
Age:        2m
URL:        http://hello-default.apps.ocp.example.com

Revisions:
  100%  @latest (hello-00001) [1] (2m)
        Image:  docker.io/openshift/hello-openshift (pinned to aaea76)

Conditions:
  OK TYPE                  AGE REASON
  ++ Ready                 1m
  ++ ConfigurationsReady     1m
  ++ RoutesReady             1m
```

Example output with --verbose flag

```
Name:         hello
Namespace:    default
Annotations:  serving.knative.dev/creator=system:admin
              serving.knative.dev/lastModifier=system:admin
Age:          3m
URL:          http://hello-default.apps.ocp.example.com
Cluster:      http://hello.default.svc.cluster.local
```

```
Revisions:
  100%  @latest (hello-00001) [1] (3m)
        Image:  docker.io/openshift/hello-openshift (pinned to aaea76)
        Env:    RESPONSE=Hello Serverless!

Conditions:
  OK TYPE                  AGE REASON
  ++ Ready                 3m
  ++ ConfigurationsReady     3m
  ++ RoutesReady           3m
```

- Describe a service in YAML format:

```
$ kn service describe <service_name> -o yaml
```

- Describe a service in JSON format:

```
$ kn service describe <service_name> -o json
```

- Print the service URL only:

```
$ kn service describe <service_name> -o url
```

5.1.5. Verifying your serverless application deployment

To verify that your serverless application has been deployed successfully, you must get the application URL created by Knative, and then send a request to that URL and observe the output.

NOTE

OpenShift Serverless supports the use of both HTTP and HTTPS URLs, however the output from **oc get ksvc** will always print URLs using the **http://** format.

Procedure

1. Find the application URL:

```
$ oc get ksvc <service_name>
```

Example output

```
NAME           URL                                        LATESTCREATED        LATESTREADY
READY   REASON
event-delivery   http://event-delivery-default.example.com   event-delivery-4wsd2   event-
delivery-4wsd2   True
```

2. Make a request to your cluster and observe the output.

Example HTTP request

```
$ curl http://event-delivery-default.example.com
```

Example HTTPS request

```
$ curl https://event-delivery-default.example.com
```

Example output

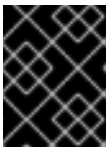
```
Hello Serverless!
```

3. Optional. If you receive an error relating to a self-signed certificate in the certificate chain, you can add the **--insecure** flag to the curl command to ignore the error:

```
$ curl https://event-delivery-default.example.com --insecure
```

Example output

```
Hello Serverless!
```



IMPORTANT

Self-signed certificates must not be used in a production deployment. This method is only for testing purposes.

4. Optional. If your OpenShift Container Platform cluster is configured with a certificate that is signed by a certificate authority (CA) but not yet globally configured for your system, you can specify this with the **curl** command. The path to the certificate can be passed to the curl command by using the **--cacert** flag:

```
$ curl https://event-delivery-default.example.com --cacert <file>
```

Example output

```
Hello Serverless!
```

5.1.6. Interacting with a serverless application using HTTP2 and gRPC

OpenShift Serverless supports only insecure or edge-terminated routes.

Insecure or edge-terminated routes do not support HTTP2 on OpenShift Container Platform. These routes also do not support gRPC because gRPC is transported by HTTP2.

If you use these protocols in your application, you must call the application using the ingress gateway directly. To do this you must find the ingress gateway's public address and the application's specific host.

Procedure

1. Find the application host. See the instructions in *Verifying your serverless application deployment*.

2. Find the ingress gateway's public address:

```
$ oc -n knative-serving-ingress get svc kourier
```

Example output

```
NAME                TYPE           CLUSTER-IP      EXTERNAL-IP
PORT(S)
AGE
kourier   LoadBalancer   172.30.51.103   a83e86291bcdd11e993af02b7a65e514-
33544245.us-east-1.elb.amazonaws.com   80:31380/TCP,443:31390/TCP   67m
```

The public address is surfaced in the **EXTERNAL-IP** field, and in this case is **a83e86291bcdd11e993af02b7a65e514-33544245.us-east-1.elb.amazonaws.com**.

3. Manually set the host header of your HTTP request to the application's host, but direct the request itself against the public address of the ingress gateway.

```
$ curl -H "Host: hello-default.example.com" a83e86291bcdd11e993af02b7a65e514-
33544245.us-east-1.elb.amazonaws.com
```

Example output

```
Hello Serverless!
```

You can also make a gRPC request by setting the authority to the application's host, while directing the request against the ingress gateway directly:

```
grpc.Dial(
    "a83e86291bcdd11e993af02b7a65e514-33544245.us-east-1.elb.amazonaws.com:80",
    grpc.WithAuthority("hello-default.example.com:80"),
    grpc.WithInsecure(),
)
```

NOTE

Ensure that you append the respective port, 80 by default, to both hosts as shown in the previous example.

5.1.7. Enabling communication with Knative applications on a cluster with restrictive network policies

If you are using a cluster that multiple users have access to, your cluster might use network policies to control which pods, services, and namespaces can communicate with each other over the network.

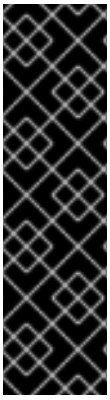
If your cluster uses restrictive network policies, it is possible that Knative system pods are not able to access your Knative application. For example, if your namespace has the following network policy, which denies all requests, Knative system pods cannot access your Knative application:

Example NetworkPolicy object that denies all requests to the namespace

```
kind: NetworkPolicy
apiVersion: networking.k8s.io/v1
metadata:
```

```
  name: deny-by-default
  namespace: example-namespace
spec:
  podSelector:
  ingress: []
```

To allow access to your applications from Knative system pods, you must add a label to each of the Knative system namespaces, and then create a **NetworkPolicy** object in your application namespace that allows access to the namespace for other namespaces that have this label.



IMPORTANT

A network policy that denies requests to non-Knative services on your cluster still prevents access to these services. However, by allowing access from Knative system namespaces to your Knative application, you are allowing access to your Knative application from all namespaces in the cluster.

If you do not want to allow access to your Knative application from all namespaces on the cluster, you might want to use *JSON Web Token authentication for Knative services* instead (see the *Knative Serving* documentation). JSON Web Token authentication for Knative services requires Service Mesh.

Procedure

1. Add the **knative.openshift.io/system-namespace=true** label to each Knative system namespace that requires access to your application:
   a. Label the **knative-serving** namespace:

```
$ oc label namespace knative-serving knative.openshift.io/system-namespace=true
```

   b. Label the **knative-serving-ingress** namespace:

```
$ oc label namespace knative-serving-ingress knative.openshift.io/system-namespace=true
```

   c. Label the **knative-eventing** namespace:

```
$ oc label namespace knative-eventing knative.openshift.io/system-namespace=true
```

   d. Label the **knative-kafka** namespace:

```
$ oc label namespace knative-kafka knative.openshift.io/system-namespace=true
```

2. Create a **NetworkPolicy** object in your application namespace to allow access from namespaces with the **knative.openshift.io/system-namespace** label:

Example NetworkPolicy object

```
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: <network_policy_name> 1
```

```
    namespace: <namespace> 2
  spec:
    ingress:
    - from:
      - namespaceSelector:
          matchLabels:
            knative.openshift.io/system-namespace: "true"
    podSelector: {}
    policyTypes:
    - Ingress
```

1 Provide a name for your network policy.

2 The namespace where your application (Knative service) exists.

5.1.8. HTTPS redirection per service

You can enable or disable HTTPS redirection for a service by configuring the **networking.knative.dev/httpOption** annotation, as shown in the following example:

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: example
  namespace: default
  annotations:
    networking.knative.dev/httpOption: "redirected"
spec:
  ...
```

5.1.9. Using kn CLI in offline mode

IMPORTANT

The offline mode of the kn CLI is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see https://access.redhat.com/support/offerings/techpreview/.

5.1.9.1. About offline mode

Normally, when you execute **kn service** commands, the changes immediately propagate to the cluster. However, as an alternative, you can execute **kn service** commands in offline mode:

1. When you create a service in offline mode, no changes happen on the cluster. Instead, the only thing that happens is the creation of the service descriptor file on your local machine.

2. After the descriptor file is created, you can manually modify it and track it in a version control system.

3. Finally, you can propagate changes to the cluster by using the **kn service create -f**, **kn service apply -f**, or **oc apply -f** commands on the descriptor files.

The offline mode has several uses:

- You can manually modify the descriptor file before using it to make changes on the cluster.
- You can locally track the descriptor file of a service in a version control system. This enables you to reuse the descriptor file in places other than the target cluster, for example in continuous integration (CI) pipelines, development environments, or demos.
- You can examine the created descriptor files to learn about Knative services. In particular, you can see how the resulting service is influenced by the different arguments passed to the **kn** command.

The offline mode has its advantages: it is fast, and does not require a connection to the cluster. However, offline mode lacks server-side validation. Consequently, you cannot, for example, verify that the service name is unique or that the specified image can be pulled.

5.1.9.2. Creating a service using offline mode

Prerequisites

- OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have installed the **kn** CLI.

Procedure

1. In offline mode, create a local Knative service descriptor file:

```
$ kn service create event-display \
    --image quay.io/openshift-knative/knative-eventing-sources-event-display:latest \
    --target ./ \
    --namespace test
```

Example output

```
Service 'event-display' created in namespace 'test'.
```

- The **--target ./** flag enables offline mode and specifies **./** as the directory for storing the new directory tree.
  If you do not specify an existing directory, but use a filename, such as **--target my-service.yaml**, then no directory tree is created. Instead, only the service descriptor file **my-service.yaml** is created in the current directory.

  The filename can have the **.yaml**, **.yml**, or **.json** extension. Choosing **.json** creates the service descriptor file in the JSON format.

- The **--namespace test** option places the new service in the **test** namespace.
  If you do not use **--namespace**, and you are logged in to an OpenShift Container Platform cluster, the descriptor file is created in the current namespace. Otherwise, the descriptor file is created in the **default** namespace.

2. Examine the created directory structure:

```
$ tree ./
```

Example output

```
./
└── test
    └── ksvc
        └── event-display.yaml

2 directories, 1 file
```

- The current **./** directory specified with **--target** contains the new **test/** directory that is named after the specified namespace.
- The **test/** directory contains the **ksvc** directory, named after the resource type.
- The **ksvc** directory contains the descriptor file **event-display.yaml**, named according to the specified service name.

3. Examine the generated service descriptor file:

```
$ cat test/ksvc/event-display.yaml
```

Example output

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  creationTimestamp: null
  name: event-display
  namespace: test
spec:
  template:
    metadata:
      annotations:
        client.knative.dev/user-image: quay.io/openshift-knative/knative-eventing-sources-event-
display:latest
      creationTimestamp: null
    spec:
      containers:
      - image: quay.io/openshift-knative/knative-eventing-sources-event-display:latest
        name: ""
        resources: {}
status: {}
```

4. List information about the new service:

```
$ kn service describe event-display --target ./ --namespace test
```

Example output

```
Name:       event-display
Namespace:  test
```

```
Age:
URL:

Revisions:

Conditions:
  OK TYPE    AGE REASON
```

- The **--target ./** option specifies the root directory for the directory structure containing namespace subdirectories.
  Alternatively, you can directly specify a YAML or JSON filename with the **--target** option. The accepted file extensions are **.yaml**, **.yml**, and **.json**.

- The **--namespace** option specifies the namespace, which communicates to **kn** the subdirectory that contains the necessary service descriptor file.
  If you do not use **--namespace**, and you are logged in to an OpenShift Container Platform cluster, **kn** searches for the service in the subdirectory that is named after the current namespace. Otherwise, **kn** searches in the **default**/ subdirectory.

5. Use the service descriptor file to create the service on the cluster:

```
$ kn service create -f test/ksvc/event-display.yaml
```

Example output

```
Creating service 'event-display' in namespace 'test':

  0.058s The Route is still working to reflect the latest desired specification.
  0.098s ...
  0.168s Configuration "event-display" is waiting for a Revision to become ready.
 23.377s ...
 23.419s Ingress has not yet been reconciled.
 23.534s Waiting for load balancer to be ready
 23.723s Ready to serve.

Service 'event-display' created to latest revision 'event-display-00001' is available at URL:
http://event-display-test.apps.example.com
```

5.2. AUTOSCALING

Knative Serving provides automatic scaling, or *autoscaling*, for applications to match incoming demand. For example, if an application is receiving no traffic, and scale-to-zero is enabled, Knative Serving scales the application down to zero replicas. If scale-to-zero is disabled, the application is scaled down to the minimum number of replicas specified for applications on the cluster . Replicas can also be scaled up to meet demand if traffic to the application increases.

If Knative autoscaling is enabled for your cluster, you can configure concurrency and scale bounds for your application.

NOTE

Any limits or targets set in the revision template are measured against a single instance of your application. For example, setting the **target** annotation to **50** configures the autoscaler to scale the application so that each revision handles 50 requests at a time.

5.2.1. Scale bounds

Scale bounds determine the minimum and maximum numbers of replicas that can serve an application at any given time.

You can set scale bounds for an application to help prevent cold starts or control computing costs.

5.2.1.1. Minimum scale bounds

The minimum number of replicas that can serve an application is determined by the **minScale** annotation.

The **minScale** value defaults to **0** replicas if the following conditions are met:

- The **minScale** annotation is not set
- Scaling to zero is enabled
- The class **KPA** is used

If scale to zero is not enabled, the **minScale** value defaults to **1**.

Example service spec with minScale spec

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: example-service
  namespace: default
spec:
  template:
    metadata:
      annotations:
        autoscaling.knative.dev/minScale: "0"
...
```

5.2.1.1.1. Setting the minScale annotation by using the Knative CLI

You can use the **kn service** command with the **--min-scale** flag to create or modify the **--min-scale** value for a service.

Procedure

- Set the minimum number of replicas for the service by using the **--min-scale** flag:

```
$ kn service create <service_name> --image <image_uri> --min-scale <integer>
```

Example command

```
$ kn service create example-service --image quay.io/openshift-knative/knative-eventing-sources-event-display:latest --min-scale 2
```

5.2.1.2. Maximum scale bounds

The maximum number of replicas that can serve an application is determined by the **maxScale** annotation. If the **maxScale** annotation is not set, there is no upper limit for the number of replicas created.

Example service spec with maxScale spec

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: example-service
  namespace: default
spec:
  template:
    metadata:
      annotations:
        autoscaling.knative.dev/maxScale: "10"
...
```

5.2.1.2.1. Setting the maxScale annotation by using the Knative CLI

You can use the **kn service** command with the **--max-scale** flag to create or modify the **--max-scale** value for a service.

Procedure

- Set the maximum number of replicas for the service by using the **--max-scale** flag:

```
$ kn service create <service_name> --image <image_uri> --max-scale <integer>
```

Example command

```
$ kn service create example-service --image quay.io/openshift-knative/knative-eventing-sources-event-display:latest --max-scale 10
```

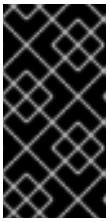
5.2.2. Concurrency

Concurrency determines the number of simultaneous requests that can be processed by each replica of an application at any given time.

5.2.2.1. Concurrency limits and targets

Concurrency can be configured as either a *soft limit* or a *hard limit*:

- A soft limit is a targeted requests limit, rather than a strictly enforced bound. For example, if there is a sudden burst of traffic, the soft limit target can be exceeded.
- A hard limit is a strictly enforced upper bound requests limit. If concurrency reaches the hard limit, surplus requests are buffered and must wait until there is enough free capacity to execute the requests.



IMPORTANT

Using a hard limit configuration is only recommended if there is a clear use case for it with your application. Having a low, hard limit specified may have a negative impact on the throughput and latency of an application, and might cause cold starts.

Adding a soft target and a hard limit means that the autoscaler targets the soft target number of concurrent requests, but imposes a hard limit of the hard limit value for the maximum number of requests.

If the hard limit value is less than the soft limit value, the soft limit value is tuned down, because there is no need to target more requests than the number that can actually be handled.

5.2.2.2. Configuring a soft concurrency target

You can specify a soft concurrency target for your Knative service by setting the **autoscaling.knative.dev/target** annotation in the spec, or by using the **kn service** command with the correct flags.

Procedure

- Optional: Set the **autoscaling.knative.dev/target** annotation for your Knative service in the spec of the **Service** custom resource:

  Example service spec

  ```
  apiVersion: serving.knative.dev/v1
  kind: Service
  metadata:
    name: example-service
    namespace: default
  spec:
    template:
      metadata:
        annotations:
          autoscaling.knative.dev/target: "200"
  ```

- Optional: Use the **kn service** command to specify the **--concurrency-target** flag:

  ```
  $ kn service create <service_name> --image <image_uri> --concurrency-target <integer>
  ```

  Example command to create a service with a concurrency target of 50 requests

  ```
  $ kn service create example-service --image quay.io/openshift-knative/knative-eventing-sources-event-display:latest --concurrency-target 50
  ```

5.2.2.3. Configuring a hard concurrency limit

You can specify a hard concurrency limit for your Knative service by modifying the **containerConcurrency** spec or by using the **kn service** command with the correct flags.

Procedure

- Optional: Set the **containerConcurrency** spec for your Knative service in the spec of the **Service** custom resource:

  Example service spec

  ```
  apiVersion: serving.knative.dev/v1
  kind: Service
  metadata:
    name: example-service
    namespace: default
  spec:
    template:
      spec:
        containerConcurrency: 50
  ```

  The default value is **0**, which means that there is no limit on the number of simultaneous requests that are permitted to flow into one replica of the service at a time.

  A value greater than **0** specifies the exact number of requests that are permitted to flow into one replica of the service at a time. This example would enable a hard concurrency limit of 50 requests.

- Optional: Use the **kn service** command to specify the **--concurrency-limit** flag:

  ```
  $ kn service create <service_name> --image <image_uri> --concurrency-limit <integer>
  ```

  Example command to create a service with a concurrency limit of 50 requests

  ```
  $ kn service create example-service --image quay.io/openshift-knative/knative-eventing-sources-event-display:latest --concurrency-limit 50
  ```

5.2.2.4. Concurrency target utilization

This value specifies the percentage of the concurrency limit that is actually targeted by the autoscaler. This is also known as specifying the *hotness* at which a replica runs, which enables the autoscaler to scale up before the defined hard limit is reached.

For example, if the **containerConcurrency** annotation value is set to 10, and the **targetUtilizationPercentage** value is set to 70 percent, the autoscaler creates a new replica when the average number of concurrent requests across all existing replicas reaches 7. Requests numbered 7 to 10 are still sent to the existing replicas, but additional replicas are started in anticipation of being required after the **containerConcurrency** annotation limit is reached.

Example service configured using the targetUtilizationPercentage annotation

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: example-service
  namespace: default
spec:
  template:
    metadata:
```

```
    annotations:
      autoscaling.knative.dev/targetUtilizationPercentage: "70"
...
```

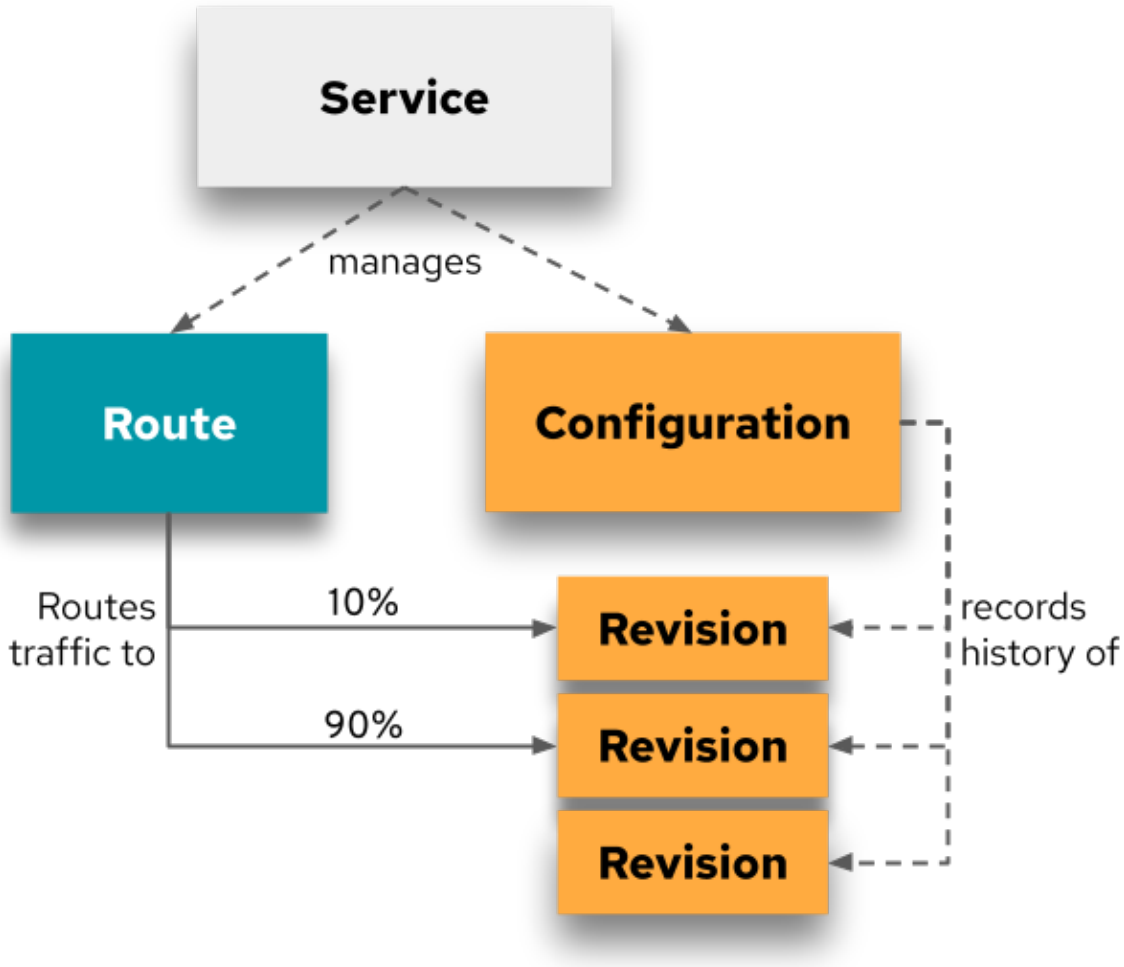
5.2.3. Additional resources

- Scale-to-zero can be enabled or disabled for the cluster by cluster administrators. For more information, see Enabling scale-to-zero.

5.3. TRAFFIC MANAGEMENT

A *revision* is a point-in-time snapshot of the code and configuration for each modification made to a Knative service. Each time the configuration of a service is updated, a new revision for the service is created. Revisions are immutable objects and can be retained for as long as they are required or used. Knative Serving revisions can be automatically scaled up and down according to incoming traffic.

You can manage traffic routing to different revisions of a Knative service by modifying the **traffic** spec of the service resource.



5.3.1. Traffic routing examples

When you create a Knative service, it does not have any default **traffic** spec settings. By setting the **traffic** spec, you can split traffic over any number of fixed revisions, or send traffic to the latest revision.

5.3.1.1. Traffic routing between multiple revisions

The following example shows how the list of revisions in the **traffic** spec can be extended so that traffic is split between multiple revisions.

This example sends 50% of traffic to the revision tagged as **current**, and 50% of traffic to the revision tagged as **candidate**:

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: example-service
  namespace: default
spec:
...
  traffic:
  - tag: current
    revisionName: example-service-1
    percent: 50
  - tag: candidate
    revisionName: example-service-2
    percent: 50
  - tag: latest
    latestRevision: true
    percent: 0
```

5.3.1.2. Traffic routing to the latest revision

The following example shows a **traffic** spec where 100% of traffic is routed to the latest revision of the service. Under **status**, you can see the name of the latest revision that **latestRevision** resolves to:

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: example-service
  namespace: default
spec:
...
  traffic:
  - latestRevision: true
    percent: 100
status:
  ...
  traffic:
  - percent: 100
    revisionName: example-service
```

5.3.1.3. Traffic routing to the current revision

The following example shows a **traffic** spec where 100% of traffic is routed to the revision tagged as **current**, and the name of that revision is specified as **example-service**. The revision tagged as **latest** is kept available, even though no traffic is routed to it:

```
apiVersion: serving.knative.dev/v1
```

```
kind: Service
metadata:
  name: example-service
  namespace: default
spec:
...
  traffic:
  - tag: current
    revisionName: example-service
    percent: 100
  - tag: latest
    latestRevision: true
    percent: 0
```

5.3.2. Managing traffic between revisions by using the OpenShift Container Platform web console

After you create a serverless application, the application is displayed in the **Topology** view of the **Developer** perspective in the OpenShift Container Platform web console. The application revision is represented by the node, and the Knative service is indicated by a quadrilateral around the node.

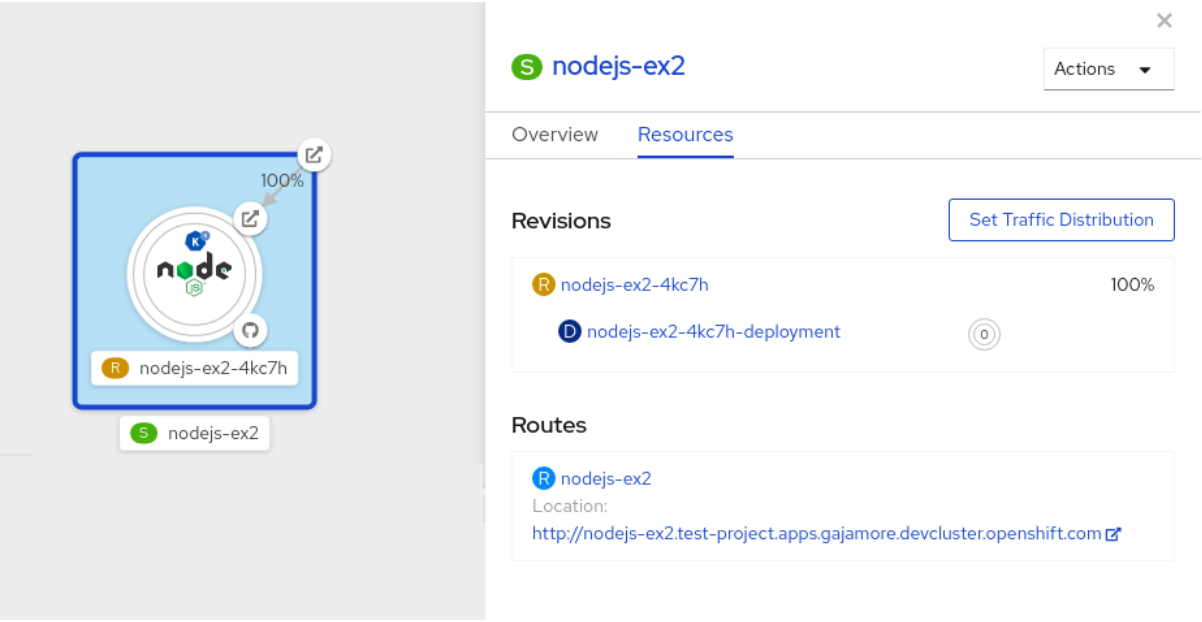
Any new change in the code or the service configuration creates a new revision, which is a snapshot of the code at a given time. For a service, you can manage the traffic between the revisions of the service by splitting and routing it to the different revisions as required.

Procedure

To split traffic between multiple revisions of an application in the **Topology** view:

1. Click the Knative service to see its overview in the side panel.
2. Click the **Resources** tab, to see a list of **Revisions** and **Routes** for the service.

Figure 5.1. Serverless application



3. Click the service, indicated by the **S** icon at the top of the side panel, to see an overview of the service details.

4. Click the **YAML** tab and modify the service configuration in the YAML editor, and click **Save**. For example, change the **timeoutseconds** from 300 to 301 . This change in the configuration triggers a new revision. In the **Topology** view, the latest revision is displayed and the **Resources** tab for the service now displays the two revisions.

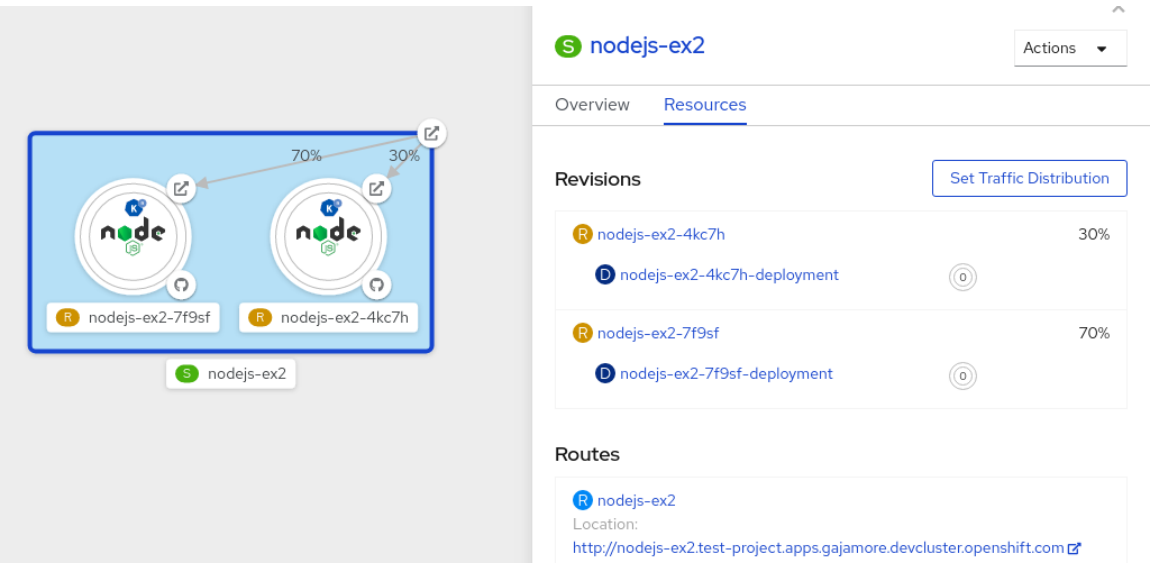
5. In the **Resources** tab, click **Set Traffic Distribution** to see the traffic distribution dialog box:

   a. Add the split traffic percentage portion for the two revisions in the **Splits** field.

   b. Add tags to create custom URLs for the two revisions.

   c. Click **Save** to see two nodes representing the two revisions in the Topology view.

   Figure 5.2. Serverless application revisions



5.3.3. Traffic management using the Knative CLI

You can use the **kn service update** command to split traffic between revisions of a service.

Example command

```
$ kn service update <service_name> --traffic <revision>=<percent>
```

Where:

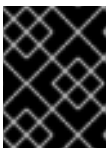
- **<service_name>** is the name of the Knative service that you are configuring traffic routing for.
- **<revision>** is the revision that you want to configure to receive a percentage of traffic. You can either specify the name of the revision, or a tag that you assigned to the revision by using the **--tag** flag.
- **<percent>** is the percentage of traffic that you want to send to the specified revision.

5.3.3.1. Multiple flags and order precedence

All traffic-related flags can be specified using a single **kn service update** command. **kn** defines the precedence of these flags. The order of the flags specified when using the command is not taken into account.

The precedence of the flags as they are evaluated by **kn** are:

1. **--untag**: All the referenced revisions with this flag are removed from the traffic block.
2. **--tag**: Revisions are tagged as specified in the traffic block.
3. **--traffic**: The referenced revisions are assigned a portion of the traffic split.



IMPORTANT

The **--traffic** flag can be specified multiple times in one command, and is valid only if the sum of the **Percent** values in all flags totals 100.

You can add tags to revisions and then split traffic according to the tags you have set.

5.3.3.2. Example traffic management commands

In the following command, the **@latest** tag means that **blue** resolves to the latest revision of the service:

```
$ kn service update example-service --tag green=revision-0001 --tag blue=@latest
```

After the **green** and **blue** tags have been applied, you can run the following command to split traffic for the service named **example-service**, by sending 80% of traffic to the revision **green** and 20% of traffic to the revision **blue**:

```
$ kn service update example-service --traffic green=80 --traffic blue=20
```

Alternatively, you could use the following command to send 80% of traffic to the latest revision and 20% to a revision named **v1**, without using tags:

```
$ kn service update example-service --traffic @latest=80 --traffic v1=20
```

NOTE

You can only use the identifier **@latest** once per command with the **--traffic** flag.

5.3.3.3. Knative CLI traffic management flags

The **kn** CLI supports traffic operations on the traffic block of a service as part of the **kn service update** command.

The following table displays a summary of traffic splitting flags, value formats, and the operation the flag performs. The **Repetition** column denotes whether repeating the particular value of flag is allowed in a **kn service update** command.

Flag	Value(s)	Operation	Repetition
--traffic	**RevisionName=Percent**	Gives **Percent** traffic to **RevisionName**	Yes
--traffic	**Tag=Percent**	Gives **Percent** traffic to the revision having **Tag**	Yes

Flag	Value(s)	Operation	Repetition
--traffic	**@latest=Percent**	Gives **Percent** traffic to the latest ready revision	No
--tag	**RevisionName=Tag**	Gives **Tag** to **RevisionName**	Yes
--tag	**@latest=Tag**	Gives **Tag** to the latest ready revision	No
--untag	**Tag**	Removes **Tag** from revision	Yes

5.3.3.4. Custom URLs for revisions

Assigning a **--tag** flag to a service by using the **kn service update** command creates a custom URL for the revision that is created when you update the service. The custom URL follows the pattern **https://<tag>-<service_name>-<namespace>.<domain>** or **http://<tag>-<service_name>-<namespace>.<domain>**.

The **--tag** and **--untag** flags use the following syntax:

- Require one value.
- Denote a unique tag in the traffic block of the service.
- Can be specified multiple times in one command.

5.3.3.4.1. Example: Assign a tag to a revision

The following example assigns the tag **latest** to a revision named **example-revision**:

```
$ kn service update <service_name> --tag @latest=example-tag
```

5.3.3.4.2. Example: Remove a tag from a revision

You can remove a tag to remove the custom URL, by using the **--untag** flag.

NOTE

If a revision has its tags removed, and it is assigned 0% of the traffic, the revision is removed from the traffic block entirely.

The following command removes all tags from the revision named **example-revision**:

```
$ kn service update <service_name> --untag example-tag
```

5.3.4. Routing and managing traffic by using a blue-green deployment strategy

You can safely reroute traffic from a production version of an app to a new version, by using a blue-green deployment strategy.

Procedure

1. Create and deploy an app as a Knative service.
2. Find the name of the first revision that was created when you deployed the service, by viewing the output from the following command:

```
$ oc get ksvc <service_name> -o=jsonpath='{.status.latestCreatedRevisionName}'
```

Example command

```
$ oc get ksvc example-service -o=jsonpath='{.status.latestCreatedRevisionName}'
```

Example output

```
$ example-service-00001
```

3. Add the following YAML to the service **spec** to send inbound traffic to the revision:

```
...
spec:
  traffic:
    - revisionName: <first_revision_name>
      percent: 100 # All traffic goes to this revision
...
```

4. Verify that you can view your app at the URL output you get from running the following command:

```
$ oc get ksvc <service_name>
```

5. Deploy a second revision of your app by modifying at least one field in the **template** spec of the service and redeploying it. For example, you can modify the **image** of the service, or an **env** environment variable. You can redeploy the service by applying the service YAML file, or by using the **kn service update** command if you have installed the **kn** CLI.
6. Find the name of the second, latest revision that was created when you redeployed the service, by running the command:

```
$ oc get ksvc <service_name> -o=jsonpath='{.status.latestCreatedRevisionName}'
```

At this point, both the first and second revisions of the service are deployed and running.

7. Update your existing service to create a new, test endpoint for the second revision, while still sending all other traffic to the first revision:

Example of updated service spec with test endpoint

```
...
spec:
  traffic:
    - revisionName: <first_revision_name>
      percent: 100 # All traffic is still being routed to the first revision
    - revisionName: <second_revision_name>
      percent: 0 # No traffic is routed to the second revision
      tag: v2 # A named route
...
```

After you redeploy this service by reapplying the YAML resource, the second revision of the app is now staged. No traffic is routed to the second revision at the main URL, and Knative creates a new service named **v2** for testing the newly deployed revision.

8. Get the URL of the new service for the second revision, by running the following command:

```
$ oc get ksvc <service_name> --output jsonpath="{.status.traffic[*].url}"
```

You can use this URL to validate that the new version of the app is behaving as expected before you route any traffic to it.

9. Update your existing service again, so that 50% of traffic is sent to the first revision, and 50% is sent to the second revision:

Example of updated service spec splitting traffic 50/50 between revisions

```
...
spec:
  traffic:
    - revisionName: <first_revision_name>
      percent: 50
    - revisionName: <second_revision_name>
      percent: 50
      tag: v2
...
```

10. When you are ready to route all traffic to the new version of the app, update the service again to send 100% of traffic to the second revision:

Example of updated service spec sending all traffic to the second revision

```
...
spec:
  traffic:
    - revisionName: <first_revision_name>
      percent: 0
    - revisionName: <second_revision_name>
      percent: 100
      tag: v2
...
```

TIP

You can remove the first revision instead of setting it to 0% of traffic if you do not plan to roll back the revision. Non-routeable revision objects are then garbage-collected.

11. Visit the URL of the first revision to verify that no more traffic is being sent to the old version of the app.

5.4. ROUTING

Knative leverages OpenShift Container Platform TLS termination to provide routing for Knative services. When a Knative service is created, an OpenShift Container Platform route is automatically created for the service. This route is managed by the OpenShift Serverless Operator. The OpenShift Container Platform route exposes the Knative service through the same domain as the OpenShift Container Platform cluster.

You can disable Operator control of OpenShift Container Platform routing so that you can configure a Knative route to directly use your TLS certificates instead.

Knative routes can also be used alongside the OpenShift Container Platform route to provide additional fine-grained routing capabilities, such as traffic splitting.

5.4.1. Configuring OpenShift Container Platform routes for Knative services

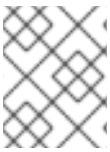
If you want to configure a Knative service to use your TLS certificate on OpenShift Container Platform, you must disable the automatic creation of a route for the service by the OpenShift Serverless Operator and instead manually create a route for the service.

NOTE

When you complete the following procedure, the default OpenShift Container Platform route in the **knative-serving-ingress** namespace is not created. However, the Knative route for the application is still created in this namespace.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving component must be installed on your OpenShift Container Platform cluster.

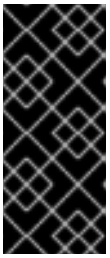


NOTE

You must modify the replaceable values in the example commands for the following procedure.

Procedure

1. Create a Knative service that includes the **serving.knative.openshift.io/disableRoute=true** annotation:



IMPORTANT

The **serving.knative.openshift.io/disableRoute=true** annotation instructs OpenShift Serverless to not automatically create a route for you. However, the service still shows a URL and reaches a status of **Ready**. This URL does not work externally until you create your own route with the same hostname as the hostname in the URL.

a. Create a Knative **Service** resource:

Example resource

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: <service_name>
  annotations:
    serving.knative.openshift.io/disableRoute: "true"
spec:
  template:
    spec:
      containers:
      - image: <image>
...
```

b. Apply the **Service** resource:

```
$ oc apply -f <filename>
```

c. Optional. Create a Knative service by using the **kn service create** command:

Example kn command

```
$ kn service create <service_name> \
  --image=gcr.io/knative-samples/helloworld-go \
  --annotation serving.knative.openshift.io/disableRoute=true
```

2. Verify that no OpenShift Container Platform route has been created for the service:

Example command

```
$ $ oc get routes.route.openshift.io \
  -l serving.knative.openshift.io/ingressName=$KSERVICE_NAME \
  -l serving.knative.openshift.io/ingressNamespace=$KSERVICE_NAMESPACE \
  -n knative-serving-ingress
```

You will see the following output:

```
No resources found in knative-serving-ingress namespace.
```

3. Create a **Route** resource in the **knative-serving-ingress** namespace:

```
apiVersion: route.openshift.io/v1
```

```
kind: Route
metadata:
  annotations:
    haproxy.router.openshift.io/timeout: 600s (1)
  name: <route_name> (2)
  namespace: knative-serving-ingress (3)
spec:
  host: <service_host> (4)
  port:
    targetPort: http2
  to:
    kind: Service
    name: kourier
    weight: 100
  tls:
    insecureEdgeTerminationPolicy: Allow
    termination: edge (5)
    key: |-
      -----BEGIN PRIVATE KEY-----
      [...]
      -----END PRIVATE KEY-----
    certificate: |-
      -----BEGIN CERTIFICATE-----
      [...]
      -----END CERTIFICATE-----
    caCertificate: |-
      -----BEGIN CERTIFICATE-----
      [...]
      -----END CERTIFICATE----
  wildcardPolicy: None
```

1. The timeout value for the OpenShift Container Platform route. You must set the same value as the **max-revision-timeout-seconds** setting (**600s** by default).
2. The name of the OpenShift Container Platform route.
3. The namespace for the OpenShift Container Platform route. This must be **knative-serving-ingress**.
4. The hostname for external access. You can set this to **<service_name>-<service_namespace>.<domain>**.
5. The certificates you want to use. Currently, only **edge** termination is supported.

4. Apply the **Route** resource:

```
$ oc apply -f <filename>
```

5.4.2. Setting cluster availability to cluster local

By default, Knative services are published to a public IP address. Being published to a public IP address means that Knative services are public applications, and have a publicly accessible URL.

Publicly accessible URLs are accessible from outside of the cluster. However, developers may need to

build back-end services that are only be accessible from inside the cluster, known as *private services*. Developers can label individual services in the cluster with the **networking.knative.dev/visibility=cluster-local** label to make them private.

IMPORTANT

For OpenShift Serverless 1.15.0 and newer versions, the **serving.knative.dev/visibility** label is no longer available. You must update existing services to use the **networking.knative.dev/visibility** label instead.

Procedure

- Set the visibility for your service by adding the **networking.knative.dev/visibility=cluster-local** label:

```
$ oc label ksvc <service_name> networking.knative.dev/visibility=cluster-local
```

Verification

- Check that the URL for your service is now in the format **http://<service_name>.<namespace>.svc.cluster.local**, by entering the following command and reviewing the output:

```
$ oc get ksvc
```

Example output

```
NAME    URL                                        LATESTCREATED
LATESTREADY    READY   REASON
hello   http://hello.default.svc.cluster.local      hello-tx2g7    hello-
tx2g7    True
```

5.5. EVENT SINKS

A sink is an addressable custom resource (CR) that can receive incoming events from other resources. Knative services, channels, and brokers are all examples of sinks.

TIP

You can configure which CRs can be used with the **--sink** flag for **kn** CLI commands by Customizing **kn**.

5.5.1. Knative CLI --sink flag

When you create an event-producing custom resource by using the Knative (**kn**) CLI, you can specify a sink where events are sent to from that resource, by using the **--sink** flag.

The following example creates a sink binding that uses a service, **http://event-display.svc.cluster.local**, as the sink:

Example command using the --sink flag

```
$ kn source binding create bind-heartbeat \
  --namespace sinkbinding-example \
```

```
--subject "Job:batch/v1:app=heartbeat-cron" \
--sink http://event-display.svc.cluster.local \ 1
--ce-override "sink=bound"
```

1 **svc** in **http://event-display.svc.cluster.local** determines that the sink is a Knative service. Other default sink prefixes include **channel**, and **broker**.

5.5.2. Connect an event source to a sink using the Developer perspective

You can create multiple event source types in OpenShift Container Platform that can be connected to sinks.

Prerequisites

To connect an event source to a sink using the **Developer** perspective, ensure that:

- The OpenShift Serverless Operator, Knative Serving, and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have created a sink.
- You have logged in to the web console and are in the **Developer** perspective.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.

Procedure

1. Create an event source of any type, by navigating to **+Add → Event Sources** and then selecting the event source type that you want to create.
2. In the **Sink** section of the **Event Sources** form view, select **Resource**. Then use the drop-down list to select your sink.
3. Click **Create**.

Verification

You can verify that the event source was created and is connected to the sink by viewing the **Topology** page.

1. In the **Developer** perspective, navigate to **Topology**.
2. View the event source and click on the connected sink to see the sink details in the side panel.

5.5.3. Connecting a trigger to a sink

You can connect a trigger to a sink, so that events from a broker are filtered before they are sent to the sink. A sink that is connected to a trigger is configured as a **subscriber** in the **Trigger** resource spec.

Example of a trigger connected to a Kafka sink

```
apiVersion: eventing.knative.dev/v1
kind: Trigger
metadata:
```

```
  name: <trigger_name> 1
spec:
...
  subscriber:
    ref:
      apiVersion: eventing.knative.dev/v1alpha1
      kind: KafkaSink
      name: <kafka_sink_name> 2
```

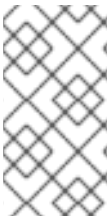
1. The name of the trigger being connected to the sink.
2. The name of a **KafkaSink** object.

5.6. USING THE API SERVER SOURCE

The API server source is an event source that can be used to connect an event sink, such as a Knative service, to the Kubernetes API server. The API server source watches for Kubernetes events and forwards them to the Knative Eventing broker.

5.6.1. Prerequisites

- You must have a current installation of OpenShift Serverless, including Knative Serving and Eventing, in your OpenShift Container Platform cluster. This can be installed by a cluster administrator.
- Event sources need a service to use as an event *sink*. The sink is the service or application that events are sent to from the event source.
- You must create or update a service account, role and role binding for the event source.



NOTE

Some of the following procedures require you to create YAML files.

If you change the names of the YAML files from those used in the examples, you must ensure that you also update the corresponding CLI commands.

5.6.2. Creating a service account, role, and role binding for event sources

Procedure

1. Create a service account, role, and role binding for the event source as a YAML file:

NOTE

If you want to re-use an existing service account, you can modify your existing **ServiceAccount** resource to include the required permissions instead of creating a new resource.

```
apiVersion: v1
kind: ServiceAccount
metadata:
```

```
  name: events-sa
  namespace: default 1

---
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: event-watcher
  namespace: default 2
rules:
  - apiGroups:
      - ""
    resources:
      - events
    verbs:
      - get
      - list
      - watch

---
apiVersion: rbac.authorization.k8s.io/v1
kind: RoleBinding
metadata:
  name: k8s-ra-event-watcher
  namespace: default 3
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: Role
  name: event-watcher
subjects:
  - kind: ServiceAccount
    name: events-sa
    namespace: default 4
```

1 2 3 4 Change this namespace to the namespace that you have selected for installing the event source.

2. Apply the YAML file:

```
$ oc apply -f <filename>
```

5.6.3. Creating an API server source event source using the Developer perspective

Procedure

1. In the **Developer** perspective, navigate to **+Add → Event Source**. The **Event Sources** page is displayed.

2. Optional: If you have multiple providers for your event sources, select the required provider from the **Providers** list to filter the available event sources from the provider.

3. Select **ApiServerSource** and then click **Create Event Source** The **Create Event Source** page is displayed.

4. Configure the **ApiServerSource** settings by using the **Form view** or **YAML view**:

NOTE

You can switch between the **Form view** and **YAML view**. The data is persisted when switching between the views.

   a. Enter **v1** as the **APIVERSION** and **Event** as the **KIND**.

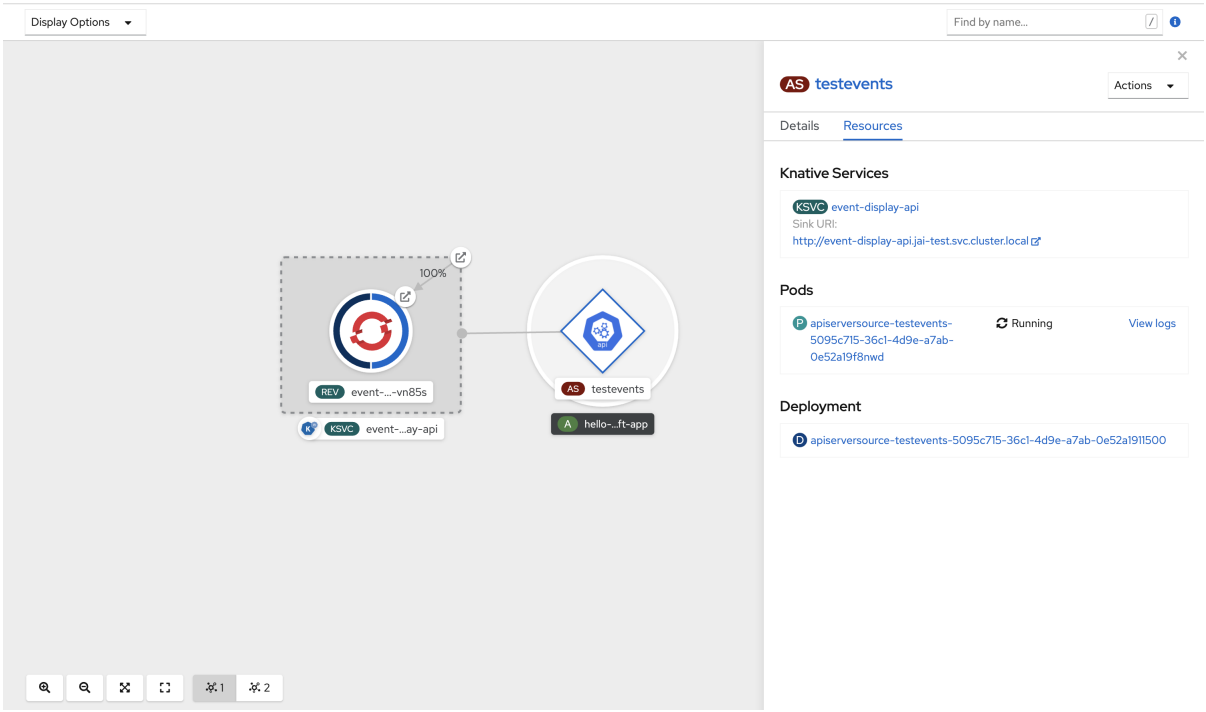
   b. Select the **Service Account Name** for the service account that you created.

   c. Select the **Sink** for the event source. A **Sink** can be either a **Resource**, such as a channel, broker, or service, or a **URI**.

5. Click **Create**.

Verification

- After you have created the API server source, you will see it connected to the service it is sinked to in the **Topology** view.



NOTE

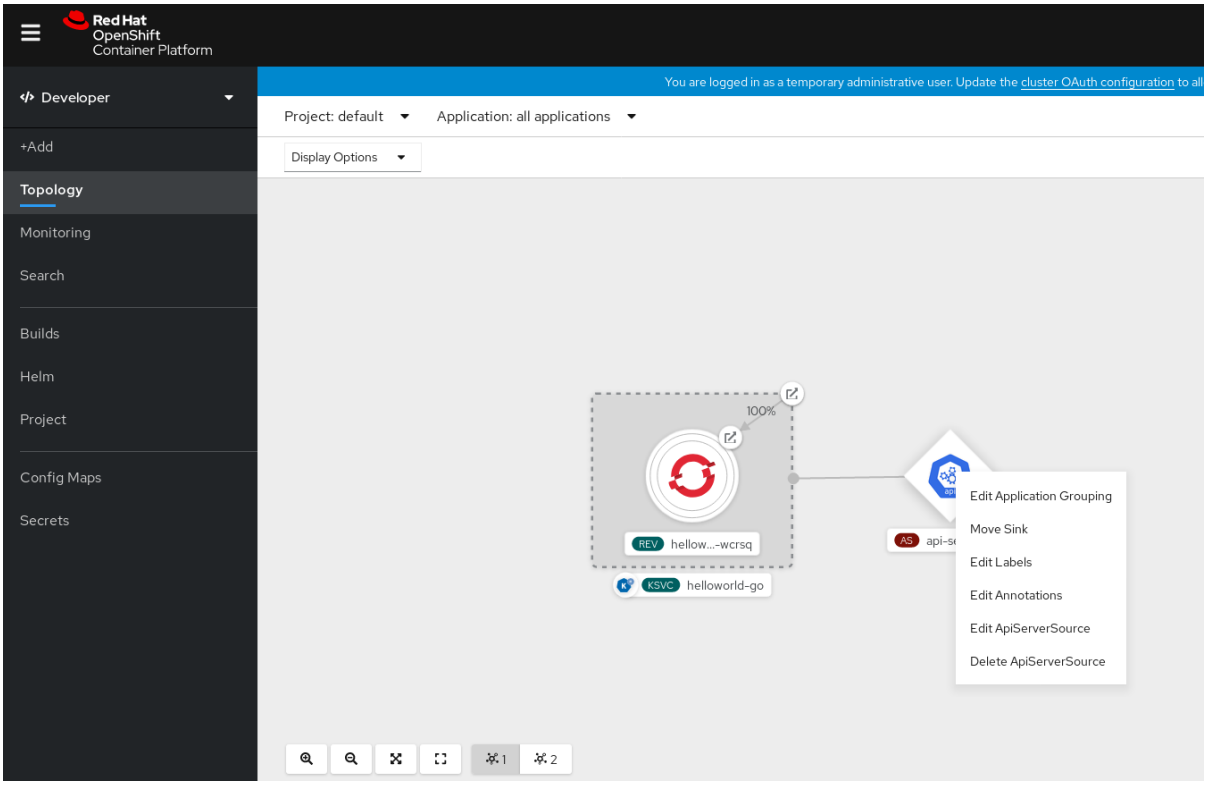
If a URI sink is used, modify the URI by right-clicking on **URI sink → Edit URI**.

5.6.4. Deleting an API server source using the Developer perspective

Procedure

1. Navigate to the **Topology** view.

2. Right-click the API server source and select **Delete ApiServerSource**.



5.6.5. Creating an API server source by using the Knative CLI

This section describes the steps required to create an API server source using **kn** commands.

Prerequisites

- You must have OpenShift Serverless, the Knative Serving and Eventing components, and the **kn** CLI installed.

Procedure

1. Create an API server source that uses a broker as a sink:

```
$ kn source apiserver create <event_source_name> --sink broker:<broker_name> --resource "event:v1" --service-account <service_account_name> --mode Resource
```

2. To check that the API server source is set up correctly, create a Knative service that dumps incoming messages to its log:

```
$ kn service create <service_name> --image quay.io/openshift-knative/knative-eventing-sources-event-display:latest
```

3. Create a trigger to filter events from the **default** broker to the service:

```
$ kn trigger create <trigger_name> --sink ksvc:<service_name>
```

4. Create events by launching a pod in the default namespace:

```
$ oc create deployment hello-node --image quay.io/openshift-knative/knative-eventing-sources-event-display:latest
```

5. Check that the controller is mapped correctly by inspecting the output generated by the following command:

```
$ kn source apiserver describe <source_name>
```

Example output

```
Name:                mysource
Namespace:           default
Annotations:         sources.knative.dev/creator=developer,
sources.knative.dev/lastModifier=developer
Age:                 3m
ServiceAccountName:  events-sa
Mode:                Resource
Sink:
  Name:       default
  Namespace:  default
  Kind:       Broker (eventing.knative.dev/v1)
Resources:
  Kind:        event (v1)
  Controller:  false
Conditions:
  OK TYPE                   AGE REASON
  ++ Ready                  3m
  ++ Deployed               3m
  ++ SinkProvided           3m
  ++ SufficientPermissions  3m
  ++ EventTypesProvided     3m
```

Verification

You can verify that the Kubernetes events were sent to Knative by looking at the message dumper function logs.

1. Get the pods:

```
$ oc get pods
```

2. View the message dumper function logs for the pods:

```
$ oc logs $(oc get pod -o name | grep event-display) -c user-container
```

Example output

```
☁  cloudevents.Event
Validation: valid
Context Attributes,
  specversion: 1.0
  type: dev.knative.apiserver.resource.update
  datacontenttype: application/json
  ...
Data,
  {
    "apiVersion": "v1",
```

```
    "involvedObject": {
      "apiVersion": "v1",
      "fieldPath": "spec.containers{hello-node}",
      "kind": "Pod",
      "name": "hello-node",
      "namespace": "default",
       .....
    },
    "kind": "Event",
    "message": "Started container",
    "metadata": {
      "name": "hello-node.159d7608e3a3572c",
      "namespace": "default",
      ....
    },
    "reason": "Started",
    ...
}
```

5.6.5.1. Knative CLI --sink flag

When you create an event-producing custom resource by using the Knative (**kn**) CLI, you can specify a sink where events are sent to from that resource, by using the **--sink** flag.

The following example creates a sink binding that uses a service, **http://event-display.svc.cluster.local**, as the sink:

Example command using the --sink flag

```
$ kn source binding create bind-heartbeat \
  --namespace sinkbinding-example \
  --subject "Job:batch/v1:app=heartbeat-cron" \
  --sink http://event-display.svc.cluster.local \ 1
  --ce-override "sink=bound"
```

1 **svc** in **http://event-display.svc.cluster.local** determines that the sink is a Knative service. Other default sink prefixes include **channel**, and **broker**.

5.6.6. Deleting the API server source by using the Knative CLI

This section describes the steps used to delete the API server source, trigger, service account, cluster role, and cluster role binding using **kn** and **oc** commands.

Prerequisites

- You must have the **kn** CLI installed.

Procedure

1. Delete the trigger:

```
$ kn trigger delete <trigger_name>
```

2. Delete the event source:

```
$ kn source apiserver delete <source_name>
```

3. Delete the service account, cluster role, and cluster binding:

```
$ oc delete -f authentication.yaml
```

5.6.7. Using the API server source with the YAML method

This guide describes the steps required to create an API server source using YAML files.

Prerequisites

- You will need to have a Knative Serving and Eventing installation.
- You will need to have created the **default** broker in the same namespace as the one defined in the API server source YAML file.

Procedure

1. Create a service account, role, and role binding for the API server source as a YAML file:

NOTE

If you want to re-use an existing service account, you can modify your existing **ServiceAccount** resource to include the required permissions instead of creating a new resource.

```
apiVersion: v1
kind: ServiceAccount
metadata:
  name: events-sa
  namespace: default 1

---
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  name: event-watcher
  namespace: default 2
rules:
  - apiGroups:
      - ""
    resources:
      - events
    verbs:
      - get
      - list
      - watch

---
apiVersion: rbac.authorization.k8s.io/v1
```

```
kind: RoleBinding
metadata:
  name: k8s-ra-event-watcher
  namespace: default 3
roleRef:
  apiGroup: rbac.authorization.k8s.io
  kind: Role
  name: event-watcher
subjects:
  - kind: ServiceAccount
    name: events-sa
    namespace: default 4
```

1 2 3 4 Change this namespace to the namespace that you have selected for installing the API server source.

2. Apply the YAML file:

```
$ oc apply -f <filename>
```

3. Create an API server source as a YAML file:

```
apiVersion: sources.knative.dev/v1alpha1
kind: ApiServerSource
metadata:
  name: testevents
spec:
  serviceAccountName: events-sa
  mode: Resource
  resources:
    - apiVersion: v1
      kind: Event
  sink:
    ref:
      apiVersion: eventing.knative.dev/v1
      kind: Broker
      name: default
```

4. Apply the **ApiServerSource** YAML file:

```
$ oc apply -f <filename>
```

5. To check that the API server source is set up correctly, create a Knative service as a YAML file that dumps incoming messages to its log:

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: event-display
  namespace: default
spec:
  template:
```

```
    spec:
      containers:
        - image: quay.io/openshift-knative/knative-eventing-sources-event-display:latest
```

6. Apply the **Service** YAML file:

```
$ oc apply -f <filename>
```

7. Create a **Trigger** object as a YAML file that filters events from the **default** broker to the service created in the previous step:

```
apiVersion: eventing.knative.dev/v1
kind: Trigger
metadata:
  name: event-display-trigger
  namespace: default
spec:
  broker: default
  subscriber:
    ref:
      apiVersion: serving.knative.dev/v1
      kind: Service
      name: event-display
```

8. Apply the **Trigger** YAML file:

```
$ oc apply -f <filename>
```

9. Create events by launching a pod in the default namespace:

```
$ oc create deployment hello-node --image=quay.io/openshift-knative/knative-eventing-sources-event-display
```

10. Check that the controller is mapped correctly, by entering the following command and inspecting the output:

```
$ oc get apiserversource.sources.knative.dev testevents -o yaml
```

Example output

```
apiVersion: sources.knative.dev/v1alpha1
kind: ApiServerSource
metadata:
  annotations:
  creationTimestamp: "2020-04-07T17:24:54Z"
  generation: 1
  name: testevents
  namespace: default
  resourceVersion: "62868"
  selfLink:
/apis/sources.knative.dev/v1alpha1/namespaces/default/apiserversources/testevents2
  uid: 1603d863-bb06-4d1c-b371-f580b4db99fa
spec:
```

```
  mode: Resource
  resources:
  - apiVersion: v1
    controller: false
    controllerSelector:
      apiVersion: ""
      kind: ""
      name: ""
      uid: ""
    kind: Event
    labelSelector: {}
  serviceAccountName: events-sa
  sink:
    ref:
      apiVersion: eventing.knative.dev/v1
      kind: Broker
      name: default
```

Verification

To verify that the Kubernetes events were sent to Knative, you can look at the message dumper function logs.

1. Get the pods by entering the following command:

```
$ oc get pods
```

2. View the message dumper function logs for the pods by entering the following command:

```
$ oc logs $(oc get pod -o name | grep event-display) -c user-container
```

Example output

```
☁  cloudevents.Event
Validation: valid
Context Attributes,
  specversion: 1.0
  type: dev.knative.apiserver.resource.update
  datacontenttype: application/json
  ...
Data,
  {
    "apiVersion": "v1",
    "involvedObject": {
      "apiVersion": "v1",
      "fieldPath": "spec.containers{hello-node}",
      "kind": "Pod",
      "name": "hello-node",
      "namespace": "default",
       .....
    },
    "kind": "Event",
    "message": "Started container",
    "metadata": {
      "name": "hello-node.159d7608e3a3572c",
```

```
    "namespace": "default",
    ....
  },
  "reason": "Started",
  ...
}
```

5.6.8. Deleting the API server source

This section describes how to delete the API server source, trigger, service account, cluster role, and cluster role binding by deleting their YAML files.

Procedure

1. Delete the trigger:

```
$ oc delete -f trigger.yaml
```

2. Delete the event source:

```
$ oc delete -f k8s-events.yaml
```

3. Delete the service account, cluster role, and cluster binding:

```
$ oc delete -f authentication.yaml
```

5.7. USING A PING SOURCE

A ping source is used to periodically send ping events with a constant payload to an event consumer.

A ping source can be used to schedule sending events, similar to a timer.

Example ping source YAML

```
apiVersion: sources.knative.dev/v1alpha2
kind: PingSource
metadata:
  name: test-ping-source
spec:
  schedule: "*/2 * * * *" 1
  jsonData: '{"message": "Hello world!"}' 2
  sink: 3
    ref:
      apiVersion: serving.knative.dev/v1
      kind: Service
      name: event-display
```

1. The schedule of the event specified using CRON expression.
2. The event message body expressed as a JSON encoded data string.
3. These are the details of the event consumer. In this example, we are using a Knative service named **event-display**.

5.7.1. Creating a ping source using the Developer perspective

You can create and verify a basic ping source from the OpenShift Container Platform web console.

Prerequisites

To create a ping source using the **Developer** perspective, ensure that:

- The OpenShift Serverless Operator, Knative Serving, and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have logged in to the web console.
- You are in the **Developer** perspective.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.

Procedure

1. To verify that the ping source is working, create a simple Knative service that dumps incoming messages to the logs of the service.
   a. In the **Developer** perspective, navigate to **+Add → YAML**.
   b. Copy the example YAML:

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: event-display
spec:
  template:
    spec:
      containers:
        - image: quay.io/openshift-knative/knative-eventing-sources-event-display:latest
```

   c. Click **Create**.
2. Create a ping source in the same namespace as the service created in the previous step, or any other sink that you want to send events to.
   a. In the **Developer** perspective, navigate to **+Add → Event Source**. The **Event Sources** page is displayed.
   b. Optional: If you have multiple providers for your event sources, select the required provider from the **Providers** list to filter the available event sources from the provider.
   c. Select **Ping Source** and then click **Create Event Source**. The **Create Event Source** page is displayed.

NOTE

You can configure the **PingSource** settings by using the **Form view** or **YAML view** and can switch between the views. The data is persisted when switching between the views.

d. Enter a value for **Schedule**. In this example, the value is ***/2 * * * ***, which creates a PingSource that sends a message every two minutes.

e. Optional: You can enter a value for **Data**, which is the message payload.

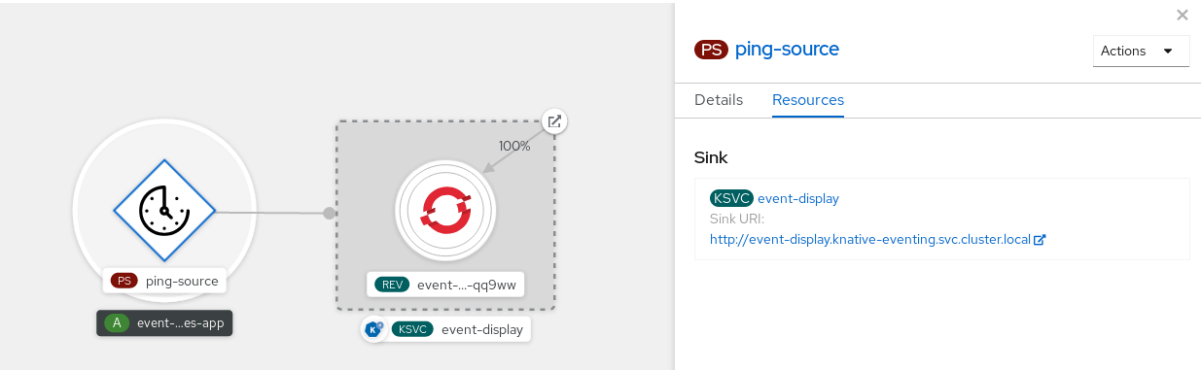
f. Select a **Sink**. This can be either a **Resource** or a **URI**. In this example, the **event-display** service created in the previous step is used as the **Resource** sink.

g. Click **Create**.

Verification

You can verify that the ping source was created and is connected to the sink by viewing the **Topology** page.

1. In the **Developer** perspective, navigate to **Topology**.
2. View the ping source and sink.



5.7.2. Creating a ping source by using the Knative CLI

The following procedure describes how to create a basic ping source by using the **kn** CLI.

Prerequisites

- You have Knative Serving and Eventing installed.
- You have the **kn** CLI installed.

Procedure

1. To verify that the ping source is working, create a simple Knative service that dumps incoming messages to the service logs:

```
$ kn service create event-display \
    --image quay.io/openshift-knative/knative-eventing-sources-event-display:latest
```

2. For each set of ping events that you want to request, create a ping source in the same namespace as the event consumer:

```
$ kn source ping create test-ping-source \
    --schedule "*/2 * * * *" \
    --data '{"message": "Hello world!"}' \
    --sink ksvc:event-display
```

3. Check that the controller is mapped correctly by entering the following command and inspecting the output:

```
$ kn source ping describe test-ping-source
```

Example output

```
Name:         test-ping-source
Namespace:    default
Annotations:  sources.knative.dev/creator=developer,
sources.knative.dev/lastModifier=developer
Age:          15s
Schedule:     */2 * * * *
Data:         {"message": "Hello world!"}

Sink:
  Name:       event-display
  Namespace:  default
  Resource:   Service (serving.knative.dev/v1)

Conditions:
  OK TYPE               AGE REASON
  ++ Ready              8s
  ++ Deployed             8s
  ++ SinkProvided         15s
  ++ ValidSchedule        15s
  ++ EventTypeProvided    15s
  ++ ResourcesCorrect     15s
```

Verification

You can verify that the Kubernetes events were sent to the Knative event sink by looking at the logs of the sink pod.

By default, Knative services terminate their pods if no traffic is received within a 60 second period. The example shown in this guide creates a ping source that sends a message every 2 minutes, so each message should be observed in a newly created pod.

1. Watch for new pods created:

```
$ watch oc get pods
```

2. Cancel watching the pods using Ctrl+C, then look at the logs of the created pod:

```
$ oc logs $(oc get pod -o name | grep event-display) -c user-container
```

Example output

```
☁  cloudevents.Event
Validation: valid
Context Attributes,
  specversion: 1.0
  type: dev.knative.sources.ping
  source: /apis/v1/namespaces/default/pingsources/test-ping-source
```

```
  id: 99e4f4f6-08ff-4bff-acf1-47f61ded68c9
  time: 2020-04-07T16:16:00.000601161Z
  datacontenttype: application/json
Data,
  {
    "message": "Hello world!"
  }
```

5.7.2.1. Knative CLI --sink flag

When you create an event-producing custom resource by using the Knative (**kn**) CLI, you can specify a sink where events are sent to from that resource, by using the **--sink** flag.

The following example creates a sink binding that uses a service, **http://event-display.svc.cluster.local**, as the sink:

Example command using the --sink flag

```
$ kn source binding create bind-heartbeat \
  --namespace sinkbinding-example \
  --subject "Job:batch/v1:app=heartbeat-cron" \
  --sink http://event-display.svc.cluster.local \ 1
  --ce-override "sink=bound"
```

1 **svc** in **http://event-display.svc.cluster.local** determines that the sink is a Knative service. Other default sink prefixes include **channel**, and **broker**.

5.7.3. Deleting a ping source by using the Knative CLI

The following procedure describes how to delete a ping source using the **kn** CLI.

- Delete the ping source:

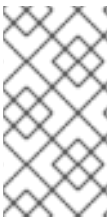
```
$ kn delete pingsources.sources.knative.dev <ping_source_name>
```

5.7.4. Using a ping source with YAML

The following sections describe how to create a basic ping source using YAML files.

Prerequisites

- You have Knative Serving and Eventing installed.



NOTE

The following procedure requires you to create YAML files.

If you change the names of the YAML files from those used in the examples, you must ensure that you also update the corresponding CLI commands.

Procedure

1. To verify that the ping source is working, create a simple Knative service that dumps incoming messages to the service's logs.

   a. Copy the example YAML into a file named **service.yaml**:

   ```
   apiVersion: serving.knative.dev/v1
   kind: Service
   metadata:
     name: event-display
   spec:
     template:
       spec:
         containers:
           - image: quay.io/openshift-knative/knative-eventing-sources-event-display:latest
   ```

   b. Create the service:

   ```
   $ oc apply --filename service.yaml
   ```

2. For each set of ping events that you want to request, create a ping source in the same namespace as the event consumer.

   a. Copy the example YAML into a file named **ping-source.yaml**:

   ```
   apiVersion: sources.knative.dev/v1alpha2
   kind: PingSource
   metadata:
     name: test-ping-source
   spec:
     schedule: "*/2 * * * *"
     jsonData: '{"message": "Hello world!"}'
     sink:
       ref:
         apiVersion: serving.knative.dev/v1
         kind: Service
         name: event-display
   ```

   b. Create the ping source:

   ```
   $ oc apply --filename ping-source.yaml
   ```

3. Check that the controller is mapped correctly by entering the following command:

   ```
   $ oc get pingsource.sources.knative.dev test-ping-source -oyaml
   ```

   Example output

   ```
   apiVersion: sources.knative.dev/v1alpha2
   kind: PingSource
   metadata:
     annotations:
       sources.knative.dev/creator: developer
       sources.knative.dev/lastModifier: developer
     creationTimestamp: "2020-04-07T16:11:14Z"
   ```

```
  generation: 1
  name: test-ping-source
  namespace: default
  resourceVersion: "55257"
  selfLink: /apis/sources.knative.dev/v1alpha2/namespaces/default/pingsources/test-ping-
source
  uid: 3d80d50b-f8c7-4c1b-99f7-3ec00e0a8164
spec:
  jsonData: '{ value: "hello" }'
  schedule: '*/2 * * * *'
  sink:
    ref:
      apiVersion: serving.knative.dev/v1
      kind: Service
      name: event-display
      namespace: default
```

Verification

You can verify that the Kubernetes events were sent to the Knative event sink by looking at the sink pod's logs.

By default, Knative services terminate their pods if no traffic is received within a 60 second period. The example shown in this guide creates a PingSource that sends a message every 2 minutes, so each message should be observed in a newly created pod.

1. Watch for new pods created:

```
$ watch oc get pods
```

2. Cancel watching the pods using Ctrl+C, then look at the logs of the created pod:

```
$ oc logs $(oc get pod -o name | grep event-display) -c user-container
```

Example output

```
☁  cloudevents.Event
Validation: valid
Context Attributes,
  specversion: 1.0
  type: dev.knative.sources.ping
  source: /apis/v1/namespaces/default/pingsources/test-ping-source
  id: 042ff529-240e-45ee-b40c-3a908129853e
  time: 2020-04-07T16:22:00.000791674Z
  datacontenttype: application/json
Data,
  {
    "message": "Hello world!"
  }
```

5.7.5. Deleting a ping source that was created by using YAML

The following procedure describes how to delete a ping source that was created by using YAML.

Procedure

- Delete the ping source:

```
$ oc delete -f <ping_source_yaml_filename>
```

Example command

```
$ oc delete -f ping-source.yaml
```

5.8. CUSTOM EVENT SOURCES

If you need to ingress events from an event producer that is not included in Knative, or from a producer that emits events which are not in the **CloudEvent** format, you can do this by using one of the following methods:

- Use a **PodSpecable** object as an event source, by creating a *sink binding*.
- Use a container as an event source, by creating a *container source*.

5.8.1. Using a sink binding

The **SinkBinding** object supports decoupling event production from delivery addressing. Sink binding is used to connect *event producers* to an event consumer, or *sink*. An event producer is a Kubernetes resource that embeds a **PodSpec** template and produces events. A sink is an addressable Kubernetes object that can receive events.

The **SinkBinding** object injects environment variables into the **PodTemplateSpec** of the sink, which means that the application code does not need to interact directly with the Kubernetes API to locate the event destination. These environment variables are as follows:

K_SINK

The URL of the resolved sink.

K_CE_OVERRIDES

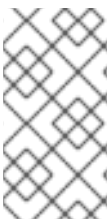
A JSON object that specifies overrides to the outbound event.

5.8.1.1. Using sink binding with the YAML method

This guide describes the steps required to create a sink binding instance using YAML files.

Prerequisites

- You have Knative Serving and Eventing installed.



NOTE

The following procedure requires you to create YAML files.

If you change the names of the YAML files from those used in the examples, you must ensure that you also update the corresponding CLI commands.

Procedure

1. To check that sink binding is set up correctly, create a Knative event display service, or event sink, that dumps incoming messages to its log.

   a. Copy the following sample YAML into a file named **service.yaml**:

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: event-display
spec:
  template:
    spec:
      containers:
        - image: quay.io/openshift-knative/knative-eventing-sources-event-display:latest
```

   b. After you have created the **service.yaml** file, apply it by entering:

```
$ oc apply -f service.yaml
```

2. Create a sink binding instance that directs events to the service.

   a. Create a file named **sinkbinding.yaml** and copy the following sample code into it:

```
apiVersion: sources.knative.dev/v1alpha1
kind: SinkBinding
metadata:
  name: bind-heartbeat
spec:
  subject:
    apiVersion: batch/v1
    kind: Job (1)
    selector:
      matchLabels:
        app: heartbeat-cron

  sink:
    ref:
      apiVersion: serving.knative.dev/v1
      kind: Service
      name: event-display
```

   (1) In this example, any Job with the label **app: heartbeat-cron** will be bound to the event sink.

   b. After you have created the **sinkbinding.yaml** file, apply it by entering:

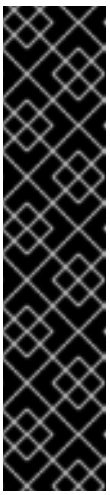
```
$ oc apply -f sinkbinding.yaml
```

3. Create a **CronJob** resource.

   a. Create a file named **heartbeats-cronjob.yaml** and copy the following sample code into it:

```
apiVersion: batch/v1
kind: CronJob
```

```
metadata:
  name: heartbeat-cron
spec:
  # Run every minute
  schedule: "* * * * *"
  jobTemplate:
    metadata:
      labels:
        app: heartbeat-cron
        bindings.knative.dev/include: "true"
    spec:
      template:
        spec:
          restartPolicy: Never
          containers:
            - name: single-heartbeat
              image: quay.io/openshift-knative/heartbeats:latest
              args:
                - --period=1
              env:
                - name: ONE_SHOT
                  value: "true"
                - name: POD_NAME
                  valueFrom:
                    fieldRef:
                      fieldPath: metadata.name
                - name: POD_NAMESPACE
                  valueFrom:
                    fieldRef:
                      fieldPath: metadata.namespace
```



IMPORTANT

To use sink binding, you must manually add a **bindings.knative.dev/include=true** label to your Knative resources.

For example, to add this label to a **CronJob** resource, add the following lines to the **Job** resource YAML definition:

```
jobTemplate:
  metadata:
    labels:
      app: heartbeat-cron
      bindings.knative.dev/include: "true"
```

b. After you have created the **heartbeats-cronjob.yaml** file, apply it by entering:

```
$ oc apply -f heartbeats-cronjob.yaml
```

4. Check that the controller is mapped correctly by entering the following command and inspecting the output:

```
$ oc get sinkbindings.sources.knative.dev bind-heartbeat -oyaml
```

Example output

```
spec:
  sink:
    ref:
      apiVersion: serving.knative.dev/v1
      kind: Service
      name: event-display
      namespace: default
  subject:
    apiVersion: batch/v1
    kind: Job
    namespace: default
    selector:
      matchLabels:
        app: heartbeat-cron
```

Verification

You can verify that the Kubernetes events were sent to the Knative event sink by looking at the message dumper function logs.

1. Enter the command:

```
$ oc get pods
```

2. Enter the command:

```
$ oc logs $(oc get pod -o name | grep event-display) -c user-container
```

Example output

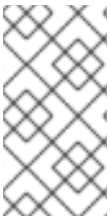
```
☁  cloudevents.Event
Validation: valid
Context Attributes,
  specversion: 1.0
  type: dev.knative.eventing.samples.heartbeat
  source: https://knative.dev/eventing-contrib/cmd/heartbeats/#event-test/mypod
  id: 2b72d7bf-c38f-4a98-a433-608fbcdd2596
  time: 2019-10-18T15:23:20.809775386Z
  contenttype: application/json
Extensions,
  beats: true
  heart: yes
  the: 42
Data,
  {
    "id": 1,
    "label": ""
  }
```

5.8.1.2. Creating a sink binding by using the Knative CLI

This guide describes the steps required to create a sink binding instance using **kn** commands.

Prerequisites

- You have Knative Serving and Eventing installed.
- You have the **kn** CLI installed.



NOTE

The following procedure requires you to create YAML files.

If you change the names of the YAML files from those used in the examples, you must ensure that you also update the corresponding CLI commands.

Procedure

1. To check that sink binding is set up correctly, create a Knative event display service, or event sink, that dumps incoming messages to its log:

```
$ kn service create event-display --image quay.io/openshift-knative/knative-eventing-sources-event-display:latest
```

2. Create a sink binding instance that directs events to the service:

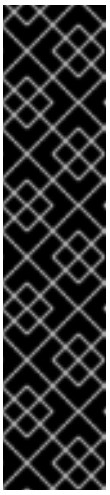
```
$ kn source binding create bind-heartbeat --subject Job:batch/v1:app=heartbeat-cron --sink ksvc:event-display
```

3. Create a **CronJob** custom resource (CR).

   a. Create a file named **heartbeats-cronjob.yaml** and copy the following sample code into it:

```
apiVersion: batch/v1
kind: CronJob
metadata:
  name: heartbeat-cron
spec:
  # Run every minute
  schedule: "* * * * *"
  jobTemplate:
    metadata:
      labels:
        app: heartbeat-cron
        bindings.knative.dev/include: "true"
    spec:
      template:
        spec:
          restartPolicy: Never
          containers:
            - name: single-heartbeat
              image: quay.io/openshift-knative/heartbeats:latest
              args:
                - --period=1
              env:
                - name: ONE_SHOT
                  value: "true"
                - name: POD_NAME
```

```
      valueFrom:
        fieldRef:
          fieldPath: metadata.name
    - name: POD_NAMESPACE
      valueFrom:
        fieldRef:
          fieldPath: metadata.namespace
```



IMPORTANT

To use sink binding, you must manually add a **bindings.knative.dev/include=true** label to your Knative CRs.

For example, to add this label to a **CronJob** CR, add the following lines to the **Job** CR YAML definition:

```
jobTemplate:
  metadata:
    labels:
      app: heartbeat-cron
      bindings.knative.dev/include: "true"
```

b. After you have created the **heartbeats-cronjob.yaml** file, apply it by entering:

```
$ oc apply -f heartbeats-cronjob.yaml
```

4. Check that the controller is mapped correctly by entering the following command and inspecting the output:

```
$ kn source binding describe bind-heartbeat
```

Example output

```
Name:         bind-heartbeat
Namespace:    demo-2
Annotations:  sources.knative.dev/creator=minikube-user,
sources.knative.dev/lastModifier=minikub ...
Age:          2m
Subject:
  Resource:   job (batch/v1)
  Selector:
    app:      heartbeat-cron
Sink:
  Name:       event-display
  Resource:   Service (serving.knative.dev/v1)

Conditions:
  OK TYPE     AGE REASON
  ++ Ready    2m
```

Verification

You can verify that the Kubernetes events were sent to the Knative event sink by looking at the message dumper function logs.

- View the message dumper function logs by entering the following commands:

```
$ oc get pods
```

```
$ oc logs $(oc get pod -o name | grep event-display) -c user-container
```

Example output

```
☁  cloudevents.Event
Validation: valid
Context Attributes,
  specversion: 1.0
  type: dev.knative.eventing.samples.heartbeat
  source: https://knative.dev/eventing-contrib/cmd/heartbeats/#event-test/mypod
  id: 2b72d7bf-c38f-4a98-a433-608fbcdd2596
  time: 2019-10-18T15:23:20.809775386Z
  contenttype: application/json
Extensions,
  beats: true
  heart: yes
  the: 42
Data,
  {
    "id": 1,
    "label": ""
  }
```

5.8.1.2.1. Knative CLI --sink flag

When you create an event-producing custom resource by using the Knative (**kn**) CLI, you can specify a sink where events are sent to from that resource, by using the **--sink** flag.

The following example creates a sink binding that uses a service, **http://event-display.svc.cluster.local**, as the sink:

Example command using the --sink flag

```
$ kn source binding create bind-heartbeat \
  --namespace sinkbinding-example \
  --subject "Job:batch/v1:app=heartbeat-cron" \
  --sink http://event-display.svc.cluster.local \ 1
  --ce-override "sink=bound"
```

1 **svc** in **http://event-display.svc.cluster.local** determines that the sink is a Knative service. Other default sink prefixes include **channel**, and **broker**.

5.8.1.3. Creating a sink binding using the web console

You can create and verify a basic sink binding from the OpenShift Container Platform web console.

Prerequisites

To create a sink binding using the **Developer** perspective, ensure that:

- The OpenShift Serverless Operator, Knative Serving, and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have logged in to the web console.
- You are in the **Developer** perspective.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.

Procedure

1. Create a Knative service to use as a sink:
   a. In the **Developer** perspective, navigate to **+Add → YAML**.
   b. Copy the example YAML:

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: event-display
spec:
  template:
    spec:
      containers:
        - image: quay.io/openshift-knative/knative-eventing-sources-event-display:latest
```

   c. Click **Create**.
2. Create a **CronJob** resource that is used as an event source and sends an event every minute.
   a. In the **Developer** perspective, navigate to **+Add → YAML**.
   b. Copy the example YAML:

```
apiVersion: batch/v1
kind: CronJob
metadata:
  name: heartbeat-cron
spec:
  # Run every minute
  schedule: "*/1 * * * *"
  jobTemplate:
    metadata:
      labels:
        app: heartbeat-cron
        bindings.knative.dev/include: true (1)
    spec:
      template:
        spec:
          restartPolicy: Never
```

```
containers:
  - name: single-heartbeat
    image: quay.io/openshift-knative/heartbeats
    args:
    - --period=1
    env:
      - name: ONE_SHOT
        value: "true"
      - name: POD_NAME
        valueFrom:
          fieldRef:
            fieldPath: metadata.name
      - name: POD_NAMESPACE
        valueFrom:
          fieldRef:
            fieldPath: metadata.namespace
```

1 Ensure that you include the **bindings.knative.dev/include: true** label. The default namespace selection behavior of OpenShift Serverless uses inclusion mode.

c. Click **Create**.

3. Create a sink binding in the same namespace as the service created in the previous step, or any other sink that you want to send events to.

a. In the **Developer** perspective, navigate to **+Add → Event Source**. The **Event Sources** page is displayed.

b. Optional: If you have multiple providers for your event sources, select the required provider from the **Providers** list to filter the available event sources from the provider.

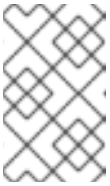
c. Select **Sink Binding** and then click **Create Event Source**. The **Create Event Source** page is displayed.

NOTE

You can configure the **Sink Binding** settings by using the **Form view** or **YAML view** and can switch between the views. The data is persisted when switching between the views.

d. In the **apiVersion** field enter **batch/v1**.

e. In the **Kind** field enter **Job**.



NOTE

The **CronJob** kind is not supported directly by OpenShift Serverless sink binding, so the **Kind** field must target the **Job** objects created by the cron job, rather than the cron job object itself.

f. Select a **Sink**. This can be either a **Resource** or a **URI**. In this example, the **event-display** service created in the previous step is used as the **Resource** sink.

g. In the **Match labels** section:

i. Enter **app** in the **Name** field.

ii. Enter **heartbeat-cron** in the **Value** field.

NOTE

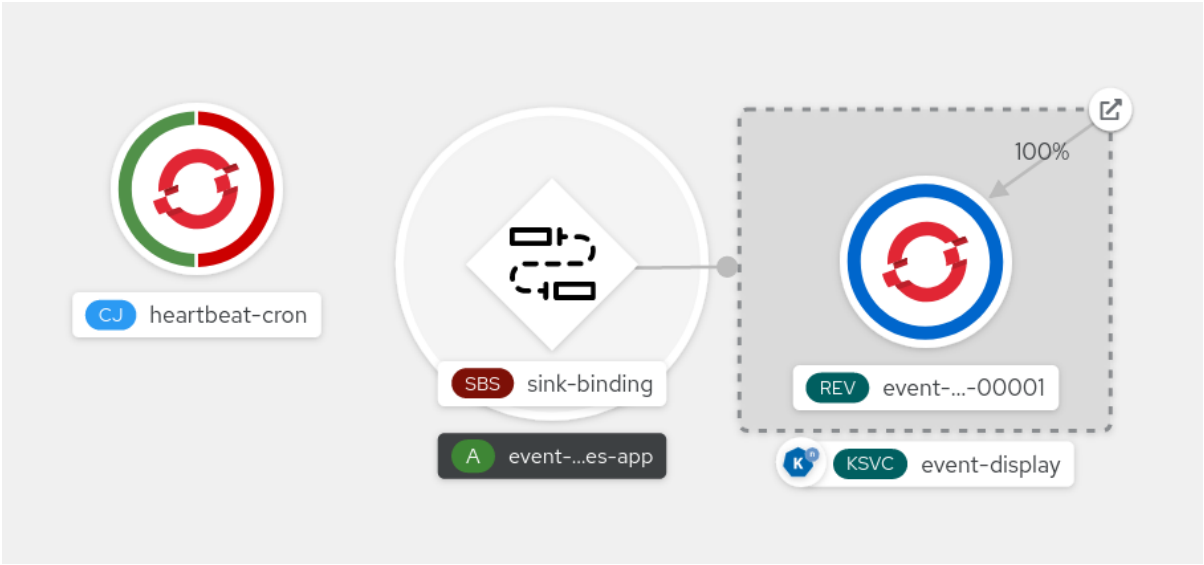
The label selector is required when using cron jobs with sink binding, rather than the resource name. This is because jobs created by a cron job do not have a predictable name, and contain a randomly generated string in their name. For example, **hearthbeat-cron-1cc23f**.

h. Click **Create**.

Verification

You can verify that the sink binding, sink, and cron job have been created and are working correctly by viewing the **Topology** page and pod logs.

1. In the **Developer** perspective, navigate to **Topology**.
2. View the sink binding, sink, and heartbeats cron job.



3. Observe that successful jobs are being registered by the cron job once the sink binding is added. This means that the sink binding is successfully reconfiguring the jobs created by the cron job.
4. Browse the logs of the **event-display** service pod to see events produced by the heartbeats cron job.

5.8.1.4. Sink binding reference

This topic provides reference information about the configurable parameters for **SinkBinding** objects.

SinkBinding objects support the following parameters:

Field	Description	Required or optional

Field	Description	Required or optional
apiVersion	Specifies the API version, for example **sources.knative.dev/v1**.	Required
kind	Identifies this resource object as a **SinkBinding** object.	Required
metadata	Specifies metadata that uniquely identifies the **SinkBinding** object. For example, a **name**.	Required
spec	Specifies the configuration information for this **SinkBinding** object.	Required
spec.sink	A reference to an object that resolves to a URI to use as the sink.	Required
spec.subject	References the resources for which the runtime contract is augmented by binding implementations.	Required
spec.ceOverrides	Defines overrides to control the output format and modifications to the event sent to the sink.	Optional

5.8.1.4.1. Subject parameter

The **Subject** parameter references the resources for which the runtime contract is augmented by binding implementations.

The **Subject** definition supports the following fields:

Field	Description	Required or optional
apiVersion	API version of the referent.	Required
kind	Kind of the referent.	Required
namespace	Namespace of the referent. If omitted, this defaults to the namespace of the object.	Optional
name	Name of the referent.	Do not use if you configure **selector**.

Field	Description	Required or optional
selector	Selector of the referents.	Do not use if you configure **name**.
selector.matchExpressions	A list of label selector requirements.	Only use one of either **matchExpressions** or **matchLabels**.
selector.matchExpressions.key	The label key that the selector applies to.	Required if using **matchExpressions**.
selector.matchExpressions.operator	Represents a key's relationship to a set of values. Valid operators are **In**, **NotIn**, **Exists** and **DoesNotExist**.	Required if using **matchExpressions**.
selector.matchExpressions.values	An array of string values. If the **operator** parameter value is **In** or **NotIn**, the values array must be non-empty. If the **operator** parameter value is **Exists** or **DoesNotExist**, the values array must be empty. This array is replaced during a strategic merge patch.	Required if using **matchExpressions**.
selector.matchLabels	A map of key-value pairs. Each key-value pair in the **matchLabels** map is equivalent to an element of **matchExpressions**, where the key field is **matchLabels.<key>**, the **operator** is **In**, and the **values** array contains only **matchLabels.<value>**.	Only use one of either **matchExpressions** or **matchLabels**.

5.8.1.4.1.1. Subject parameter examples

Given the following YAML, the **Deployment** object named **mysubject** in the **default** namespace is selected:

```
apiVersion: sources.knative.dev/v1
kind: SinkBinding
metadata:
  name: bind-heartbeat
spec:
  subject:
    apiVersion: apps/v1
    kind: Deployment
```

```
    namespace: default
    name: mysubject
  ...
```

Given the following YAML, any **Job** object with the label **working=example** in the **default** namespace is selected:

```
apiVersion: sources.knative.dev/v1
kind: SinkBinding
metadata:
  name: bind-heartbeat
spec:
  subject:
    apiVersion: batch/v1
    kind: Job
    namespace: default
    selector:
      matchLabels:
        working: example
  ...
```

Given the following YAML, any **Pod** object with the label **working=example** or **working=sample** in the **default** namespace is selected:

```
apiVersion: sources.knative.dev/v1
kind: SinkBinding
metadata:
  name: bind-heartbeat
spec:
  subject:
    apiVersion: v1
    kind: Pod
    namespace: default
    selector:
      - matchExpression:
        key: working
        operator: In
        values:
          - example
          - sample
  ...
```

5.8.1.4.2. CloudEvent overrides

A **ceOverrides** definition provides overrides that control the CloudEvent's output format and modifications sent to the sink

A **ceOverrides** definition supports the following fields:

Field	Description	Required or optional

Field	Description	Required or optional
extensions	Specifies which attributes are added or overridden on the outbound event. Each **extensions** key-value pair is set independently on the event as an attribute extension.	Optional

NOTE

Only valid **CloudEvent** attribute names are allowed as extensions. You cannot set the spec defined attributes from the extensions override configuration. For example, you can not modify the **type** attribute.

CloudEvent Overrides example

```
apiVersion: sources.knative.dev/v1
kind: SinkBinding
metadata:
  name: bind-heartbeat
spec:
  ...
  ceOverrides:
    extensions:
      extra: this is an extra attribute
      additional: 42
```

This sets the **K_CE_OVERRIDES** environment variable on the **subject**:

Example output

```
{ "extensions": { "extra": "this is an extra attribute", "additional": "42" } }
```

5.8.1.4.3. The include label

To use a SinkBinding, you need to do assign the **bindings.knative.dev/include: "true"** label to either the resource or the namespace. If the resource definition does not include the label, a cluster administrator can attach it to the namespace by running:

```
$ oc label namespace <namespace> bindings.knative.dev/include=true
```

5.8.2. Using a container source

Container sources create a container image that generates events and sends events to a sink. You can use a container source to create a custom event source, by creating a container image and a **ContainerSource** object that uses your image URI.

5.8.2.1. Guidelines for creating a container image

- Two environment variables are injected by the container source controller: **K_SINK** and **K_CE_OVERRIDES**. These variables are resolved from the **sink** and **ceOverrides** spec, respectively.

- Event messages are sent to the sink URI specified in the **K_SINK** environment variable. The event message can be in any format; however, using the **CloudEvent** spec is recommended.

5.8.2.1.1. Example container images

The following is an example of a heartbeats container image:

```
package main

import (
 "context"
 "encoding/json"
 "flag"
 "fmt"
 "log"
 "os"
 "strconv"
 "time"

 duckv1 "knative.dev/pkg/apis/duck/v1"

 cloudevents "github.com/cloudevents/sdk-go/v2"
 "github.com/kelseyhightower/envconfig"
)

type Heartbeat struct {
 Sequence int    `json:"id"`
 Label    string `json:"label"`
}

var (
 eventSource string
 eventType   string
 sink        string
 label       string
 periodStr   string
)

func init() {
 flag.StringVar(&eventSource, "eventSource", "", "the event-source (CloudEvents)")
 flag.StringVar(&eventType, "eventType", "dev.knative.eventing.samples.heartbeat", "the event-type
(CloudEvents)")
 flag.StringVar(&sink, "sink", "", "the host url to heartbeat to")
 flag.StringVar(&label, "label", "", "a special label")
 flag.StringVar(&periodStr, "period", "5", "the number of seconds between heartbeats")
}

type envConfig struct {
 // Sink URL where to send heartbeat cloud events
 Sink string `envconfig:"K_SINK"`

 // CEOverrides are the CloudEvents overrides to be applied to the outbound event.
```

```
 CEOverrides string `envconfig:"K_CE_OVERRIDES"`

 // Name of this pod.
 Name string `envconfig:"POD_NAME" required:"true"`

 // Namespace this pod exists in.
 Namespace string `envconfig:"POD_NAMESPACE" required:"true"`

 // Whether to run continuously or exit.
 OneShot bool `envconfig:"ONE_SHOT" default:"false"`
}

func main() {
 flag.Parse()

 var env envConfig
 if err := envconfig.Process("", &env); err != nil {
  log.Printf("[ERROR] Failed to process env var: %s", err)
  os.Exit(1)
 }

 if env.Sink != "" {
  sink = env.Sink
 }

 var ceOverrides *duckv1.CloudEventOverrides
 if len(env.CEOverrides) > 0 {
  overrides := duckv1.CloudEventOverrides{}
  err := json.Unmarshal([]byte(env.CEOverrides), &overrides)
  if err != nil {
   log.Printf("[ERROR] Unparseable CloudEvents overrides %s: %v", env.CEOverrides, err)
   os.Exit(1)
  }
  ceOverrides = &overrides
 }

 p, err := cloudevents.NewHTTP(cloudevents.WithTarget(sink))
 if err != nil {
  log.Fatalf("failed to create http protocol: %s", err.Error())
 }

 c, err := cloudevents.NewClient(p, cloudevents.WithUUIDs(), cloudevents.WithTimeNow())
 if err != nil {
  log.Fatalf("failed to create client: %s", err.Error())
 }

 var period time.Duration
 if p, err := strconv.Atoi(periodStr); err != nil {
  period = time.Duration(5) * time.Second
 } else {
  period = time.Duration(p) * time.Second
 }

 if eventSource == "" {
  eventSource = fmt.Sprintf("https://knative.dev/eventing-contrib/cmd/heartbeats/#%s/%s",
env.Namespace, env.Name)
```

```
 log.Printf("Heartbeats Source: %s", eventSource)
}

if len(label) > 0 && label[0] == '"' {
 label, _ = strconv.Unquote(label)
}
hb := &Heartbeat{
 Sequence: 0,
 Label:    label,
}
ticker := time.NewTicker(period)
for {
 hb.Sequence++

 event := cloudevents.NewEvent("1.0")
 event.SetType(eventType)
 event.SetSource(eventSource)
 event.SetExtension("the", 42)
 event.SetExtension("heart", "yes")
 event.SetExtension("beats", true)

 if ceOverrides != nil && ceOverrides.Extensions != nil {
  for n, v := range ceOverrides.Extensions {
   event.SetExtension(n, v)
  }
 }

 if err := event.SetData(cloudevents.ApplicationJSON, hb); err != nil {
  log.Printf("failed to set cloudevents data: %s", err.Error())
 }

 log.Printf("sending cloudevent to %s", sink)
 if res := c.Send(context.Background(), event); !cloudevents.IsACK(res) {
  log.Printf("failed to send cloudevent: %v", res)
 }

 if env.OneShot {
  return
 }

 // Wait for next tick
 <-ticker.C
}
}
```

The following is an example of a container source that references the previous heartbeats container image:

```
apiVersion: sources.knative.dev/v1
kind: ContainerSource
metadata:
  name: test-heartbeats
spec:
  template:
    spec:
      containers:
```

```
        # This corresponds to a heartbeats image URI that you have built and published
        - image: gcr.io/knative-releases/knative.dev/eventing/cmd/heartbeats
          name: heartbeats
          args:
            - --period=1
          env:
            - name: POD_NAME
              value: "example-pod"
            - name: POD_NAMESPACE
              value: "event-test"
  sink:
    ref:
      apiVersion: serving.knative.dev/v1
      kind: Service
      name: example-service
...
```

5.8.2.2. Creating and managing container sources by using the Knative CLI

You can use the following **kn** commands to create and manage container sources:

Create a container source

```
$ kn source container create <container_source_name> --image <image_uri> --sink <sink>
```

Delete a container source

```
$ kn source container delete <container_source_name>
```

Describe a container source

```
$ kn source container describe <container_source_name>
```

List existing container sources

```
$ kn source container list
```

List existing container sources in YAML format

```
$ kn source container list -o yaml
```

Update a container source

This command updates the image URI for an existing container source:

```
$ kn source container update <container_source_name> --image <image_uri>
```

5.8.2.3. Creating a container source by using the web console

You can create a container source by using the **Developer** perspective of the OpenShift Container Platform web console.

Prerequisites

To create a container source using the **Developer** perspective, ensure that:

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have logged in to the web console.
- You are in the **Developer** perspective.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.

Procedure

1. In the **Developer** perspective, navigate to **+Add → Event Source**. The **Event Sources** page is displayed.
2. Select **Container Source** and then click **Create Event Source**. The **Create Event Source** page is displayed.
3. Configure the **Container Source** settings by using the **Form view** or **YAML view**:

NOTE

You can switch between the **Form view** and **YAML view**. The data is persisted when switching between the views.

   a. In the **Image** field, enter the URI of the image that you want to run in the container created by the container source.
   b. In the **Name** field, enter the name of the image.
   c. Optional: In the **Arguments** field, enter any arguments to be passed to the container.
   d. Optional: In the **Environment variables** field, add any environment variables to set in the container.
   e. In the **Sink** section, add a sink where events from the container source are routed to. If you are using the **Form** view, you can choose from the following options:
      i. Select **Resource** to use a channel, broker, or service as a sink for the event source.
      ii. Select **URI** to specify where the events from the container source are routed to.
4. After you have finished configuring the container source, click **Create**.

5.8.2.4. Container source reference

This topic provides reference information about the configurable fields for the **ContainerSource** object.

ContainerSource objects support the following fields:

Field	Description	Required or optional
apiVersion	Specifies the API version, for example **sources.knative.dev/v1**.	Required
kind	Identifies this resource object as a **ContainerSource** object.	Required
metadata	Specifies metadata that uniquely identifies the **ContainerSource** object. For example, a **name**.	Required
spec	Specifies the configuration information for this **ContainerSource** object.	Required
spec.sink	A reference to an object that resolves to a URI to use as the sink.	Required
spec.template	A **template** spec for the **ContainerSource** object.	Required
spec.ceOverrides	Defines overrides to control the output format and modifications to the event sent to the sink.	Optional

5.8.2.4.1. Template parameter example

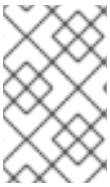
```
apiVersion: sources.knative.dev/v1
kind: ContainerSource
metadata:
  name: test-heartbeats
spec:
  template:
    spec:
      containers:
        - image: quay.io/openshift-knative/heartbeats:latest
          name: heartbeats
          args:
            - --period=1
          env:
            - name: POD_NAME
              value: "mypod"
            - name: POD_NAMESPACE
              value: "event-test"
  ...
```

5.8.2.4.2. CloudEvent overrides

A **ceOverrides** definition provides overrides that control the CloudEvent's output format and modifications sent to the sink

A **ceOverrides** definition supports the following fields:

Field	Description	Required or optional
extensions	Specifies which attributes are added or overridden on the outbound event. Each **extensions** key-value pair is set independently on the event as an attribute extension.	Optional



NOTE

Only valid **CloudEvent** attribute names are allowed as extensions. You cannot set the spec defined attributes from the extensions override configuration. For example, you can not modify the **type** attribute.

CloudEvent Overrides example

```
apiVersion: sources.knative.dev/v1
kind: ContainerSource
metadata:
  name: test-heartbeats
spec:
  ...
  ceOverrides:
    extensions:
      extra: this is an extra attribute
      additional: 42
```

This sets the **K_CE_OVERRIDES** environment variable on the **subject**:

Example output

```
{ "extensions": { "extra": "this is an extra attribute", "additional": "42" } }
```

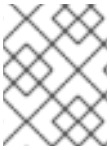
5.9. CREATING AND DELETING CHANNELS

Developers can create channels by instantiating a supported **Channel** object.

After you create a **Channel** object, a mutating admission webhook adds a set of **spec.channelTemplate** properties for the **Channel** object based on the default channel implementation. For example, for an **InMemoryChannel** default implementation, the **Channel** object looks as follows:

```
apiVersion: messaging.knative.dev/v1
kind: Channel
metadata:
  name: example-channel
  namespace: default
```

```
spec:
  channelTemplate:
    apiVersion: messaging.knative.dev/v1
    kind: InMemoryChannel
```



NOTE

The **spec.channelTemplate** properties cannot be changed after creation, because they are set by the default channel mechanism rather than by the user.

The channel controller then creates the backing channel instance based on the **spec.channelTemplate** configuration.

When this mechanism is used with the preceding example, two objects are created: a generic backing channel and an **InMemoryChannel** channel. If you are using a different default channel implementation, the **InMemoryChannel** is replaced with one that is specific to your implementation. For example, with Knative Kafka, the **KafkaChannel** channel is created.

The backing channel acts as a proxy that copies its subscriptions to the user-created channel object, and sets the user-created channel object status to reflect the status of the backing channel.

5.9.1. Creating a channel using the Developer perspective

You can create a channel with the cluster default configuration by using the OpenShift Container Platform web console.

Prerequisites

To create channels using the **Developer** perspective ensure that:

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have logged in to the web console.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.

Procedure

1. In the **Developer** perspective, navigate to **+Add → Channel**.
2. Select the type of **Channel** object that you want to create from the **Type** drop-down.

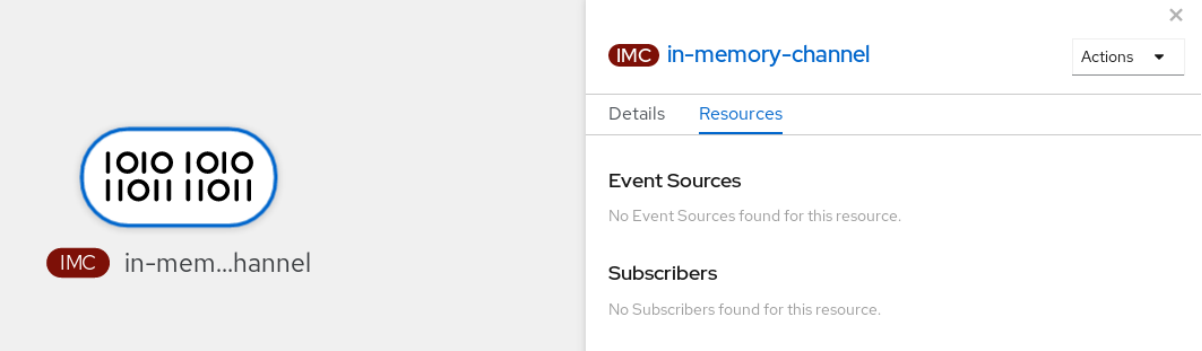
NOTE

Currently only InMemoryChannel type **Channel** objects are supported.

3. Click **Create**.

Verification

- Confirm that the channel now exists by navigating to the **Topology** page.



5.9.2. Creating a channel by using the Knative CLI

You can create a channel with the cluster default configuration by using the **kn** CLI.

Prerequisites

To create channels using the **kn** CLI, ensure that:

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the **kn** CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.

Procedure

- Create a channel:

```
$ kn channel create <channel_name> --type <channel_type>
```

The channel type is optional, but where specified, must be given in the format **Group:Version:Kind**. For example, you can create an **InMemoryChannel** object:

```
$ kn channel create mychannel --type messaging.knative.dev:v1:InMemoryChannel
```

Example output

```
Channel 'mychannel' created in namespace 'default'.
```

Verification

- To confirm that the channel now exists, list the existing channels and inspect the output:

```
$ kn channel list
```

Example output

```
kn channel list
NAME TYPE URL AGE READY REASON
mychannel InMemoryChannel http://mychannel-kn-channel.default.svc.cluster.local 93s
True
```

-

5.9.3. Creating a default implementation channel by using YAML

You can create a channel by using YAML with the cluster default configuration.

Prerequisites

- OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.

Procedure

To create a **Channel** object:

1. Create a YAML file and copy the following sample code into it:

```
apiVersion: messaging.knative.dev/v1
kind: Channel
metadata:
  name: example-channel
  namespace: default
```

2. Apply the YAML file:

```
$ oc apply -f <filename>
```

5.9.4. Creating a Kafka channel by using YAML

You can create a Kafka channel by using YAML to create the **KafkaChannel** object.

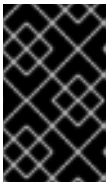
Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, and the **KnativeKafka** custom resource are installed on your OpenShift Container Platform cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.

Procedure

1. Create a **KafkaChannel** object as a YAML file:

```
apiVersion: messaging.knative.dev/v1beta1
kind: KafkaChannel
metadata:
  name: example-channel
  namespace: default
spec:
  numPartitions: 3
  replicationFactor: 1
```



IMPORTANT

Only the **v1beta1** version of the API for **KafkaChannel** objects on OpenShift Serverless is supported. Do not use the **v1alpha1** version of this API, as this version is now deprecated.

2. Apply the **KafkaChannel** YAML file:

```
$ oc apply -f <filename>
```

5.9.5. Deleting a channel by using the Knative CLI

You can delete a channel with the cluster default configuration by using the **kn** CLI.

Procedure

- Delete a channel:

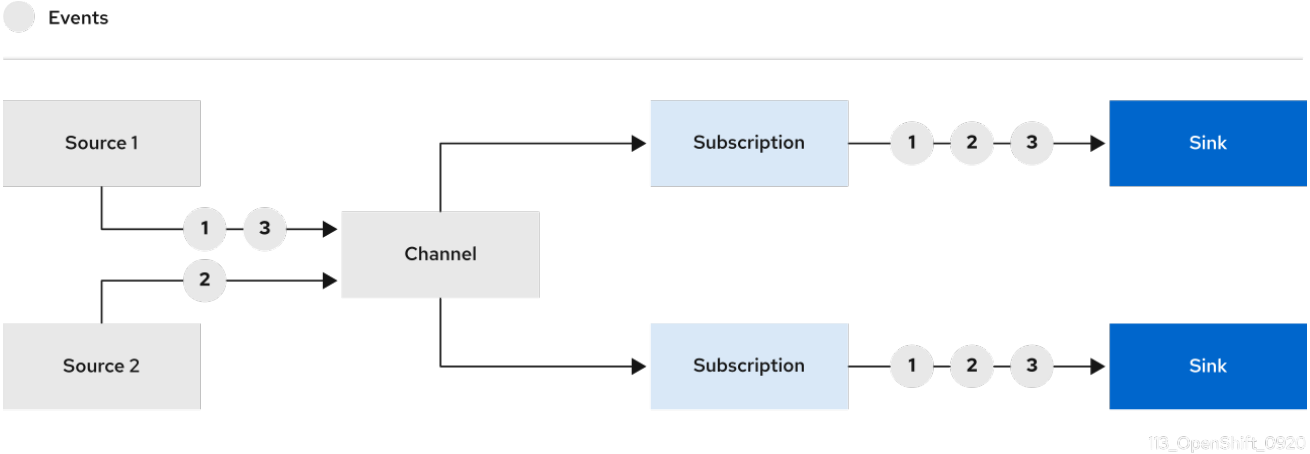
```
$ kn channel delete <channel_name>
```

5.9.6. Next steps

- After you have created a channel, see Using subscriptions for information about creating and using subscriptions for event delivery.

5.10. SUBSCRIPTIONS

After events have been sent to a channel from an event source or producer, these events can be sent to multiple Knative services, or other sinks, by using a subscription.



If a subscriber rejects an event, there are no re-delivery attempts by default. Developers can configure re-delivery attempts by modifying the **delivery** spec in a **Subscription** object.

5.10.1. Creating subscriptions

Developers can create subscriptions that allow event sinks to subscribe to channels and receive events.

5.10.1.1. Creating subscriptions in the Developer perspective

Prerequisites

To create subscriptions using the **Developer** perspective, ensure that:

- The OpenShift Serverless Operator, Knative Serving, and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have logged in to the web console.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.
- You have created an event sink, such as a Knative service, and a channel.

Procedure

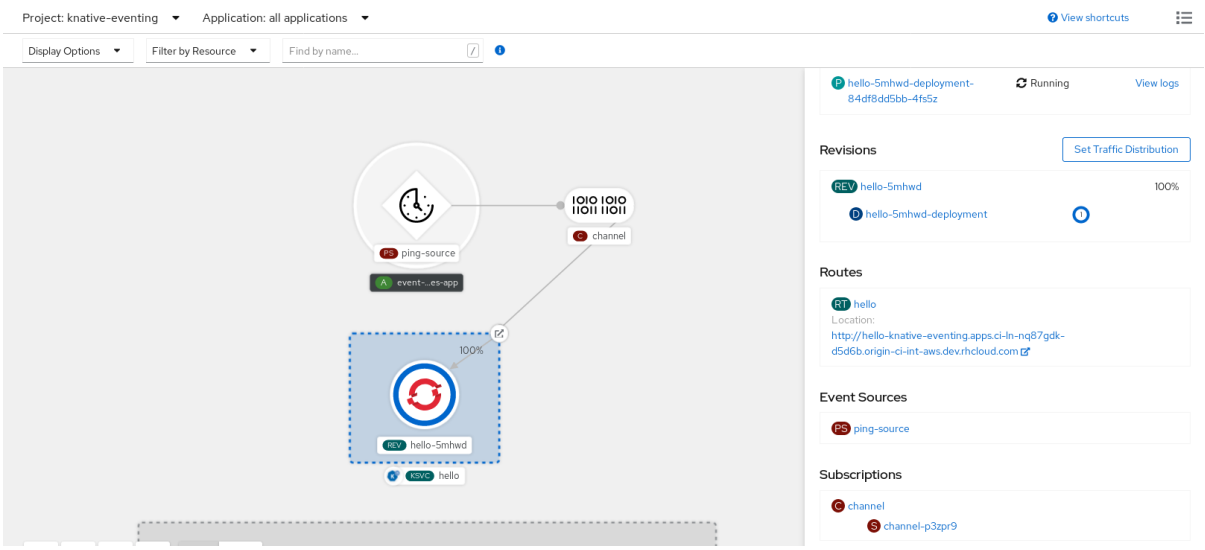
1. In the **Developer** perspective, navigate to the **Topology** page.
2. Create a subscription using one of the following methods:
   a. Hover over the channel that you want to create a subscription for, and drag the arrow. The **Add Subscription** option is displayed.

      i. Select your sink as a subscriber from the drop-down list.
      ii. Click **Add**.

   b. If the service is available in the **Topology** view under the same namespace or project as the channel, click on the channel that you want to create a subscription for, and drag the arrow directly to a service to immediately create a subscription from the channel to that service.

Verification

- After the subscription has been created, you can see it represented as a line that connects the channel to the service in the **Topology** view:



You can view the event source, channel, and subscriptions for the sink by clicking on the service.

5.10.1.2. Creating subscriptions by using the Knative CLI

You can create a subscription to connect a channel to a sink by using the **kn** CLI.

Prerequisites

To create subscriptions using the **kn** CLI, ensure that:

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the **kn** CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.

Procedure

- Create a subscription to connect a sink to a channel:

```
$ kn subscription create <subscription_name> \
  --channel <group:version:kind>:<channel_name> \ 1
  --sink <sink_prefix>:<sink_name> \ 2
  --sink-dead-letter <sink_prefix>:<sink_name> 3
```

1 **--channel** specifies the source for cloud events that should be processed. You must provide the channel name. If you are not using the default **InMemoryChannel** channel that is backed by the **Channel** custom resource, you must prefix the channel name with the **<group:version:kind>** for the specified channel type. For example, this will be **messaging.knative.dev:v1beta1:KafkaChannel** for a Kafka backed channel.

2 **--sink** specifies the target destination to which the event should be delivered. By default, the **<sink_name>** is interpreted as a Knative service of this name, in the same namespace as the subscription. You can specify the type of the sink by using one of the following prefixes:

ksvc
: A Knative service.

channel
A channel that should be used as destination. Only default channel types can be referenced here.

broker
An Eventing broker.

3 Optional: **--sink-dead-letter** is an optional flag that can be used to specify a sink which events should be sent to in cases where events fail to be delivered. For more information, see the OpenShift Serverless *Event delivery* documentation.

Example command

```
$ kn subscription create mysubscription --channel mychannel --sink ksvc:event-display
```

Example output

```
Subscription 'mysubscription' created in namespace 'default'.
```

Verification

- To confirm that the channel is connected to the event sink, or *subscriber*, by a subscription, list the existing subscriptions and inspect the output:

```
$ kn subscription list
```

Example output

```
NAME           CHANNEL           SUBSCRIBER          REPLY   DEAD LETTER SINK   READY   REASON
mysubscription   Channel:mychannel   ksvc:event-display                         True
```

5.10.1.3. Creating subscriptions by using YAML

You can create a subscription to connect a channel to a sink by using YAML.

Procedure

- Create a **Subscription** object.
  - Create a YAML file and copy the following sample code into it:

```
apiVersion: messaging.knative.dev/v1beta1
kind: Subscription
metadata:
  name: my-subscription 1
  namespace: default
spec:
  channel: 2
    apiVersion: messaging.knative.dev/v1beta1
    kind: Channel
    name: example-channel
  delivery: 3
```

```
  deadLetterSink:
    ref:
      apiVersion: serving.knative.dev/v1
      kind: Service
      name: error-handler
  subscriber: 4
    ref:
      apiVersion: serving.knative.dev/v1
      kind: Service
      name: event-display
```

1. Name of the subscription.
2. Configuration settings for the channel that the subscription connects to.
3. Configuration settings for event delivery. This tells the subscription what happens to events that cannot be delivered to the subscriber. When this is configured, events that failed to be consumed are sent to the **deadLetterSink**. The event is dropped, no re-delivery of the event is attempted, and an error is logged in the system. The **deadLetterSink** value must be a Destination.
4. Configuration settings for the subscriber. This is the event sink that events are delivered to from the channel.

- Apply the YAML file:

```
$ oc apply -f <filename>
```

5.10.2. Configuring event delivery failure parameters using subscriptions

Developers can configure event delivery parameters for individual subscriptions by modifying the **delivery** settings for a **Subscription** object.

Example subscription YAML

```
apiVersion: messaging.knative.dev/v1
kind: Subscription
metadata:
  name: <subscription_name>
  namespace: <subscription_namespace>
spec:
  delivery:
    deadLetterSink: 1
      ref:
        apiVersion: serving.knative.dev/v1
        kind: Service
        name: <sink_name>
    backoffDelay: <duration> 2
    backoffPolicy: <policy_type> 3
    retry: <integer> 4
```

1. Configuration settings to enable using a dead letter sink. This tells the subscription what happens to events that cannot be delivered to the subscriber.

When this is configured, events that fail to be delivered are sent to the dead letter sink destination. The destination can be a Knative service or a URI.

2 You can set the **backoffDelay** delivery parameter to specify the time delay before an event delivery retry is attempted after a failure. The duration of the **backoffDelay** parameter is specified using the ISO 8601 format. For example, **PT1S** specifies a 1 second delay.

3 The **backoffPolicy** delivery parameter can be used to specify the retry back off policy. The policy can be specified as either **linear** or **exponential**. When using the **linear** back off policy, the back off delay is the time interval specified between retries. When using the **exponential** back off policy, the back off delay is equal to **backoffDelay*2^<numberOfRetries>**.

4 The number of times that event delivery is retried before the event is sent to the dead letter sink.

5.10.3. Describing subscriptions by using the Knative CLI

You can print information about a subscription in the terminal by using the **kn** CLI.

Prerequisites

To describe subscriptions using the **kn** CLI, ensure that:

- You have installed the **kn** CLI.
- You have created a subscription in your cluster.

Procedure

- Describe a subscription:

```
$ kn subscription describe <subscription_name>
```

Example output

```
Name:            my-subscription
Namespace:       default
Annotations:     messaging.knative.dev/creator=openshift-user,
messaging.knative.dev/lastModifier=min ...
Age:             43s
Channel:         Channel:my-channel (messaging.knative.dev/v1)
Subscriber:
  URI:           http://edisplay.default.example.com
Reply:
  Name:          default
  Resource:      Broker (eventing.knative.dev/v1)
DeadLetterSink:
  Name:          my-sink
  Resource:      Service (serving.knative.dev/v1)

Conditions:
  OK TYPE                 AGE REASON
  ++ Ready                43s
  ++ AddedToChannel       43s
  ++ ChannelReady         43s
  ++ ReferencesResolved   43s
```

5.10.4. Listing subscriptions by using the Knative CLI

You can list existing subscriptions on your cluster by using the **kn** CLI.

Prerequisites

- You have installed the **kn** CLI.

Procedure

- List subscriptions on your cluster:

```
$ kn subscription list
```

Example output

```
NAME            CHANNEL            SUBSCRIBER          REPLY   DEAD LETTER SINK
READY   REASON
mysubscription  Channel:mychannel  ksvc:event-display                  True
```

5.10.5. Updating subscriptions by using the Knative CLI

You can update a subscription by using the **kn** CLI.

Prerequisites

To update subscriptions using the **kn** CLI, ensure that:

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the **kn** CLI.
- You have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.
- You have created a subscription.

Procedure

- Update a subscription:

```
$ kn subscription update <subscription_name> \
  --sink <sink_prefix>:<sink_name> \ 1
  --sink-dead-letter <sink_prefix>:<sink_name> 2
```

1 **--sink** specifies the updated target destination to which the event should be delivered. You can specify the type of the sink by using one of the following prefixes:

ksvc
: A Knative service.

channel

A channel that should be used as destination. Only default channel types can be referenced here.

broker
An Eventing broker.

2 Optional: **--sink-dead-letter** is an optional flag that can be used to specify a sink which events should be sent to in cases where events fail to be delivered. For more information, see the OpenShift Serverless *Event delivery* documentation.

Example command

```
$ kn subscription update mysubscription --sink ksvc:event-display
```

5.10.6. Deleting subscriptions by using the Knative CLI

You can delete a subscription by using the **kn** CLI.

Procedure

- Delete a subscription:

```
$ kn subscription delete <subscription_name>
```

5.11. KNATIVE KAFKA

Knative Kafka functionality is available in an OpenShift Serverless installation if a cluster administrator has installed the **KnativeKafka** custom resource.

Knative Kafka provides additional options, such as:

- Kafka event source
- Kafka channel

NOTE

Knative Kafka is not currently supported for IBM Z and IBM Power Systems.

5.11.1. Event delivery and retries

Using Kafka components in an event-driven architecture provides "at least once" event delivery. This means that operations are retried until a return code value is received. This makes applications more resilient to lost events; however, it might result in duplicate events being sent.

For the Kafka event source, there is a fixed number of retries for event delivery by default. For Kafka channels, retries are only performed if they are configured in the Kafka channel **Delivery** spec.

5.11.2. Using a Kafka event source

You can create a Knative Kafka event source that reads events from an Apache Kafka cluster and passes these events to a sink.

5.11.2.1. Creating a Kafka event source by using the web console

You can create and verify a Kafka event source from the OpenShift Container Platform web console.

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, and the **KnativeKafka** custom resource are installed on your cluster.
- You have logged in to the web console.
- You are in the **Developer** perspective.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.

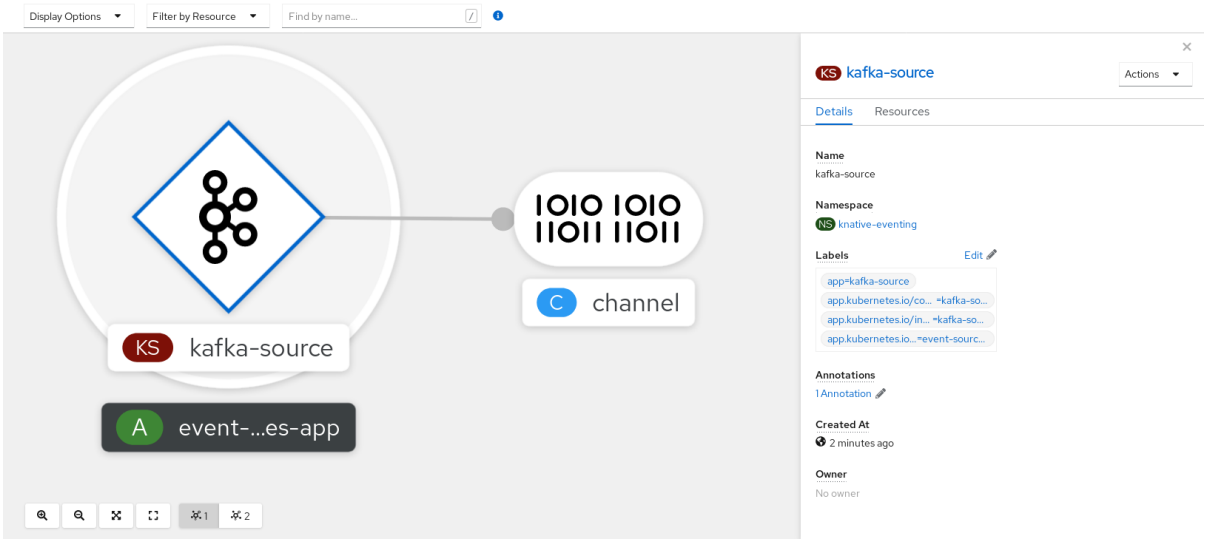
Procedure

1. Navigate to the **Add** page and select **Event Source**.
2. In the **Event Sources** page, select **Kafka Source** in the **Type** section.
3. Configure the **Kafka Source** settings:
    a. Add a comma-separated list of **Bootstrap Servers**.
    b. Add a comma-separated list of **Topics**.
    c. Add a **Consumer Group**.
    d. Select the **Service Account Name** for the service account that you created.
    e. Select the **Sink** for the event source. A **Sink** can be either a **Resource**, such as a channel, broker, or service, or a **URI**.
    f. Enter a **Name** for the Kafka event source.
4. Click **Create**.

Verification

You can verify that the Kafka event source was created and is connected to the sink by viewing the **Topology** page.

1. In the **Developer** perspective, navigate to **Topology**.
2. View the Kafka event source and sink.



5.11.2.2. Creating a Kafka event source by using the Knative CLI

This section describes how to create a Kafka event source by using the **kn** command.

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, Knative Serving, and the **KnativeKafka** custom resource (CR) are installed on your cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.
- You have access to a Red Hat AMQ Streams (Kafka) cluster that produces the Kafka messages you want to import.

Procedure

1. To verify that the Kafka event source is working, create a Knative service that dumps incoming events into the service logs:

```
$ kn service create event-display \
    --image quay.io/openshift-knative/knative-eventing-sources-event-display
```

2. Create a **KafkaSource** CR:

```
$ kn source kafka create <kafka_source_name> \
    --servers <cluster_kafka_bootstrap>.kafka.svc:9092 \
    --topics <topic_name> --consumergroup my-consumer-group \
    --sink event-display
```

NOTE

Replace the placeholder values in this command with values for your source name, bootstrap servers, and topics.

The **--servers**, **--topics**, and **--consumergroup** options specify the connection parameters to the Kafka cluster. The **--consumergroup** option is optional.

3. Optional: View details about the **KafkaSource** CR you created:

```
$ kn source kafka describe <kafka_source_name>
```

Example output

```
Name:              example-kafka-source
Namespace:         kafka
Age:               1h
BootstrapServers:  example-cluster-kafka-bootstrap.kafka.svc:9092
Topics:            example-topic
ConsumerGroup:     example-consumer-group

Sink:
  Name:       event-display
  Namespace:  default
  Resource:   Service (serving.knative.dev/v1)

Conditions:
  OK TYPE            AGE REASON
  ++ Ready           1h
  ++ Deployed        1h
  ++ SinkProvided    1h
```

Verification steps

1. Trigger the Kafka instance to send a message to the topic:

```
$ oc -n kafka run kafka-producer \
    -ti --image=quay.io/strimzi/kafka:latest-kafka-2.7.0 --rm=true \
    --restart=Never -- bin/kafka-console-producer.sh \
    --broker-list <cluster_kafka_bootstrap>:9092 --topic my-topic
```

Enter the message in the prompt. This command assumes that:

- The Kafka cluster is installed in the **kafka** namespace.
- The **KafkaSource** object has been configured to use the **my-topic** topic.

2. Verify that the message arrived by viewing the logs:

```
$ oc logs $(oc get pod -o name | grep event-display) -c user-container
```

Example output

```
☁  cloudevents.Event
Validation: valid
Context Attributes,
  specversion: 1.0
  type: dev.knative.kafka.event
  source: /apis/v1/namespaces/default/kafkasources/example-kafka-source#example-topic
  subject: partition:46#0
  id: partition:46/offset:0
  time: 2021-03-10T11:21:49.4Z
```

```
Extensions,
  traceparent: 00-161ff3815727d8755848ec01c866d1cd-7ff3916c44334678-00
Data,
  Hello!
```

5.11.2.2.1. Knative CLI --sink flag

When you create an event-producing custom resource by using the Knative (**kn**) CLI, you can specify a sink where events are sent to from that resource, by using the **--sink** flag.

The following example creates a sink binding that uses a service, **http://event-display.svc.cluster.local**, as the sink:

Example command using the --sink flag

```
$ kn source binding create bind-heartbeat \
  --namespace sinkbinding-example \
  --subject "Job:batch/v1:app=heartbeat-cron" \
  --sink http://event-display.svc.cluster.local \ 1
  --ce-override "sink=bound"
```

1 **svc** in **http://event-display.svc.cluster.local** determines that the sink is a Knative service. Other default sink prefixes include **channel**, and **broker**.

5.11.2.3. Creating a Kafka event source by using YAML

You can create a Kafka event source by using YAML.

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, and the **KnativeKafka** custom resource are installed on your cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.

Procedure

1. Create a **KafkaSource** object as a YAML file:

```
apiVersion: sources.knative.dev/v1beta1
kind: KafkaSource
metadata:
  name: <source_name>
spec:
  consumerGroup: <group_name> 1
  bootstrapServers:
  - <list_of_bootstrap_servers>
  topics:
  - <list_of_topics> 2
  sink:
  - <list_of_sinks> 3
```

1. A consumer group is a group of consumers that use the same group ID, and consume data from a topic.
2. A topic provides a destination for the storage of data. Each topic is split into one or more partitions.
3. A sink specifies where events are sent to from a source.

IMPORTANT

Only the **v1beta1** version of the API for **KafkaSource** objects on OpenShift Serverless is supported. Do not use the **v1alpha1** version of this API, as this version is now deprecated.

Example KafkaSource object

```
apiVersion: sources.knative.dev/v1beta1
kind: KafkaSource
metadata:
  name: kafka-source
spec:
  consumerGroup: knative-group
  bootstrapServers:
  - my-cluster-kafka-bootstrap.kafka:9092
  topics:
  - knative-demo-topic
  sink:
    ref:
      apiVersion: serving.knative.dev/v1
      kind: Service
      name: event-display
```

2. Apply the **KafkaSource** YAML file:

```
$ oc apply -f <filename>
```

Verification

- Verify that the Kafka event source was created by entering the following command:

```
$ oc get pods
```

Example output

```
NAME                                 READY   STATUS    RESTARTS   AGE
kafkasource-kafka-source-5ca0248f-...   1/1     Running   0          13m
```

5.11.3. Additional resources

- See the Red Hat AMQ Streams documentation for more information about Kafka concepts.
- See Event sources.

CHAPTER 6. ADMINISTER

6.1. CONFIGURING OPENSHIFT SERVERLESS

The OpenShift Serverless Operator manages the global configuration of a Knative installation, including propagating values from the **KnativeServing** and **KnativeEventing** custom resources to system config maps.

Any updates to config maps which are applied manually are overwritten by the Operator. However, modifying the Knative custom resources allows you to set values for these config maps.

Knative has multiple config maps that are named with the prefix **config-**.

All Knative config maps are created in the same namespace as the custom resource that they apply to. For example, if the **KnativeServing** custom resource is created in the **knative-serving** namespace, all Knative Serving config maps are also created in this namespace.

The **spec.config** in the Knative custom resources have one **<name>** entry for each config map, named **config-<name>**, with a value which is be used for the config map **data**.

Examples of global configuration

You can specify that the **KnativeServing** custom resource uses the **config-domain** config map as follows:

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
spec:
  config:
    domain: 1
      example.org: |
        selector:
          app: prod
      example.com: ""
```

1 Specifies the **config-domain** config map.

You can apply values to multiple config maps. This example sets **stable-window** to 60s in the **config-autoscaler** config map, as well as specifying the **config-domain** config map:

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
spec:
  config:
    domain: 1
      example.org: |
        selector:
          app: prod
```

```
    example.com: ""
  autoscaler: 2
    stable-window: "60s"
```

1 Specifies the **config-domain** config map.

2 Specifies the **stable-window** setting in the **config-autoscaler** config map.

6.2. CONFIGURING CHANNEL DEFAULTS

If you have cluster administrator permissions, you can set default options for channels, either for the whole cluster or for a specific namespace. These options are modified using config maps.

6.2.1. Configuring the default channel implementation

The **default-ch-webhook** config map can be used to specify the default channel implementation for the cluster or for one or more namespaces.

You can make changes to the **knative-eventing** namespace config maps, including the **default-ch-webhook** config map, by using the OpenShift Serverless Operator to propagate changes. To do this, you must modify the **KnativeEventing** custom resource.

Prerequisites

- You have cluster administrator permissions on OpenShift Container Platform.
- You have installed the OpenShift Serverless Operator and Knative Eventing on your cluster.

Procedure

- Modify the **KnativeEventing** custom resource to add configuration details for the **default-ch-webhook** config map:

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeEventing
metadata:
  name: knative-eventing
  namespace: knative-eventing
spec:
  config: 1
    default-ch-webhook: 2
      default-ch-config: |
        clusterDefault: 3
          apiVersion: messaging.knative.dev/v1
          kind: InMemoryChannel
          spec:
            delivery:
              backoffDelay: PT0.5S
              backoffPolicy: exponential
              retry: 5
        namespaceDefaults: 4
          my-namespace:
            apiVersion: messaging.knative.dev/v1beta1
```

```
    kind: KafkaChannel
    spec:
      numPartitions: 1
      replicationFactor: 1
```

1. In **spec.config**, you can specify the config maps that you want to add modified configurations for.
2. The **default-ch-webhook** config map can be used to specify the default channel implementation for the cluster or for one or more namespaces.
3. The cluster-wide default channel type configuration. In this example, the default channel implementation for the cluster is **InMemoryChannel**.
4. The namespace-scoped default channel type configuration. In this example, the default channel implementation for the **my-namespace** namespace is **KafkaChannel**.

IMPORTANT

Configuring a namespace-specific default overrides any cluster-wide settings.

6.3. KNATIVE KAFKA

In addition to the Knative Eventing components that are provided as part of a core OpenShift Serverless installation, cluster administrators can install the **KnativeKafka** custom resource (CR).

The **KnativeKafka** CR provides users with additional options, such as:

- Kafka event source
- Kafka channel

NOTE

Knative Kafka is not currently supported for IBM Z and IBM Power Systems.

6.3.1. Installing Knative Kafka

The OpenShift Serverless Operator provides the Knative Kafka API that can be used to create a **KnativeKafka** custom resource:

Example KnativeKafka custom resource

```
apiVersion: operator.serverless.openshift.io/v1alpha1
kind: KnativeKafka
metadata:
  name: knative-kafka
  namespace: knative-eventing
spec:
  channel:
    enabled: true 1
```

```
    bootstrapServers: <bootstrap_servers> 2
  source:
    enabled: true 3
```

1. Enables developers to use the **KafkaChannel** channel type in the cluster.
2. A comma-separated list of bootstrap servers from your AMQ Streams cluster.
3. Enables developers to use the **KafkaSource** event source type in the cluster.

Prerequisites

- You have installed OpenShift Serverless, including Knative Eventing, in your OpenShift Container Platform cluster.
- You have access to a Red Hat AMQ Streams cluster.
- You have cluster administrator permissions on OpenShift Container Platform.
- You are logged in to the OpenShift Container Platform web console.

Procedure

1. In the **Administrator** perspective, navigate to **Operators → Installed Operators**.
2. Check that the **Project** dropdown at the top of the page is set to **Project: knative-eventing**.
3. In the list of **Provided APIs** for the OpenShift Serverless Operator, find the **Knative Kafka** box and click **Create Instance**.
4. Configure the **KnativeKafka** object in the **Create Knative Kafka** page.

IMPORTANT

To use the Kafka channel or Kafka source on your cluster, you must toggle the **Enable** switch for the options you want to use to **true**. These switches are set to **false** by default. Additionally, to use the Kafka channel, you must specify the Boostrap Servers.

   a. Using the form is recommended for simpler configurations that do not require full control of **KnativeKafka** object creation.

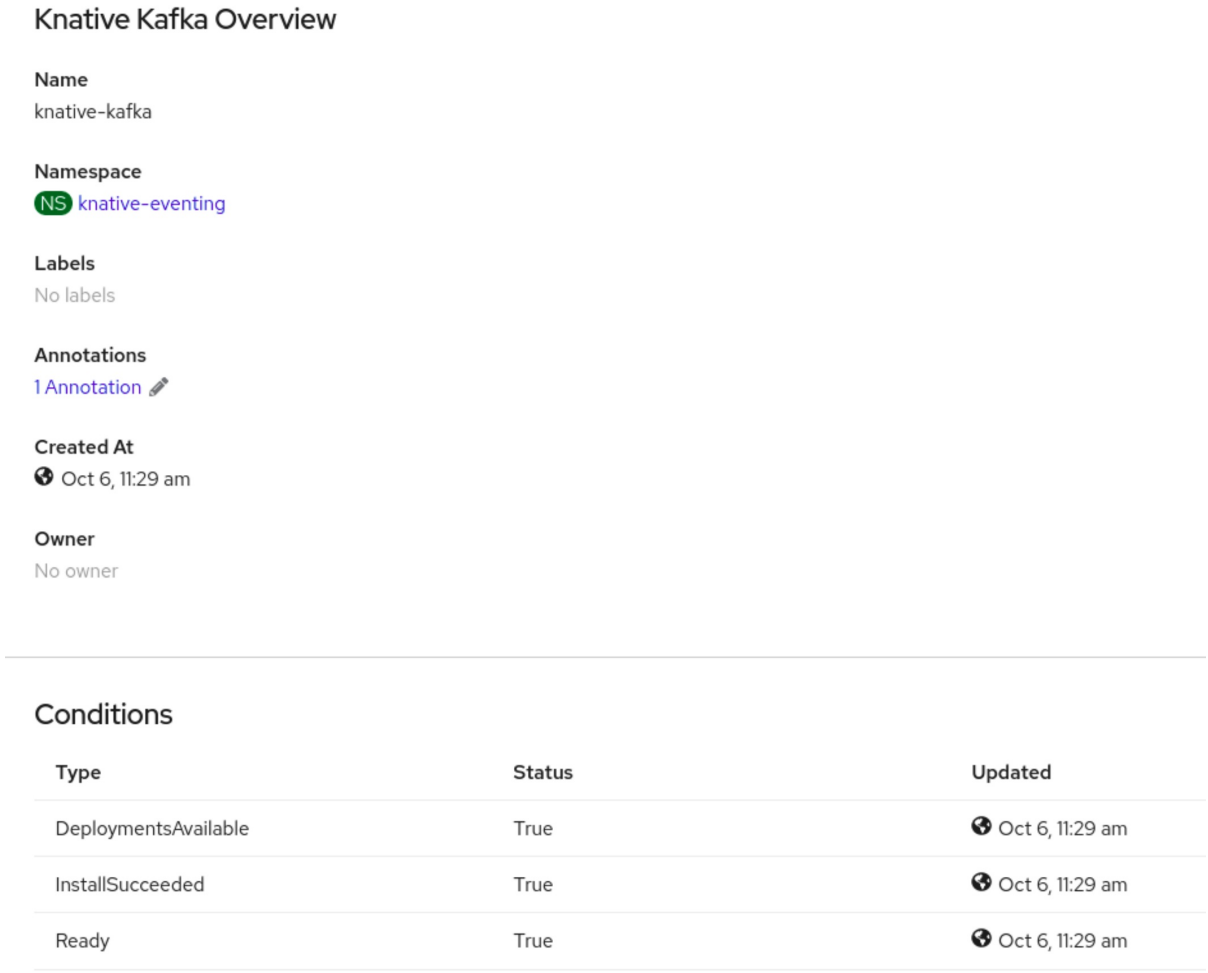
   b. Editing the YAML is recommended for more complex configurations that require full control of **KnativeKafka** object creation. You can access the YAML by clicking the **Edit YAML** link in the top right of the **Create Knative Kafka** page.

5. Click **Create** after you have completed any of the optional configurations for Kafka. You are automatically directed to the **Knative Kafka** tab where **knative-kafka** is in the list of resources.

Verification

1. Click on the **knative-kafka** resource in the **Knative Kafka** tab. You are automatically directed to the **Knative Kafka Overview** page.

2. View the list of **Conditions** for the resource and confirm that they have a status of **True**.



If the conditions have a status of **Unknown** or **False**, wait a few moments to refresh the page.

3. Check that the Knative Kafka resources have been created:

```
$ oc get pods -n knative-eventing
```

Example output

```
NAME                                      READY   STATUS    RESTARTS   AGE
kafka-ch-controller-85f879d577-xcbjh      1/1     Running   0          44s
kafka-ch-dispatcher-55d76d7db8-ggqjl      1/1     Running   0          44s
kafka-controller-manager-bc994c465-pt7qd  1/1     Running   0          40s
kafka-webhook-54646f474f-wr7bb            1/1     Running   0          42s
```

6.3.2. Additional resources

- See the Red Hat AMQ Streams documentation for more information about Kafka concepts.

6.4. CREATING EVENTING COMPONENTS IN THE ADMINISTRATOR PERSPECTIVE

You can create Knative Eventing components with OpenShift Serverless in the **Administrator** perspective of the web console.

6.4.1. Creating an event source by using the Administrator perspective

If you have cluster administrator permissions, you can create an event source by using the Administrator perspective in the web console.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have cluster administrator permissions for OpenShift Container Platform.

Procedure

1. In the **Administrator** perspective of the OpenShift Container Platform web console, navigate to **Serverless → Eventing**.
2. In the **Create** list, select **Event Source**. You will be directed to the **Event Sources** page.
3. Select the event source type that you want to create.

See Event sources for more information about which event source types are supported and can be created by using OpenShift Serverless.

6.4.2. Creating a broker by using the Administrator perspective

If you have cluster administrator permissions, you can create a broker by using the Administrator perspective in the web console.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have cluster administrator permissions for OpenShift Container Platform.

Procedure

1. In the **Administrator** perspective of the OpenShift Container Platform web console, navigate to **Serverless → Eventing**.
2. In the **Create** list, select **Broker**. You will be directed to the **Create Broker** page.
3. Optional: Modify the YAML configuration for the broker.
4. Click **Create**.

6.4.3. Creating a trigger by using the Administrator perspective

If you have cluster administrator permissions and have created a broker, you can create a trigger to connect your broker to a subscriber by using the Administrator perspective in the web console.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have cluster administrator permissions for OpenShift Container Platform.
- You have created a broker.
- You have created a Knative service to use as a subscriber.

Procedure

1. In the **Administrator** perspective of the OpenShift Container Platform web console, navigate to **Serverless → Eventing**.
2. In the **Broker** tab, select the Options menu  for the broker that you want to add a trigger to.
3. Click **Add Trigger** in the list.
4. In the **Add Trigger** dialogue box, select a **Subscriber** for the trigger. The subscriber is the Knative service that will receive events from the broker.
5. Click **Add**.

6.4.4. Creating a channel by using the Administrator perspective

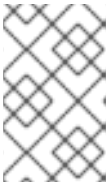
If you have cluster administrator permissions, you can create a channel by using the Administrator perspective in the web console.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have cluster administrator permissions for OpenShift Container Platform.

Procedure

1. In the **Administrator** perspective of the OpenShift Container Platform web console, navigate to **Serverless → Eventing**.
2. In the **Create** list, select **Channel**. You will be directed to the **Channel** page.
3. Select the type of **Channel** object that you want to create from the **Type** drop-down.



NOTE

Currently only **InMemoryChannel** channel objects are supported by default. Kafka channels are available if you have installed Knative Kafka on OpenShift Serverless.

4. Click **Create**.

6.4.5. Creating a subscription by using the Administrator perspective

If you have cluster administrator permissions and have created a channel, you can create a subscription to connect your broker to a subscriber by using the Administrator perspective in the web console.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have cluster administrator permissions for OpenShift Container Platform.
- You have created a channel.
- You have created a Knative service to use as a subscriber.

Procedure

1. In the **Administrator** perspective of the OpenShift Container Platform web console, navigate to **Serverless → Eventing**.
2. In the **Channel** tab, select the Options menu  for the channel that you want to add a subscription to.
3. Click **Add Subscription** in the list.
4. In the **Add Subscription** dialogue box, select a **Subscriber** for the subscription. The subscriber is the Knative service that will receive events from the channel.
5. Click **Add**.

6.4.6. Additional resources

- See Brokers.
- See Subscriptions.
- See Triggers.
- See Channels.

6.5. CREATING KNATIVE SERVING COMPONENTS IN THE ADMINISTRATOR PERSPECTIVE

If you have cluster administrator permissions on an OpenShift Container Platform cluster, you can create Knative Serving components with OpenShift Serverless in the **Administrator** perspective of the web console or by using the **kn** and **oc** CLIs.

6.5.1. Creating serverless applications using the Administrator perspective

Prerequisites

To create serverless applications using the **Administrator** perspective, ensure that you have completed the following steps.

- The OpenShift Serverless Operator and Knative Serving are installed.
- You have logged in to the web console and are in the **Administrator** perspective.

Procedure

1. Navigate to the **Serverless → Serving** page.
2. In the **Create** list, select **Service**.
3. Manually enter YAML or JSON definitions, or by dragging and dropping a file into the editor.
4. Click **Create**.

6.6. CONFIGURING THE KNATIVE SERVING CUSTOM RESOURCE

This guide describes how cluster administrators can manage settings for developer-created custom resources (CRs) that are created from the Knative Serving CR.

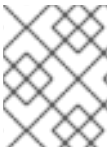
6.6.1. Overriding system deployment configurations

You can override the default configurations for some specific deployments by modifying the **deployments** spec in the **KnativeServing** custom resource (CR).

Currently, overriding default configuration settings for the **replicas**, **labels**, **annotations**, and **nodeSelector** fields are supported.

In the following example, a **KnativeServing** CR overrides the **webhook** deployment so that:

- The deployment has 3 replicas.
- The label is set to **example-label: label**.
- The label **example-label: label** is added.
- The **nodeSelector** field is set to select nodes with the **disktype: hdd** label.



NOTE

The **KnativeServing** CR label and annotation settings override the deployment's labels and annotations for both the deployment itself and the resulting pods.

KnativeServing CR example

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: ks
  namespace: knative-serving
spec:
  high-availability:
    replicas: 2
```

```
  deployments:
  - name: webhook
    replicas: 3
    labels:
      example-label: label
    annotations:
      example-annotation: annotation
    nodeSelector:
      disktype: hdd
```

6.6.2. Configuring the EmptyDir extension

This extension controls whether **emptyDir** volumes can be specified.

To enable using **emptyDir** volumes, you must modify the **KnativeServing** custom resource (CR) to include the following YAML:

```
...
spec:
  config:
    features:
      "kubernetes.podspec-volumes-emptydir": enabled
...
```

6.6.3. HTTPS redirection global settings

You can enable HTTPS redirection for all services on the cluster by configuring the **httpProtocol** spec for the **KnativeServing** custom resource, as shown in the following example:

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
spec:
  config:
    network:
      httpProtocol: "redirected"
...
```

6.6.4. Additional resources

- See Managing resources from custom resource definitions .

6.7. AUTOSCALING

As a cluster administrator, you can set global and per-namespace default configurations for autoscaling features by modifying the **KnativeServing** custom resource (CR). This propagates changes to the relevant config maps.

6.7.1. Enabling scale-to-zero

Cluster administrators can enable or disable scale-to-zero globally for the cluster.

Prerequisites

- You have installed OpenShift Serverless Operator and Knative Serving on your cluster.
- You have cluster administrator permissions.
- You are using the default Knative Pod Autoscaler. The scale to zero feature is not available if you are using the Kubernetes Horizontal Pod Autoscaler.

Procedure

- Modify the **enable-scale-to-zero** spec in the **KnativeServing** CR:

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
spec:
  config:
    autoscaler:
      enable-scale-to-zero: "false" 1
```

1 The **enable-scale-to-zero** spec can be either **"true"** or **"false"**. If set to true, scale-to-zero is enabled. If set to false, applications are scaled down to the configured *minimum scale bound*. The default value is **"true"**.

6.7.2. Configuring the scale-to-zero grace period

This setting specifies an upper bound time limit that Knative waits for scale-from-zero machinery to be in place before the last replica of an application is removed.

Prerequisites

- You have installed OpenShift Serverless Operator and Knative Serving on your cluster.
- You have cluster administrator permissions.
- You are using the default Knative Pod Autoscaler. The scale to zero feature is not available if you are using the Kubernetes Horizontal Pod Autoscaler.

Procedure

- Modify the **scale-to-zero-grace-period** spec in the **KnativeServing** CR:

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
spec:
  config:
    autoscaler:
      scale-to-zero-grace-period: "30s" 1
```

1 The grace period time in seconds. The default value is 30 seconds.

6.8. INTEGRATING SERVICE MESH WITH OPENSHIFT SERVERLESS

Using Service Mesh with OpenShift Serverless enables developers to configure additional networking and routing options.

The OpenShift Serverless Operator provides Kourier as the default ingress for Knative. However, you can use Service Mesh with OpenShift Serverless whether Kourier is enabled or not. Integrating with Kourier disabled allows you to configure additional networking and routing options that the Kourier ingress does not support.

IMPORTANT

OpenShift Serverless only supports the use of Red Hat OpenShift Service Mesh functionality that is explicitly documented in this guide, and does not support other undocumented features.

6.8.1. Integrating Service Mesh with OpenShift Serverless natively

Integrating Service Mesh with OpenShift Serverless natively, without Kourier, allows you to use additional networking and routing options that are not supported by the default Kourier ingress, such as mTLS functionality.

The examples in the following procedures use the domain **example.com**. The example certificate for this domain is used as a certificate authority (CA) that signs the subdomain certificate.

To complete and verify these procedures in your deployment, you need either a certificate signed by a widely trusted public CA or a CA provided by your organization. Example commands must be adjusted according to your domain, subdomain, and CA.

You must configure the wildcard certificate to match the domain of your OpenShift Container Platform cluster. For example, if your OpenShift Container Platform console address is **https://console-openshift-console.apps.openshift.example.com**, you must configure the wildcard certificate so that the domain is ***.apps.openshift.example.com**. For more information about configuring wildcard certificates, see the following topic about *Creating a certificate to encrypt incoming external traffic* .

If you want to use any domain name, including those which are not subdomains of the default OpenShift Container Platform cluster domain, you must set up domain mapping for those domains. For more information, see the OpenShift Serverless documentation about Creating a custom domain mapping .

6.8.1.1. Creating a certificate to encrypt incoming external traffic

By default, the Service Mesh mTLS feature only secures traffic inside of the Service Mesh itself, between the ingress gateway and individual pods that have sidecars. To encrypt traffic as it flows into the OpenShift Container Platform cluster, you must generate a certificate before you enable the OpenShift Serverless and Service Mesh integration.

Procedure

1. Create a root certificate and private key that signs the certificates for your Knative services:

```
$ openssl req -x509 -sha256 -nodes -days 365 -newkey rsa:2048 \
    -subj '/O=Example Inc./CN=example.com' \
    -keyout root.key \
    -out root.crt
```

2. Create a wildcard certificate:

```
$ openssl req -nodes -newkey rsa:2048 \
    -subj "/CN=*.apps.openshift.example.com/O=Example Inc." \
    -keyout wildcard.key \
    -out wildcard.csr
```

3. Sign the wildcard certificate:

```
$ openssl x509 -req -days 365 -set_serial 0 \
    -CA root.crt \
    -CAkey root.key \
    -in wildcard.csr \
    -out wildcard.crt
```

4. Create a secret by using the wildcard certificate:

```
$ oc create -n istio-system secret tls wildcard-certs \
    --key=wildcard.key \
    --cert=wildcard.crt
```

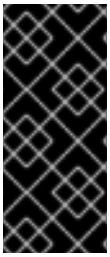
This certificate is picked up by the gateways created when you integrate OpenShift Serverless with Service Mesh, so that the ingress gateway serves traffic with this certificate.

6.8.1.2. Integrating Service Mesh with OpenShift Serverless

You can integrate Service Mesh with OpenShift Serverless without using Kourier by completing the following procedure.

Prerequisites

- You have installed the OpenShift Serverless Operator on your OpenShift Container Platform cluster.
- You have installed Red Hat OpenShift Service Mesh. OpenShift Serverless with Service Mesh only is supported for use with Red Hat OpenShift Service Mesh version 2.0.5 or higher.



IMPORTANT

Do not install the Knative Serving component before completing the following procedures. There are additional steps required when creating the **KnativeServing** custom resource defintion (CRD) to integrate Knative Serving with Service Mesh, which are not covered in the general Knative Serving installation procedure of the *Administration guide*.

Procedure

1. Create a **ServiceMeshControlPlane** object in the **istio-system** namespace. If you want to use the mTLS functionality, this must be enabled for the **istio-system** namespace.
2. Add the namespaces that you would like to integrate with Service Mesh to the **ServiceMeshMemberRoll** object as members:

```
apiVersion: maistra.io/v1
```

```
kind: ServiceMeshMemberRoll
metadata:
  name: default
  namespace: istio-system
spec:
  members: 1
    - knative-serving
    - <namespace>
```

1 A list of namespaces to be integrated with Service Mesh.

IMPORTANT

This list of namespaces must include the **knative-serving** namespace.

3. Apply the **ServiceMeshMemberRoll** resource:

```
$ oc apply -f <filename>
```

4. Create the necessary gateways so that Service Mesh can accept traffic:

Example knative-local-gateway object using HTTP

```
apiVersion: networking.istio.io/v1alpha3
kind: Gateway
metadata:
  name: knative-ingress-gateway
  namespace: knative-serving
spec:
  selector:
    istio: ingressgateway
  servers:
    - port:
        number: 443
        name: https
        protocol: HTTPS
      hosts:
        - "*"
      tls:
        mode: SIMPLE
        credentialName: <wildcard_certs> 1
---
apiVersion: networking.istio.io/v1alpha3
kind: Gateway
metadata:
 name: knative-local-gateway
 namespace: knative-serving
spec:
 selector:
   istio: ingressgateway
 servers:
   - port:
       number: 8081
```

```
      name: http
      protocol: HTTP 2
    hosts:
     - "*"
---
apiVersion: v1
kind: Service
metadata:
 name: knative-local-gateway
 namespace: istio-system
 labels:
   experimental.istio.io/disable-gateway-port-translation: "true"
spec:
 type: ClusterIP
 selector:
   istio: ingressgateway
 ports:
   - name: http2
     port: 80
     targetPort: 8081
```

1 Add the name of your wildcard certificate.

2 The **knative-local-gateway** serves HTTP traffic. Using HTTP means that traffic coming from outside of Service Mesh, but using an internal hostname, such as **example.default.svc.cluster.local**, is not encrypted. You can set up encryption for this path by creating another wildcard certificate and an additional gateway that uses a different **protocol** spec.

Example knative-local-gateway object using HTTPS

```
apiVersion: networking.istio.io/v1alpha3
kind: Gateway
metadata:
  name: knative-local-gateway
  namespace: knative-serving
spec:
  selector:
    istio: ingressgateway
  servers:
    - port:
        number: 443
        name: https
        protocol: HTTPS
      hosts:
        - "*"
      tls:
        mode: SIMPLE
        credentialName: <wildcard_certs>
```

5. Apply the **Gateway** resources:

```
$ oc apply -f <filename>
```

6. Install Knative Serving by creating the following **KnativeServing** custom resource definition (CRD), which also enables the Istio integration:

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
spec:
  ingress:
    istio:
      enabled: true 1
  deployments: 2
  - name: activator
    annotations:
      "sidecar.istio.io/inject": "true"
      "sidecar.istio.io/rewriteAppHTTPProbers": "true"
  - name: autoscaler
    annotations:
      "sidecar.istio.io/inject": "true"
      "sidecar.istio.io/rewriteAppHTTPProbers": "true"
```

1. Enables Istio integration.
2. Enables sidecar injection for Knative Serving data plane pods.

7. Apply the **KnativeServing** resource:

```
$ oc apply -f <filename>
```

8. Create a Knative Service that has sidecar injection enabled and uses a pass-through route:

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: <service_name>
  namespace: <namespace> 1
  annotations:
    serving.knative.openshift.io/enablePassthrough: "true" 2
spec:
  template:
    metadata:
      annotations:
        sidecar.istio.io/inject: "true" 3
        sidecar.istio.io/rewriteAppHTTPProbers: "true"
    spec:
      containers:
      - image: <image_url>
```

1. A namespace that is part of the Service Mesh member roll.
2. Instructs Knative Serving to generate an OpenShift Container Platform pass-through enabled route, so that the certificates you have generated are served through the ingress gateway directly.

3 Injects Service Mesh sidecars into the Knative service pods.

9. Apply the **Service** resource:

```
$ oc apply -f <filename>
```

Verification

- Access your serverless application by using a secure connection that is now trusted by the CA:

```
$ curl --cacert root.crt <service_url>
```

Example command

```
$ curl --cacert root.crt https://hello-default.apps.openshift.example.com
```

Example output

```
Hello Openshift!
```

6.8.1.3. Enabling Knative Serving metrics when using Service Mesh with mTLS

If Service Mesh is enabled with mTLS, metrics for Knative Serving are disabled by default, because Service Mesh prevents Prometheus from scraping metrics. This section shows how to enable Knative Serving metrics when using Service Mesh and mTLS.

Prerequisites

- You have installed the OpenShift Serverless Operator on your OpenShift Container Platform cluster.
- You have installed Red Hat OpenShift Service Mesh with the mTLS functionality enabled.
- You have installed Knative Serving.

Procedure

1. Specify **prometheus** as the **metrics.backend-destination** in the **observability** spec of the Knative Serving custom resource (CR):

```
apiVersion: operator.knative.dev/v1beta1
kind: KnativeServing
metadata:
  name: knative-serving
spec:
  config:
    observability:
      metrics.backend-destination: "prometheus"
```

   This step prevents metrics from being disabled by default.

2. Apply the following network policy to allow traffic from the Prometheus namespace:

```
apiVersion: networking.k8s.io/v1
kind: NetworkPolicy
metadata:
  name: allow-from-openshift-monitoring-ns
  namespace: knative-serving
spec:
  ingress:
  - from:
    - namespaceSelector:
        matchLabels:
          name: "openshift-monitoring"
  podSelector: {}
```

3. Modify and reapply the default Service Mesh control plane in the **istio-system** namespace, so that it includes the following spec:

```
spec:
  proxy:
    networking:
      trafficControl:
        inbound:
          excludedPorts:
          - 8444
```

6.8.2. Integrating Service Mesh with OpenShift Serverless when Kourier is enabled

Prerequisites

- You have installed the OpenShift Serverless Operator on your OpenShift Container Platform cluster.
- You have installed Red Hat OpenShift Service Mesh. OpenShift Serverless with Service Mesh and Kourier is supported for use with both Red Hat OpenShift Service Mesh versions 1.x and 2.x.
- You have installed Knative Serving.

Procedure

1. Add the namespaces that you would like to integrate with Service Mesh to the **ServiceMeshMemberRoll** object as members:

```
apiVersion: maistra.io/v1
kind: ServiceMeshMemberRoll
metadata:
  name: default
  namespace: istio-system
spec:
  members:
    - <namespace> 1
```

1 A list of namespaces to be integrated with Service Mesh.

2. Apply the **ServiceMeshMemberRoll** resource:

```
$ oc apply -f <filename>
```

3. Create a network policy that permits traffic flow from Knative system pods to Knative services:

   a. Add the **serving.knative.openshift.io/system-namespace=true** label to the **knative-serving** namespace:

   ```
   $ oc label namespace knative-serving serving.knative.openshift.io/system-namespace=true
   ```

   b. Add the **serving.knative.openshift.io/system-namespace=true** label to the **knative-serving-ingress** namespace:

   ```
   $ oc label namespace knative-serving-ingress serving.knative.openshift.io/system-namespace=true
   ```

   c. For each namespace that you want to integrate with Service Mesh, create a **NetworkPolicy** resource:

   ```
   apiVersion: networking.k8s.io/v1
   kind: NetworkPolicy
   metadata:
     name: allow-from-serving-system-namespace
     namespace: <namespace> 1
   spec:
     ingress:
     - from:
       - namespaceSelector:
           matchLabels:
             serving.knative.openshift.io/system-namespace: "true"
     podSelector: {}
     policyTypes:
     - Ingress
   ```

   1 Add the namespace that you want to integrate with Service Mesh.

   d. Apply the **NetworkPolicy** resource:

   ```
   $ oc apply -f <filename>
   ```

6.9. MONITORING SERVERLESS COMPONENTS

You can use OpenShift Container Platform monitoring dashboards to view health checks and metrics for OpenShift Serverless components.

6.9.1. Monitoring the overall health status of Knative components

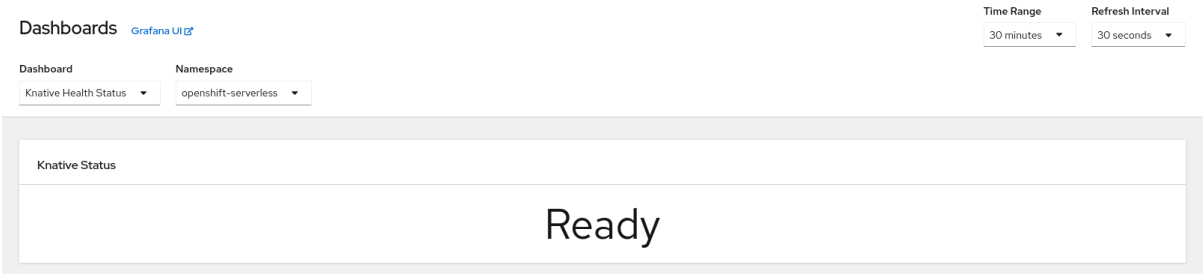
You can use the OpenShift Container Platform monitoring dashboards to view the overall health status of Knative.

Prerequisites

- You have cluster administrator permissions, and access to the **Administrator** perspective in the OpenShift Container Platform web console.
- You have installed the OpenShift Serverless Operator, as well as the Knative Serving or Knative Eventing components.
- The OpenShift Container Platform monitoring stack is enabled on your cluster. You can enable monitoring for OpenShift Serverless during installation by checking the box to **Enable operator recommended cluster monitoring on this namespace** when installing the OpenShift Serverless Operator.

Procedure

1. In the **Administrator** perspective, navigate to **Observe → Dashboards**.
2. Select the **Knative Health Status** dashboard in the **Dashboard** drop-down to view the overall health status of Knative. If your Knative deployment is running as expected, the dashboard shows a status of **Ready**.



   If you have Knative Serving or Knative Eventing installed, you can also scroll down to see the health status for each of these components.

6.9.2. Monitoring Knative Serving revision CPU and memory usage

You can use the OpenShift Container Platform monitoring dashboards to view revision CPU and memory usage metrics for Knative Serving components.

Prerequisites

- You have cluster administrator permissions, and access to the **Administrator** perspective in the OpenShift Container Platform web console.
- You have installed the OpenShift Serverless Operator, as well as the Knative Serving component.
- The OpenShift Container Platform monitoring stack is enabled on your cluster. You can enable monitoring for OpenShift Serverless during installation by checking the box to **Enable operator recommended cluster monitoring on this namespace** when installing the OpenShift Serverless Operator.

Procedure

1. In the **Administrator** perspective, navigate to **Observe → Dashboards**.
2. Select the **Knative Serving - Source CPU and Memory Usage** dashboard in the **Dashboard** drop-down list to view the following metrics:
   - Total CPU Usage (rate per minute)

- Total Memory Usage (bytes)
- Total Network I/O (rate per minute)
- Total Network Errors (rate per minute)

3. Optional: You can filter this dashboard by **Namespace**, **Configuration**, or **Revision**, by selecting an option from the drop-down list.

6.9.3. Monitoring Knative Eventing source CPU and memory usage

You can use the OpenShift Container Platform monitoring dashboards to view source CPU and memory usage metrics for Knative Eventing components.

Prerequisites

- You have cluster administrator permissions, and access to the **Administrator** perspective in the OpenShift Container Platform web console.
- You have installed the OpenShift Serverless Operator, as well as the Knative Eventing component.
- The OpenShift Container Platform monitoring stack is enabled on your cluster. You can enable monitoring for OpenShift Serverless during installation by checking the box to **Enable operator recommended cluster monitoring on this namespace** when installing the OpenShift Serverless Operator.

Procedure

1. In the **Administrator** perspective, navigate to **Observe → Dashboards**.
2. Select the **Knative Eventing - Source CPU and Memory Usage** dashboard in the **Dashboard** drop-down list to view the following metrics:
   - Total CPU Usage (rate per minute)
   - Total Memory Usage (bytes)
   - Total Network I/O (rate per minute)
   - Total Network Errors (rate per minute)

6.9.4. Monitoring event sources

You can use the OpenShift Container Platform monitoring dashboards to view metrics for event sources in your cluster.

Prerequisites

- You have cluster administrator permissions, and access to the **Administrator** perspective in the OpenShift Container Platform web console.
- You have installed the OpenShift Serverless Operator, as well as the Knative Eventing component.
- The OpenShift Container Platform monitoring stack is enabled on your cluster. You can enable

monitoring for OpenShift Serverless during installation by checking the box to **Enable operator recommended cluster monitoring on this namespace** when installing the OpenShift Serverless Operator.

Procedure

1. In the **Administrator** perspective, navigate to **Observe → Dashboards**.
2. Select the **Knative Eventing - Sources** dashboard in the **Dashboard** drop-down list.
3. You can now view the following metrics:
   a. For API server sources:
      - Event Count (rate per minute)
      - Success Rate (2xx Event, fraction rate per minute)
      - Event Count by Response Code Class (rate per minute)
      - Failure Rate (non-2xx Event, fraction rate per minute)
   b. For ping sources:
      - Event Count (rate per minute)
      - Success Rate (2xx Event, fraction rate per minute)
      - Event Count by Response Code Class (rate per minute)
      - Failure Rate (non-2xx Event, fraction rate per minute)
   c. For Kafka sources:
      - Event Count (rate per minute)
      - Success Rate (2xx Event, fraction rate per minute)
      - Event Count by Response Code Class (rate per minute)
      - Failure Rate (non-2xx Event, fraction rate per minute)

6.9.5. Monitoring Knative Eventing brokers and triggers

You can use the OpenShift Container Platform monitoring dashboards to view metrics for brokers and triggers in your cluster.

Prerequisites

- You have cluster administrator permissions, and access to the **Administrator** perspective in the OpenShift Container Platform web console.
- You have installed the OpenShift Serverless Operator, as well as the Knative Eventing component.
- The OpenShift Container Platform monitoring stack is enabled on your cluster. You can enable monitoring for OpenShift Serverless during installation by checking the box to **Enable operator**

recommended cluster monitoring on this namespace when installing the OpenShift Serverless Operator.

Procedure

1. In the **Administrator** perspective, navigate to **Observe → Dashboards**.
2. Select the **Knative Eventing - Broker/Trigger** dashboard in the **Dashboard** drop-down list.
3. You can now view the following metrics:
   a. For brokers:
      - Event Count (avg/sec, over 1m window)
      - Success Rate (2xx Event, fraction rate, over 1m window)
      - Event Count by Event Type (avg/sec, over 1m window)
      - Event Count by Response Code Class (avg/sec, over 1m window)
      - Failure Rate (non-2xx Event, fraction rate, over 1m window)
      - Event Dispatch Latency (ms)
   b. For triggers:
      - Event Count (avg/sec, over 1m window)
      - Success Rate (2xx Event, fraction rate, over 1m window)
      - Event Count by Event Type (avg/sec, over 1m window)
      - Event Count by Response Code Class (avg/sec, over 1m window)
      - Failure Rate (non-2xx Event, fraction rate, over 1m window)
      - Event Dispatch Latency (ms)
      - Event Processing Latency (ms)

6.9.6. Monitoring Knative Eventing channels

You can use the OpenShift Container Platform monitoring dashboards to view metrics for channels in your cluster.

Prerequisites

- You have cluster administrator permissions, and access to the **Administrator** perspective in the OpenShift Container Platform web console.
- You installed the OpenShift Serverless Operator, the Knative Eventing component, and the **KnativeKafka** custom resource.
- The OpenShift Container Platform monitoring stack is enabled on your cluster. You can enable monitoring for OpenShift Serverless during installation by checking the box to **Enable operator recommended cluster monitoring on this namespace** when installing the OpenShift Serverless

Operator.

Procedure

1. In the **Administrator** perspective, navigate to **Observe → Dashboards**.
2. Select the **Knative Eventing - Channel** dashboard in the **Dashboard** drop-down list.
3. You can now view the following metrics:
   a. For in-memory channels:
      - Event Count (avg/sec, over 1m window)
      - Success Rate (2xx Event, fraction rate, over 1m window)
      - Event Count by Response Code Class (avg/sec, over 1m window)
      - Failure Rate (non-2xx Event, fraction rate, over 1m window)
      - Event Dispatch Latency (ms)
   b. For Kafka channels:
      - Event Count (avg/sec, over 1m window)
      - Success Rate (2xx Event, fraction rate, over 1m window)
      - Event Count by Response Code Class (avg/sec, over 1m window)
      - Failure Rate (non-2xx Event, fraction rate, over 1m window)
      - Event Dispatch Latency (ms)

6.10. METRICS

Metrics enable cluster administrators to monitor how OpenShift Serverless cluster components and workloads are performing.

6.10.1. Prerequisites

- See the OpenShift Container Platform documentation on Managing metrics for information about enabling metrics for your cluster.
- To view metrics for Knative components on OpenShift Container Platform, you need cluster administrator permissions, and access to the web console **Administrator** perspective.

WARNING

If Service Mesh is enabled with mTLS, metrics for Knative Serving are disabled by default because Service Mesh prevents Prometheus from scraping metrics.

For information about resolving this issue, see Integrating Service Mesh with OpenShift Serverless.

6.10.2. Controller metrics

The following metrics are emitted by any component that implements a controller logic. These metrics show details about reconciliation operations and the work queue behavior upon which reconciliation requests are added to the work queue.

Metric name	Description	Type	Tags	Unit
work_queue_depth	The depth of the work queue.	Gauge	**reconciler**	Integer (no units)
reconcile_count	The number of reconcile operations.	Counter	**reconciler**, **success**	Integer (no units)
reconcile_latency	The latency of reconcile operations.	Histogram	**reconciler**, **success**	Milliseconds
workqueue_adds_total	The total number of add actions handled by the work queue.	Counter	**name**	Integer (no units)
workqueue_queue_latency_seconds	The length of time an item stays in the work queue before being requested.	Histogram	**name**	Seconds
workqueue_retries_total	The total number of retries that have been handled by the work queue.	Counter	**name**	Integer (no units)
workqueue_work_duration_seconds	The length of time it takes to process and item from the work queue.	Histogram	**name**	Seconds

Metric name	Description	Type	Tags	Unit
workqueue_unfinished_work_seconds	The length of time that outstanding work queue items have been in progress.	Histogram	**name**	Seconds
workqueue_longest_running_processor_seconds	The length of time that the longest outstanding work queue items has been in progress.	Histogram	**name**	Seconds

6.10.3. Webhook metrics

Webhook metrics report useful information about operations. For example, if a large number of operations fail, this might indicate an issue with a user-created resource.

Metric name	Description	Type	Tags	Unit
request_count	The number of requests that are routed to the webhook.	Counter	**admission_allowed**, **kind_group**, **kind_kind**, **kind_version**, **request_operation**, **resource_group**, **resource_namespace**, **resource_resource**, **resource_version**	Integer (no units)

Metric name	Description	Type	Tags	Unit
request_latencies	The response time for a webhook request.	Histogram	**admission_allowed**, **kind_group**, **kind_kind**, **kind_version**, **request_operation**, **resource_group**, **resource_namespace**, **resource_resource**, **resource_version**	Milliseconds

6.10.4. Knative Eventing metrics

Cluster administrators can view the following metrics for Knative Eventing components.

By aggregating the metrics from HTTP code, events can be separated into two categories; successful events (2xx) and failed events (5xx).

6.10.4.1. Broker ingress metrics

You can use the following metrics to debug the broker ingress, see how it is performing, and see which events are being dispatched by the ingress component.

Metric name	Description	Type	Tags	Unit
event_count	Number of events received by a broker.	Counter	**broker_name**, **event_type**, **namespace_name**, **response_code**, **response_code_class**, **unique_name**	Integer (no units)
event_dispatch_latencies	The time taken to dispatch an event to a channel.	Histogram	**broker_name**, **event_type**, **namespace_name**, **response_code**, **response_code_class**, **unique_name**	Milliseconds

6.10.4.2. Broker filter metrics

You can use the following metrics to debug broker filters, see how they are performing, and see which events are being dispatched by the filters. You can also measure the latency of the filtering action on an event.

Metric name	Description	Type	Tags	Unit
event_count	Number of events received by a broker.	Counter	**broker_name**, **container_name**, **filter_type**, **namespace_name**, **response_code**, **response_code_class**, **trigger_name**, **unique_name**	Integer (no units)
event_dispatch_latencies	The time taken to dispatch an event to a channel.	Histogram	**broker_name**, **container_name**, **filter_type**, **namespace_name**, **response_code**, **response_code_class**, **trigger_name**, **unique_name**	Milliseconds
event_processing_latencies	The time it takes to process an event before it is dispatched to a trigger subscriber.	Histogram	**broker_name**, **container_name**, **filter_type**, **namespace_name**, **trigger_name**, **unique_name**	Milliseconds

6.10.4.3. InMemoryChannel dispatcher metrics

You can use the following metrics to debug **InMemoryChannel** channels, see how they are performing, and see which events are being dispatched by the channels.

Metric name	Description	Type	Tags	Unit

Metric name	Description	Type	Tags	Unit
event_count	Number of events dispatched by **InMemoryChannel** channels.	Counter	**broker_name**, **container_name**, **filter_type**, **namespace_name**, **response_code**, **response_code_class**, **trigger_name**, **unique_name**	Integer (no units)
event_dispatch_latencies	The time taken to dispatch an event from an **InMemoryChannel** channel.	Histogram	**broker_name**, **container_name**, **filter_type**, **namespace_name**, **response_code**, **response_code_class**, **trigger_name**, **unique_name**	Milliseconds

6.10.4.4. Event source metrics

You can use the following metrics to verify that events have been delivered from the event source to the connected event sink.

Metric name	Description	Type	Tags	Unit
event_count	Number of events sent by the event source.	Counter	**broker_name**, **container_name**, **filter_type**, **namespace_name**, **response_code**, **response_code_class**, **trigger_name**, **unique_name**	Integer (no units)

Metric name	Description	Type	Tags	Unit
retry_event_count	Number of retried events sent by the event source after initially failing to be delivered.	Counter	**event_source**, **event_type**, **name**, **namespace_name**, **resource_group**, **response_code**, **response_code_class**, **response_error**, **response_timeout**	Integer (no units)

6.10.5. Knative Serving metrics

Cluster administrators can view the following metrics for Knative Serving components.

6.10.5.1. Activator metrics

You can use the following metrics to understand how applications respond when traffic passes through the activator.

Metric name	Description	Type	Tags	Unit
request_concurrency	The number of concurrent requests that are routed to the activator, or average concurrency over a reporting period.	Gauge	**configuration_name**, **container_name**, **namespace_name**, **pod_name**, **revision_name**, **service_name**	Integer (no units)
request_count	The number of requests that are routed to activator. These are requests that have been fulfilled from the activator handler.	Counter	**configuration_name**, **container_name**, **namespace_name**, **pod_name**, **response_code**, **response_code_class**, **revision_name**, **service_name**,	Integer (no units)

Metric name	Description	Type	Tags	Unit
request_latencies	The response time in milliseconds for a fulfilled, routed request.	Histogram	**configuration_name**, **container_name**, **namespace_name**, **pod_name**, **response_code**, **response_code_class**, **revision_name**, **service_name**	Milliseconds

6.10.5.2. Autoscaler metrics

The autoscaler component exposes a number of metrics related to autoscaler behavior for each revision. For example, at any given time, you can monitor the targeted number of pods the autoscaler tries to allocate for a service, the average number of requests per second during the stable window, or whether the autoscaler is in panic mode if you are using the Knative pod autoscaler (KPA).

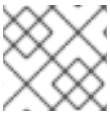
Metric name	Description	Type	Tags	Unit
desired_pods	The number of pods the autoscaler tries to allocate for a service.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)
excess_burst_capacity	The excess burst capacity served over the stable window.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)
stable_request_concurrency	The average number of requests for each observed pod over the stable window.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)
panic_request_concurrency	The average number of requests for each observed pod over the panic window.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)

Metric name	Description	Type	Tags	Unit
target_concurrency_per_pod	The number of concurrent requests that the autoscaler tries to send to each pod.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)
stable_requests_per_second	The average number of requests-per-second for each observed pod over the stable window.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)
panic_requests_per_second	The average number of requests-per-second for each observed pod over the panic window.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)
target_requests_per_second	The number of requests-per-second that the autoscaler targets for each pod.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)
panic_mode	This value is **1** if the autoscaler is in panic mode, or **0** if the autoscaler is not in panic mode.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)
requested_pods	The number of pods that the autoscaler has requested from the Kubernetes cluster.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)
actual_pods	The number of pods that are allocated and currently have a ready state.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)

Metric name	Description	Type	Tags	Unit
not_ready_pods	The number of pods that have a not ready state.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)
pending_pods	The number of pods that are currently pending.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)
terminating_pods	The number of pods that are currently terminating.	Gauge	**configuration_name**, **namespace_name**, **revision_name**, **service_name**	Integer (no units)

6.10.5.3. Go runtime metrics

Each Knative Serving control plane process emits a number of Go runtime memory statistics (MemStats).



NOTE

The **name** tag for each metric is an empty tag.

Metric name	Description	Type	Tags	Unit
go_alloc	The number of bytes of allocated heap objects. This metric is the same as **heap_alloc**.	Gauge	**name**	Integer (no units)
go_total_alloc	The cumulative bytes allocated for heap objects.	Gauge	**name**	Integer (no units)
go_sys	The total bytes of memory obtained from the operating system.	Gauge	**name**	Integer (no units)

Metric name	Description	Type	Tags	Unit
go_lookups	The number of pointer lookups performed by the runtime.	Gauge	**name**	Integer (no units)
go_mallocs	The cumulative count of heap objects allocated.	Gauge	**name**	Integer (no units)
go_frees	The cumulative count of heap objects that have been freed.	Gauge	**name**	Integer (no units)
go_heap_alloc	The number of bytes of allocated heap objects.	Gauge	**name**	Integer (no units)
go_heap_sys	The number of bytes of heap memory obtained from the operating system.	Gauge	**name**	Integer (no units)
go_heap_idle	The number of bytes in idle, unused spans.	Gauge	**name**	Integer (no units)
go_heap_in_use	The number of bytes in spans that are currently in use.	Gauge	**name**	Integer (no units)
go_heap_released	The number of bytes of physical memory returned to the operating system.	Gauge	**name**	Integer (no units)
go_heap_objects	The number of allocated heap objects.	Gauge	**name**	Integer (no units)
go_stack_in_use	The number of bytes in stack spans that are currently in use.	Gauge	**name**	Integer (no units)

Metric name	Description	Type	Tags	Unit
go_stack_sys	The number of bytes of stack memory obtained from the operating system.	Gauge	**name**	Integer (no units)
go_mspan_in_use	The number of bytes of allocated **mspan** structures.	Gauge	**name**	Integer (no units)
go_mspan_sys	The number of bytes of memory obtained from the operating system for **mspan** structures.	Gauge	**name**	Integer (no units)
go_mcache_in_use	The number of bytes of allocated **mcache** structures.	Gauge	**name**	Integer (no units)
go_mcache_sys	The number of bytes of memory obtained from the operating system for **mcache** structures.	Gauge	**name**	Integer (no units)
go_bucket_hash_sys	The number of bytes of memory in profiling bucket hash tables.	Gauge	**name**	Integer (no units)
go_gc_sys	The number of bytes of memory in garbage collection metadata.	Gauge	**name**	Integer (no units)
go_other_sys	The number of bytes of memory in miscellaneous, off-heap runtime allocations.	Gauge	**name**	Integer (no units)
go_next_gc	The target heap size of the next garbage collection cycle.	Gauge	**name**	Integer (no units)

Metric name	Description	Type	Tags	Unit
go_last_gc	The time that the last garbage collection was completed in *Epoch* or Unix time.	Gauge	**name**	Nanoseconds
go_total_gc_pause_ns	The cumulative time in garbage collection *stop-the-world* pauses since the program started.	Gauge	**name**	Nanoseconds
go_num_gc	The number of completed garbage collection cycles.	Gauge	**name**	Integer (no units)
go_num_forced_gc	The number of garbage collection cycles that were forced due to an application calling the garbage collection function.	Gauge	**name**	Integer (no units)
go_gc_cpu_fraction	The fraction of the available CPU time of the program that has been used by the garbage collector since the program started.	Gauge	**name**	Integer (no units)

6.11. HIGH AVAILABILITY ON OPENSHIFT SERVERLESS

High availability (HA) is a standard feature of Kubernetes APIs that helps to ensure that APIs stay operational if a disruption occurs. In an HA deployment, if an active controller crashes or is deleted, another controller is available to take over processing of the APIs that were being serviced by the controller that is now unavailable.

HA in OpenShift Serverless is available through leader election, which is enabled by default after the Knative Serving or Eventing control plane is installed.

When using a leader election HA pattern, instances of controllers are already scheduled and running inside the cluster before they are required. These controller instances compete to use a shared resource, known as the leader election lock. The instance of the controller that has access to the leader

election lock resource at any given time is referred to as the leader.

6.11.1. Configuring high availability replicas on OpenShift Serverless

High availability (HA) functionality is available by default on OpenShift Serverless for Knative Serving, Knative Eventing, and Knative Kafka. These are the components scaled for each of them:

- Knative Serving: **activator**, **autoscaler**, **autoscaler-hpa**, **controller**, **webhook**, **kourier-control**, **kourier-gateway**.
- Knative Eventing: **eventing-controller**, **eventing-webhook**, **imc-controller**, **imc-dispatcher**, **mt-broker-controller**, **sugar-controller**.
- Knative Kafka: **kafka-ch-controller**, **kafka-controller-manager**, **kafka-webhook**.

These components are configured with two replicas by default.

For Knative Eventing, the **mt-broker-filter** and **mt-broker-ingress** deployments are not scaled by HA. If multiple deployments are needed, scale these components manually.

You modify the number of replicas that are created per component by changing the configuration of **spec.high-availability.replicas** in the KnativeServing custom resource (CR), the KnativeEventing CR, or the KnativeKafka CR.

6.11.1.1. Configuring high availability replicas for Serving

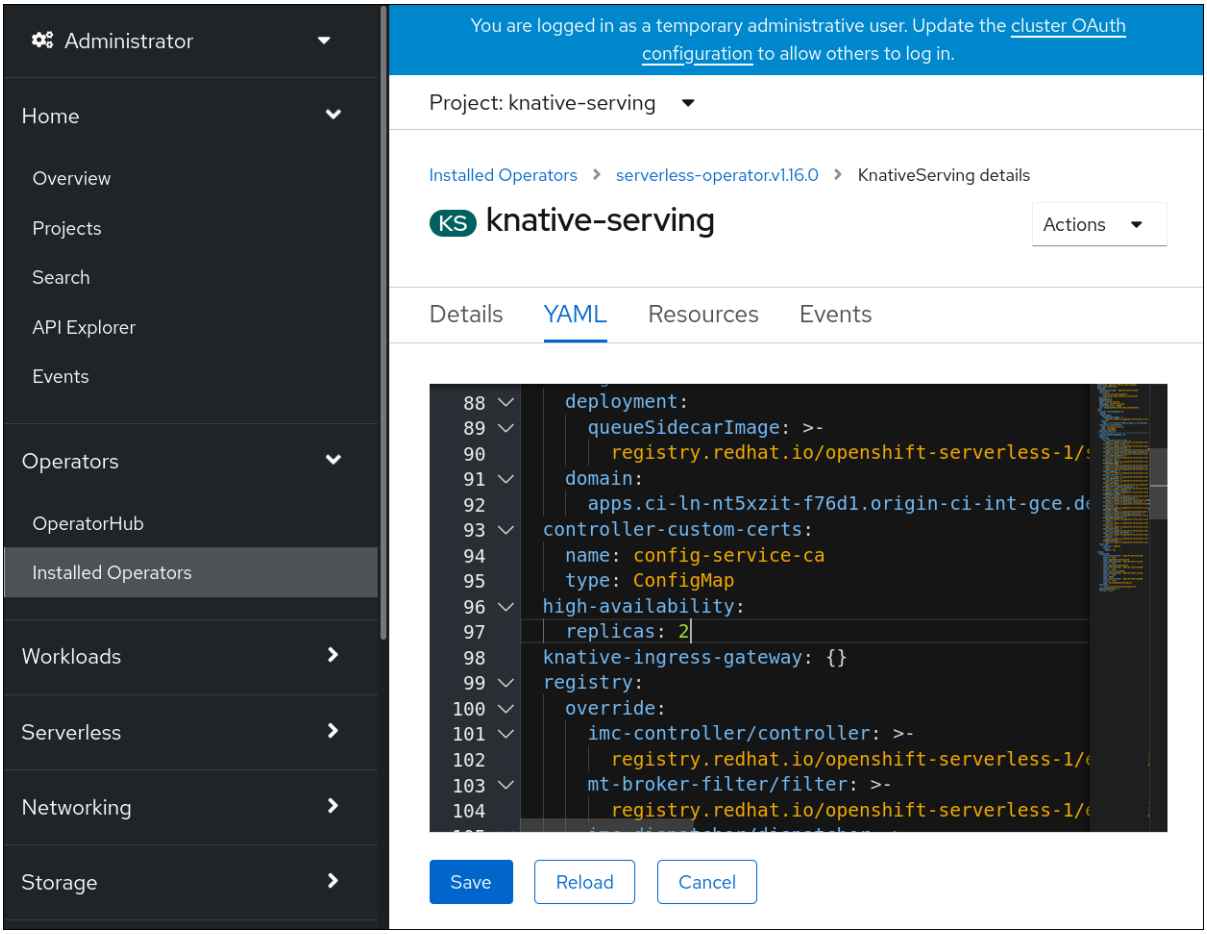
You can scale Knative Serving components by modifying the **spec.high-availability.replicas** value in the KnativeServing custom resource.

Prerequisites

- You have access to an OpenShift Container Platform cluster with cluster administrator permissions.
- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.

Procedure

1. In the OpenShift Container Platform web console **Administrator** perspective, navigate to **OperatorHub → Installed Operators**.
2. Select the **knative-serving** namespace.
3. Click **Knative Serving** in the list of **Provided APIs** for the OpenShift Serverless Operator to go to the **Knative Serving** tab.
4. Click **knative-serving**, then go to the **YAML** tab in the **knative-serving** page.

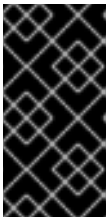


5. Modify the number of replicas in the **KnativeServing** CRD:

Example YAML

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
spec:
  high-availability:
    replicas: 3 (1)
```

(1) Sets the number of replicas to **3**.



IMPORTANT

Do not modify any YAML contained inside the **config** field. Some of the configuration values in this field are injected by the OpenShift Serverless Operator, and modifying them will cause your deployment to become unsupported.

- The **replicas** value sets the replica count for all HA controllers.
- The default **replicas** value is **2**.
- You can increase the number of replicas by changing the value to **3** or more.

6.11.1.2. Configuring high availability replicas for Eventing

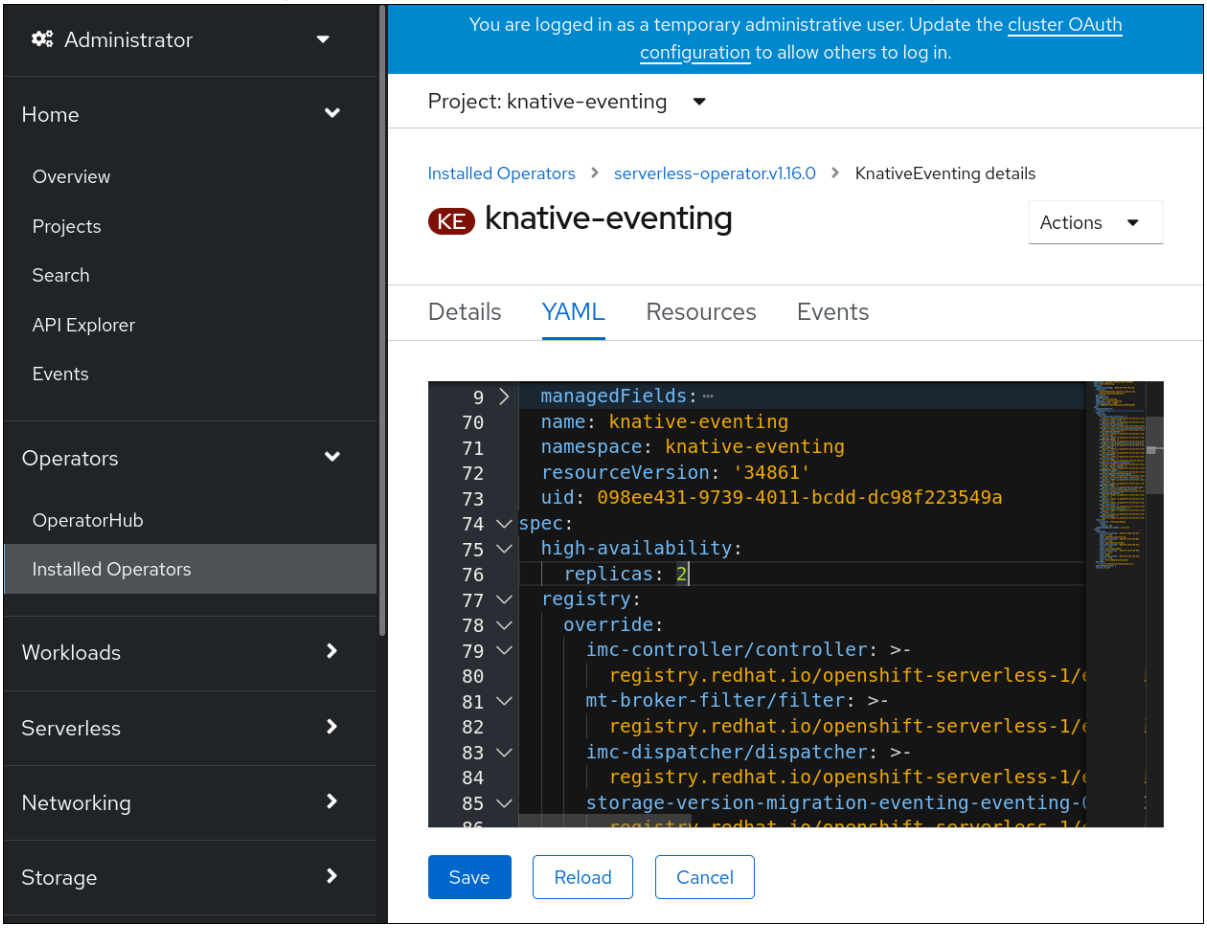
You can scale Knative Eventing components by modifying the **spec.high-availability.replicas** value in the KnativeEventing custom resource.

Prerequisites

- You have access to an OpenShift Container Platform cluster with cluster administrator permissions.
- The OpenShift Serverless Operator and Knative Eventing are installed on your cluster.

Procedure

1. In the OpenShift Container Platform web console **Administrator** perspective, navigate to **OperatorHub → Installed Operators**.
2. Select the **knative-eventing** namespace.
3. Click **Knative Eventing** in the list of **Provided APIs** for the OpenShift Serverless Operator to go to the **Knative Eventing** tab.
4. Click **knative-eventing**, then go to the **YAML** tab in the **knative-eventing** page.



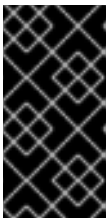
5. Modify the number of replicas in the **KnativeEventing** CRD:

Example YAML

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeEventing
```

```
metadata:
  name: knative-eventing
  namespace: knative-eventing
spec:
  high-availability:
    replicas: 3 (1)
```

(1) Sets the number of replicas to **3**.



IMPORTANT

Do not modify any YAML contained inside the **config** field. Some of the configuration values in this field are injected by the OpenShift Serverless Operator, and modifying them will cause your deployment to become unsupported.

- The **replicas** value sets the replica count for all HA controllers.
- The default **replicas** value is **2**.
- You can increase the number of replicas by changing the value to **3** or more.

6.11.1.3. Configuring high availability replicas for Kafka

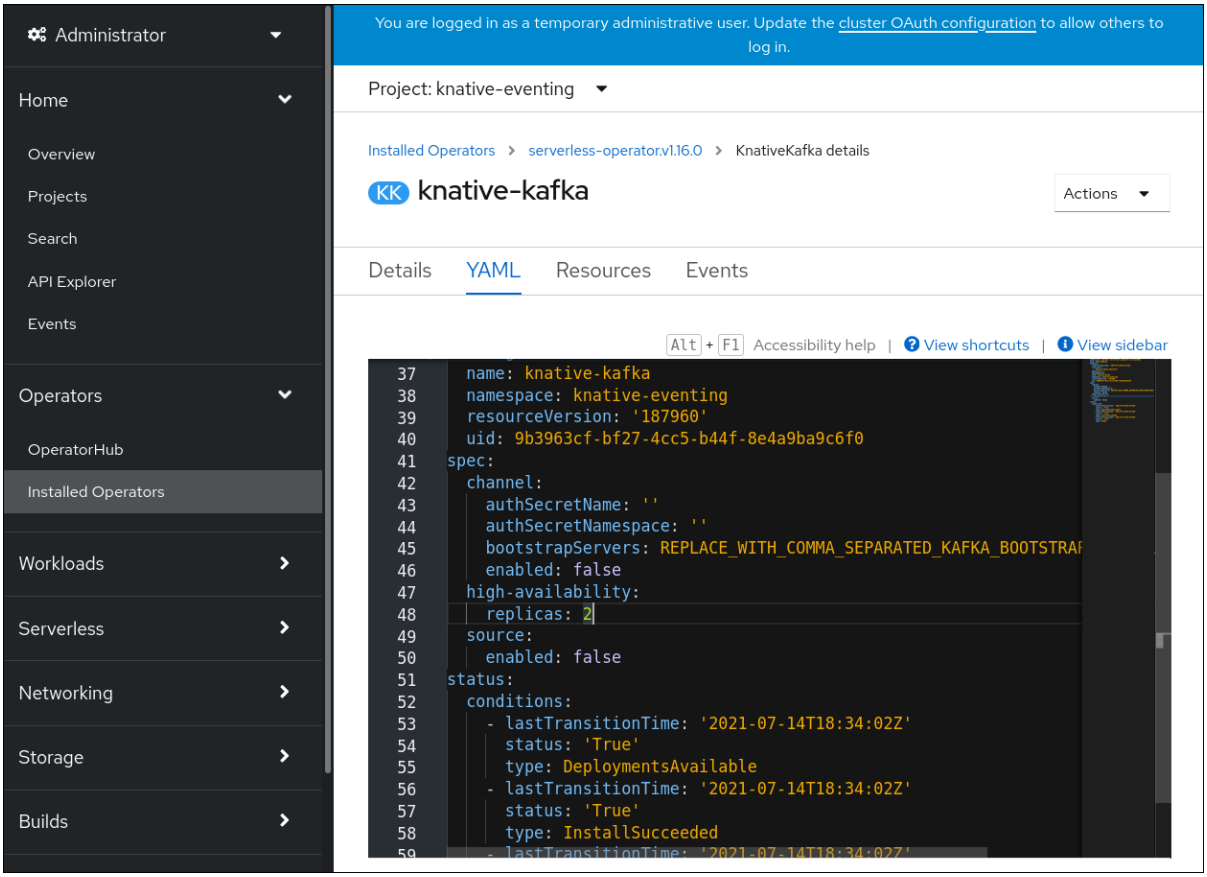
You can scale Knative Kafka components by modifying the **spec.high-availability.replicas** value in the KnativeKafka custom resource.

Prerequisites

- You have access to an OpenShift Container Platform cluster with cluster administrator permissions.
- The OpenShift Serverless Operator and Knative Kafka are installed on your cluster.

Procedure

1. In the OpenShift Container Platform web console **Administrator** perspective, navigate to **OperatorHub → Installed Operators**.
2. Select the **knative-eventing** namespace.
3. Click **Knative Kafka** in the list of **Provided APIs** for the OpenShift Serverless Operator to go to the **Knative Kafka** tab.
4. Click **knative-kafka**, then go to the **YAML** tab in the **knative-kafka** page.

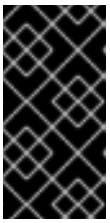


5. Modify the number of replicas in the **KnativeKafka** CRD:

Example YAML

```
apiVersion: operator.serverless.openshift.io/v1alpha1
kind: KnativeKafka
metadata:
  name: knative-kafka
  namespace: knative-eventing
spec:
  high-availability:
    replicas: 3 (1)
```

(1) Sets the number of replicas to **3**.



IMPORTANT

Do not modify any YAML contained inside the **config** field. Some of the configuration values in this field are injected by the OpenShift Serverless Operator, and modifying them will cause your deployment to become unsupported.

- The **replicas** value sets the replica count for all HA controllers.
- The default **replicas** value is **2**.
- You can increase the number of replicas by changing the value to **3** or more.

CHAPTER 7. MONITOR

7.1. USING OPENSHIFT LOGGING WITH OPENSHIFT SERVERLESS

7.1.1. About deploying OpenShift Logging

OpenShift Container Platform cluster administrators can deploy OpenShift Logging using the OpenShift Container Platform web console or CLI to install the OpenShift Elasticsearch Operator and Red Hat OpenShift Logging Operator. When the operators are installed, you create a **ClusterLogging** custom resource (CR) to schedule OpenShift Logging pods and other resources necessary to support OpenShift Logging. The operators are responsible for deploying, upgrading, and maintaining OpenShift Logging.

The **ClusterLogging** CR defines a complete OpenShift Logging environment that includes all the components of the logging stack to collect, store and visualize logs. The Red Hat OpenShift Logging Operator watches the OpenShift Logging CR and adjusts the logging deployment accordingly.

Administrators and application developers can view the logs of the projects for which they have view access.

7.1.2. About deploying and configuring OpenShift Logging

OpenShift Logging is designed to be used with the default configuration, which is tuned for small to medium sized OpenShift Container Platform clusters.

The installation instructions that follow include a sample **ClusterLogging** custom resource (CR), which you can use to create a OpenShift Logging instance and configure your OpenShift Logging environment.

If you want to use the default OpenShift Logging install, you can use the sample CR directly.

If you want to customize your deployment, make changes to the sample CR as needed. The following describes the configurations you can make when installing your OpenShift Logging instance or modify after installation. See the Configuring sections for more information on working with each component, including modifications you can make outside of the **ClusterLogging** custom resource.

7.1.2.1. Configuring and Tuning OpenShift Logging

You can configure your OpenShift Logging environment by modifying the **ClusterLogging** custom resource deployed in the **openshift-logging** project.

You can modify any of the following components upon install or after install:

Memory and CPU

You can adjust both the CPU and memory limits for each component by modifying the **resources** block with valid memory and CPU values:

```
spec:
  logStore:
    elasticsearch:
      resources:
        limits:
          cpu:
          memory: 16Gi
```

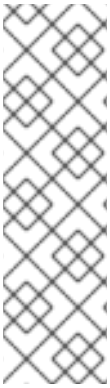
```
      requests:
        cpu: 500m
        memory: 16Gi
    type: "elasticsearch"
collection:
  logs:
    fluentd:
      resources:
        limits:
          cpu:
          memory:
        requests:
          cpu:
          memory:
      type: "fluentd"
visualization:
  kibana:
    resources:
      limits:
        cpu:
        memory:
      requests:
        cpu:
        memory:
    type: kibana
```

Elasticsearch storage

You can configure a persistent storage class and size for the Elasticsearch cluster using the **storageClass name** and **size** parameters. The Red Hat OpenShift Logging Operator creates a persistent volume claim (PVC) for each data node in the Elasticsearch cluster based on these parameters.

```
spec:
  logStore:
    type: "elasticsearch"
    elasticsearch:
      nodeCount: 3
      storage:
        storageClassName: "gp2"
        size: "200G"
```

This example specifies each data node in the cluster will be bound to a PVC that requests "200G" of "gp2" storage. Each primary shard will be backed by a single replica.



NOTE

Omitting the **storage** block results in a deployment that includes ephemeral storage only.

```
spec:
  logStore:
    type: "elasticsearch"
    elasticsearch:
      nodeCount: 3
      storage: {}
```

Elasticsearch replication policy

You can set the policy that defines how Elasticsearch shards are replicated across data nodes in the cluster:

- **FullRedundancy**. The shards for each index are fully replicated to every data node.
- **MultipleRedundancy**. The shards for each index are spread over half of the data nodes.
- **SingleRedundancy**. A single copy of each shard. Logs are always available and recoverable as long as at least two data nodes exist.
- **ZeroRedundancy**. No copies of any shards. Logs may be unavailable (or lost) in the event a node is down or fails.

7.1.2.2. Sample modified ClusterLogging custom resource

The following is an example of a **ClusterLogging** custom resource modified using the options previously described.

Sample modified ClusterLogging custom resource

```
apiVersion: "logging.openshift.io/v1"
kind: "ClusterLogging"
metadata:
  name: "instance"
  namespace: "openshift-logging"
spec:
  managementState: "Managed"
  logStore:
    type: "elasticsearch"
    retentionPolicy:
      application:
        maxAge: 1d
      infra:
        maxAge: 7d
      audit:
        maxAge: 7d
    elasticsearch:
      nodeCount: 3
      resources:
        limits:
          memory: 32Gi
        requests:
          cpu: 3
          memory: 32Gi
        storage:
          storageClassName: "gp2"
          size: "200G"
      redundancyPolicy: "SingleRedundancy"
  visualization:
    type: "kibana"
    kibana:
      resources:
        limits:
          memory: 1Gi
```

```
      requests:
        cpu: 500m
        memory: 1Gi
    replicas: 1
collection:
  logs:
    type: "fluentd"
    fluentd:
      resources:
        limits:
          memory: 1Gi
        requests:
          cpu: 200m
          memory: 1Gi
```

7.1.3. Using OpenShift Logging to find logs for Knative Serving components

Procedure

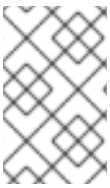
1. Get the Kibana route:

```
$ oc -n openshift-logging get route kibana
```

2. Use the route's URL to navigate to the Kibana dashboard and log in.

3. Check that the index is set to **.all**. If the index is not set to **.all**, only the OpenShift Container Platform system logs will be listed.

4. Filter the logs by using the **knative-serving** namespace. Enter **kubernetes.namespace_name:knative-serving** in the search box to filter results.



NOTE

Knative Serving uses structured logging by default. You can enable the parsing of these logs by customizing the OpenShift Logging Fluentd settings. This makes the logs more searchable and enables filtering on the log level to quickly identify issues.

7.1.4. Using OpenShift Logging to find logs for services deployed with Knative Serving

With OpenShift Logging, the logs that your applications write to the console are collected in Elasticsearch. The following procedure outlines how to apply these capabilities to applications deployed by using Knative Serving.

Procedure

1. Get the Kibana route:

```
$ oc -n openshift-logging get route kibana
```

2. Use the route's URL to navigate to the Kibana dashboard and log in.

3. Check that the index is set to **.all**. If the index is not set to **.all**, only the OpenShift system logs will be listed.

4. Filter the logs by using the **knative-serving** namespace. Enter a filter for the service in the search box to filter results.

   Example filter

   ```
   kubernetes.namespace_name:default AND kubernetes.labels.serving_knative_dev\/service:{service_name}
   ```

   You can also filter by using **/configuration** or **/revision**.

5. Narrow your search by using **kubernetes.container_name:<user_container>** to only display the logs generated by your application. Otherwise, you will see logs from the queue-proxy.

NOTE

Use JSON-based structured logging in your application to allow for the quick filtering of these logs in production environments.

7.2. TRACING REQUESTS USING JAEGER

Using Jaeger with OpenShift Serverless allows you to enable *distributed tracing* for your serverless applications on OpenShift Container Platform.

Distributed tracing records the path of a request through the various services that make up an application.

It is used to tie information about different units of work together, to understand a whole chain of events in a distributed transaction. The units of work might be executed in different processes or hosts.

Developers can visualize call flows in large architectures with distributed tracing. which is useful for understanding serialization, parallelism, and sources of latency.

For more information about distributed tracing, see distributed tracing architecture and Installing distributed tracing.

7.2.1. Configuring Jaeger for use with OpenShift Serverless

Prerequisites

To configure Jaeger for use with OpenShift Serverless, you will need:

- Cluster administrator permissions on an OpenShift Container Platform cluster.
- A current installation of OpenShift Serverless Operator and Knative Serving.
- A current installation of the Jaeger Operator.

Procedure

1. Create and apply a **Jaeger** custom resource (CR) that contains the following:

   Jaeger CR

```
apiVersion: jaegertracing.io/v1
kind: Jaeger
metadata:
  name: jaeger
  namespace: default
```

2. Enable tracing for Knative Serving, by editing the **KnativeServing** CR and adding a YAML configuration for tracing:

Tracing YAML example

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
spec:
  config:
    tracing:
      sample-rate: "0.1" 1
      backend: zipkin 2
      zipkin-endpoint: http://jaeger-collector.default.svc.cluster.local:9411/api/v2/spans 3
      debug: "false" 4
```

1. The **sample-rate** defines sampling probability. Using **sample-rate: "0.1"** means that 1 in 10 traces will be sampled.
2. **backend** must be set to **zipkin**.
3. The **zipkin-endpoint** must point to your **jaeger-collector** service endpoint. To get this endpoint, substitute the namespace where the Jaeger CR is applied.
4. Debugging should be set to **false**. Enabling debug mode by setting **debug: "true"** allows all spans to be sent to the server, bypassing sampling.

Verification

You can access the Jaeger web console to see tracing data, by using the **jaeger** route.

1. Get the **jaeger** route's hostname by entering the following command:

```
$ oc get route jaeger
```

Example output

```
NAME     HOST/PORT                         PATH   SERVICES      PORT    TERMINATION
WILDCARD
jaeger   jaeger-default.apps.example.com          jaeger-query  <all>   reencrypt     None
```

2. Open the endpoint address in your browser to view the console.

7.3. METRICS

Metrics enable developers to monitor how Knative services are performing.

7.3.1. Prerequisites

- To view metrics for Knative components on OpenShift Container Platform, you need access to the web console **Developer** perspective.

WARNING

If Service Mesh is enabled with mTLS, metrics for Knative Serving are disabled by default because Service Mesh prevents Prometheus from scraping metrics.

For information about resolving this issue, see Integrating Service Mesh with OpenShift Serverless.

7.3.2. Queue proxy metrics

Each Knative service has a proxy container that proxies the connections to the application container. A number of metrics are reported for the queue proxy performance.

You can use the following metrics to measure if requests are queued at the proxy side and the actual delay in serving requests at the application side.

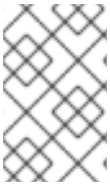
Metric name	Description	Type	Tags	Unit
revision_request_count	The number of requests that are routed to **queue-proxy** pod.	Counter	**configuration_name**, **container_name**, **namespace_name**, **pod_name**, **response_code**, **response_code_class**, **revision_name**, **service_name**	Integer (no units)
revision_request_latencies	The response time of revision requests.	Histogram	**configuration_name**, **container_name**, **namespace_name**, **pod_name**, **response_code**, **response_code_class**, **revision_name**, **service_name**	Milliseconds

Metric name	Description	Type	Tags	Unit
revision_app_request_count	The number of requests that are routed to the **user-container** pod.	Counter	**configuration_name**, **container_name**, **namespace_name**, **pod_name**, **response_code**, **response_code_class**, **revision_name**, **service_name**	Integer (no units)
revision_app_request_latencies	The response time of revision app requests.	Histogram	**configuration_name**, **namespace_name**, **pod_name**, **response_code**, **response_code_class**, **revision_name**, **service_name**	Milliseconds
revision_queue_depth	The current number of items in the **serving** and **waiting** queues. This metric is not reported if unlimited concurrency is configured.	Gauge	**configuration_name**, **event-display**, **container_name**, **namespace_name**, **pod_name**, **response_code_class**, **revision_name**, **service_name**	Integer (no units)

7.4. MONITORING KNATIVE SERVICES

You can use the OpenShift Container Platform monitoring stack to record and view health checks and metrics for your Knative services. This section describes the following topics:

- What metrics Knative services expose by default
- How to configure exposing custom metrics
- How to configure the monitoring stack to scrape the exposed metrics
- How to view the metrics of a service



NOTE

Scraping the metrics does not affect autoscaling of a Knative service, because scraping requests do not go through the activator. Consequently, no scraping takes place if no pods are running.

Additional resources

- For more information on OpenShift Container Platform monitoring stack, see Understanding the monitoring stack.
- For information on monitoring the components of Serverless itself, as opposed to Knative services, see Monitoring serverless components.

7.4.1. Knative service metrics exposed by default

Table 7.1. Metrics exposed by default for each Knative service on port 9090

Metric name, unit, and type	Description	Metric tags
queue_requests_per_second Metric unit: dimensionless Metric type: gauge	Number of requests per second that hit the queue proxy. Formula: **stats.RequestCount** / **r.reportingPeriodSeconds** **stats.RequestCount** is calculated directly from the networking **pkg** stats for the given reporting duration.	destination_configuration="event-display", destination_namespace="pingsource1", destination_pod="event-display-00001-deployment-6b455479cb-75p6w", destination_revision="event-display-00001"
queue_proxied_operations_per_second Metric unit: dimensionless Metric type: gauge	Number of proxied requests per second. Formula: **stats.ProxiedRequestCount** / **r.reportingPeriodSeconds** **stats.ProxiedRequestCount** is calculated directly from the networking **pkg** stats for the given reporting duration.	

Metric name, unit, and type	Description	Metric tags
queue_average_concurrent_requests Metric unit: dimensionless Metric type: gauge	Number of requests currently being handled by this pod. Average concurrency is calculated at the networking **pkg** side as follows: ● When a **req** change happens, the time delta between changes is calculated. Based on the result, the current concurrency number over delta is computed and added to the current computed concurrency. Additionally, a sum of the deltas is kept. Current concurrency over delta is computed as follows: **global_concurrency** × delta ● Each time a reporting is done, the sum and current computed concurrency are reset. ● When reporting the average concurrency the current computed concurrency is divided by the sum of deltas. ● When a new request comes in, the global concurrency counter is increased. When a request is completed, the counter is decreased.	destination_configuration="event-display", destination_namespace="pingsource1", destination_pod="event-display-00001-deployment-6b455479cb-75p6w", destination_revision="event-display-00001"
queue_average_proxied_concurrent_requests Metric unit: dimensionless Metric type: gauge	Number of proxied requests currently being handled by this pod: **stats.AverageProxiedConcurrency**	destination_configuration="event-display", destination_namespace="pingsource1", destination_pod="event-display-00001-deployment-6b455479cb-75p6w", destination_revision="event-display-00001"

Metric name, unit, and type	Description	Metric tags
process_uptime Metric unit: seconds Metric type: gauge	The number of seconds that the process has been up.	destination_configuration="event-display", destination_namespace="pingsource1", destination_pod="event-display-00001-deployment-6b455479cb-75p6w", destination_revision="event-display-00001"

Table 7.2. Metrics exposed by default for each Knative service on port 9091

Metric name, unit, and type	Description	Metric tags
request_count Metric unit: dimensionless Metric type: counter	The number of requests that are routed to **queue-proxy**.	configuration_name="event-display", container_name="queue-proxy", namespace_name="apiserversource1", pod_name="event-display-00001-deployment-658fd4f9cf-qcnr5", response_code="200", response_code_class="2xx", revision_name="event-display-00001", service_name="event-display"
request_latencies Metric unit: milliseconds Metric type: histogram	The response time in milliseconds.	configuration_name="event-display", container_name="queue-proxy", namespace_name="apiserversource1", pod_name="event-display-00001-deployment-658fd4f9cf-qcnr5", response_code="200", response_code_class="2xx", revision_name="event-display-00001", service_name="event-display"
app_request_count Metric unit: dimensionless Metric type: counter	The number of requests that are routed to **user-container**.	configuration_name="event-display", container_name="queue-proxy", namespace_name="apiserversource1", pod_name="event-display-00001-deployment-658fd4f9cf-qcnr5", response_code="200", response_code_class="2xx", revision_name="event-display-00001", service_name="event-display"

Metric name, unit, and type	Description	Metric tags
app_request_latencies Metric unit: milliseconds Metric type: histogram	The response time in milliseconds.	configuration_name="event-display", container_name="queue-proxy", namespace_name="apiserversource1", pod_name="event-display-00001-deployment-658fd4f9cf-qcnr5", response_code="200", response_code_class="2xx", revision_name="event-display-00001", service_name="event-display"
queue_depth Metric unit: dimensionless Metric type: gauge	The current number of items in the serving and waiting queue, or not reported if unlimited concurrency. **breaker.inFlight** is used.	configuration_name="event-display", container_name="queue-proxy", namespace_name="apiserversource1", pod_name="event-display-00001-deployment-658fd4f9cf-qcnr5", response_code="200", response_code_class="2xx", revision_name="event-display-00001", service_name="event-display"

7.4.2. Knative service with custom application metrics

You can extend the set of metrics exported by a Knative service. The exact implementation depends on your application and the language used.

The following listing implements a sample Go application that exports the count of processed events custom metric.

```
package main

import (
  "fmt"
  "log"
  "net/http"
  "os"

  "github.com/prometheus/client_golang/prometheus" (1)
  "github.com/prometheus/client_golang/prometheus/promauto"
  "github.com/prometheus/client_golang/prometheus/promhttp"
)

var (
  opsProcessed = promauto.NewCounter(prometheus.CounterOpts{ (2)
    Name: "myapp_processed_ops_total",
    Help: "The total number of processed events",
```

```
  })
)


func handler(w http.ResponseWriter, r *http.Request) {
  log.Print("helloworld: received a request")
  target := os.Getenv("TARGET")
  if target == "" {
    target = "World"
  }
  fmt.Fprintf(w, "Hello %s!\n", target)
  opsProcessed.Inc() 3
}

func main() {
  log.Print("helloworld: starting server...")

  port := os.Getenv("PORT")
  if port == "" {
    port = "8080"
  }

  http.HandleFunc("/", handler)

  // Separate server for metrics requests
  go func() { 4
    mux := http.NewServeMux()
    server := &http.Server{
      Addr: fmt.Sprintf(":%s", "9095"),
      Handler: mux,
    }
    mux.Handle("/metrics", promhttp.Handler())
    log.Printf("prometheus: listening on port %s", 9095)
    log.Fatal(server.ListenAndServe())
  }()

   // Use same port as normal requests for metrics
  //http.Handle("/metrics", promhttp.Handler()) 5
  log.Printf("helloworld: listening on port %s", port)
  log.Fatal(http.ListenAndServe(fmt.Sprintf(":%s", port), nil))
}
```

1 Including the Prometheus packages.

2 Defining the **opsProcessed** metric.

3 Incrementing the **opsProcessed** metric.

4 Configuring to use a separate server for metrics requests.

5 Configuring to use the same port as normal requests for metrics and the **metrics** subpath.

7.4.3. Configuration for scraping custom metrics

Custom metrics scraping is performed by an instance of Prometheus purposed for user workload monitoring. After you enable user workload monitoring and create the application, you need a configuration that defines how the monitoring stack will scrape the metrics.

The following sample configuration defines the **ksvc** for your application and configures the service monitor. The exact configuration depends on your application and how it exports the metrics.

```
apiVersion: serving.knative.dev/v1 (1)
kind: Service
metadata:
  name: helloworld-go
spec:
  template:
    metadata:
      labels:
        app: helloworld-go
      annotations:
    spec:
      containers:
      - image: docker.io/skonto/helloworld-go:metrics
        resources:
          requests:
            cpu: "200m"
        env:
        - name: TARGET
          value: "Go Sample v1"
---
apiVersion: monitoring.coreos.com/v1 (2)
kind: ServiceMonitor
metadata:
  labels:
  name: helloworld-go-sm
spec:
  endpoints:
  - port: queue-proxy-metrics
    scheme: http
  - port: app-metrics
    scheme: http
  namespaceSelector: {}
  selector:
    matchLabels:
       name:  helloworld-go-sm
---
apiVersion: v1 (3)
kind: Service
metadata:
  labels:
    name:  helloworld-go-sm
  name:  helloworld-go-sm
spec:
  ports:
  - name: queue-proxy-metrics
    port: 9091
    protocol: TCP
    targetPort: 9091
  - name: app-metrics
```

```
    port: 9095
    protocol: TCP
    targetPort: 9095
  selector:
    serving.knative.dev/service: helloworld-go
  type: ClusterIP
```

1. Application specification.
2. Configuration of which application's metrics are scraped.
3. Configuration of the way metrics are scraped.

Additional resources

- See also Enabling monitoring for user-defined projects.
- See also Specifying how a service is monitored .

7.4.4. Examining metrics of a service

After you have configured the application to export the metrics and the monitoring stack to scrape them, you can examine the metrics in the web console.

Procedure

1. Optional: Run requests against your application that you will be able to see in the metrics:

```
$ hello_route=$(oc get ksvc helloworld-go -n ns1 -o jsonpath='{.status.url}') && \
    curl $hello_route
```

Example output

```
Hello Go Sample v1!
```

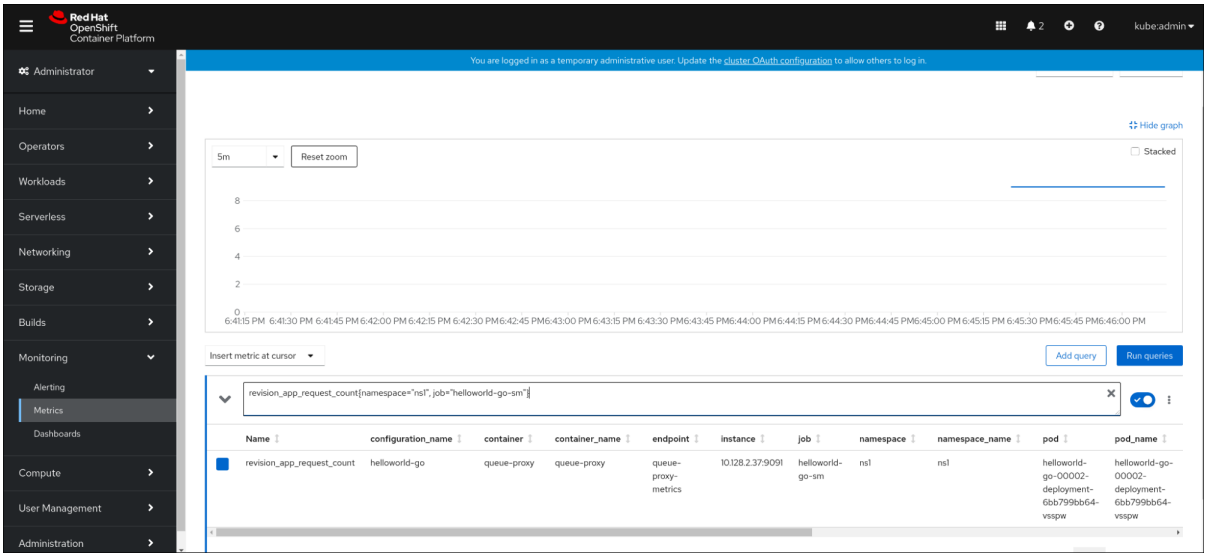
2. In the web console, navigate to the **Observe → Metrics** interface.
3. In the input field, enter the query for the metric you want to observe, for example:

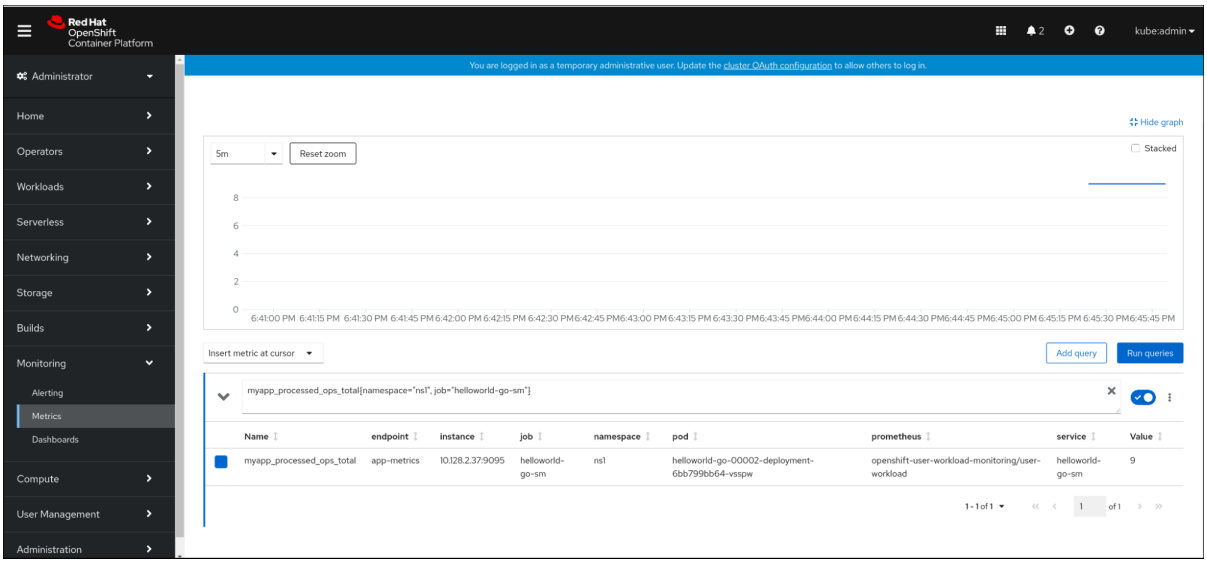
```
revision_app_request_count{namespace="ns1", job="helloworld-go-sm"}
```

Another example:

```
myapp_processed_ops_total{namespace="ns1", job="helloworld-go-sm"}
```

4. Observe the visualized metrics:



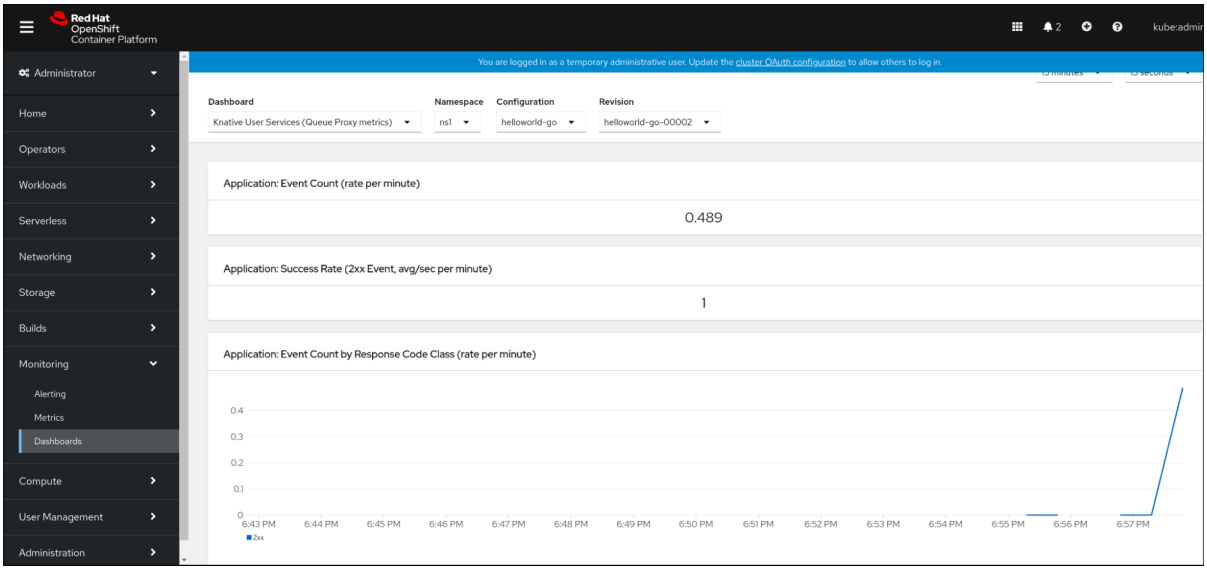


7.4.5. Examining metrics of a service in the dashboard

You can examine the metrics using a dedicated dashboard that aggregates queue proxy metrics by namespace.

Procedure

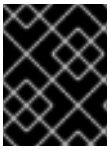
1. In the web console, navigate to the **Observe → Metrics** interface.
2. Select the **Knative User Services (Queue Proxy metrics)** dashboard.
3. Select the **Namespace**, **Configuration**, and **Revision** that correspond to your application.
4. Observe the visualized metrics:



7.5. AUTOSCALING DASHBOARD

You can use the **Knative Serving - Scaling Debugging**dashboard to examine detailed and visualized data for Knative Serving autoscaling. The dashboard is useful for several purposes:

- Troubleshooting your autoscaled workloads
- Improving understanding of how autoscaling works
- Determining why an application was autoscaled
- Evaluating resource footprint of an application, such as number of pods



IMPORTANT

Currently, this dashboard only supports the Knative pod autoscaler (KPA). It does not support the horizontal pod autoscaler (HPA).

The dashboard demonstrations in this section use an OpenShift Container Platform cluster with the **autoscale-go** sample application installed. The load is generated using the **hey** load generator.

The sample application has a concurrency limit of 5 requests. When the limit is exceeded, autoscaling requests additional pods for Knative from Kubernetes.

Additional resources

- See detailed information about autoscale-go .

7.5.1. Navigating to the autoscaling dashboard

Procedure

1. In the OpenShift Container Platform Web UI, go to the **Monitoring → Dashboards** page.
2. In the **Dashboard** field, select the **Knative Serving - Scaling Debugging**dashboard.

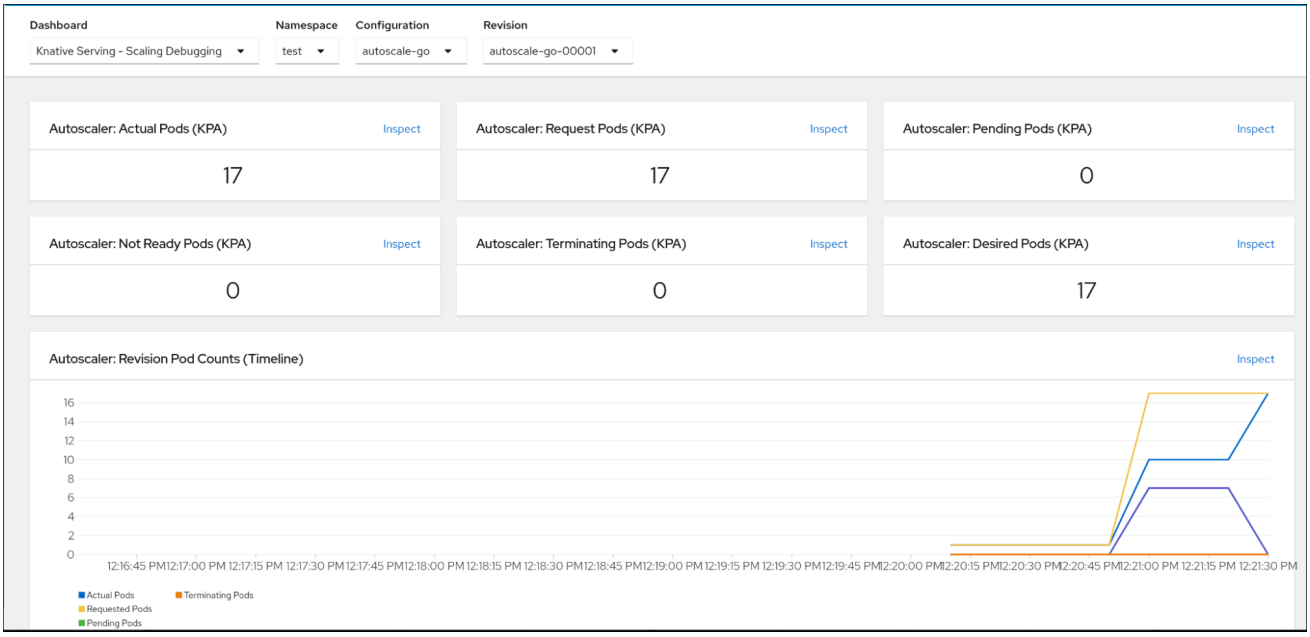
3. Use the **Namespace**, **Configuration**, and **Revision** fields to specify the workload you want to examine.

Additional resources

- See detailed information about metrics.

7.5.2. Pod information

The top of the **Knative Serving - Scaling Debugging**dashboard shows the counts of the requested pods, as well as of the pods in various stages of deployment. The **Revision Pod Counts (Timeline)** graph shows the same data visualized on the timeline. This information might be useful for general assessment of autoscaling by checking for problems with pod allocation.

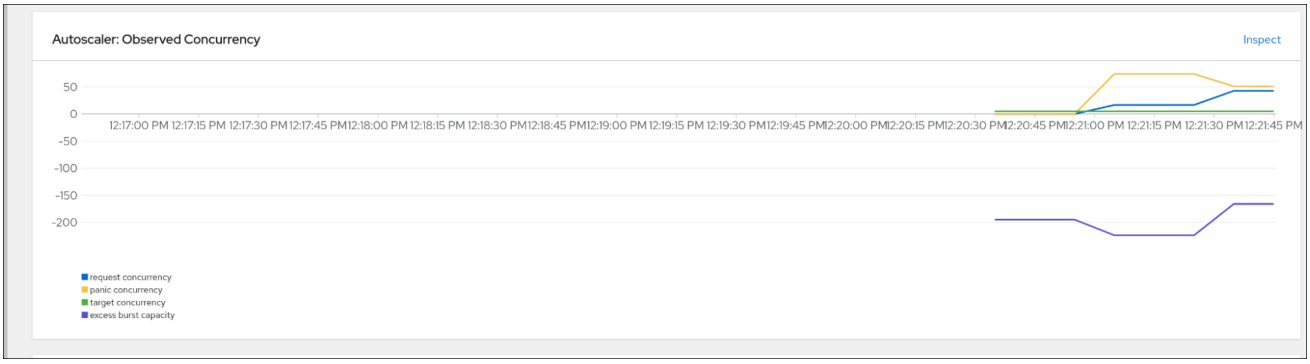


7.5.3. Observed concurrency

The **Observed Concurrency** graph shows the timeline of a set of concurrency-related metrics, including:

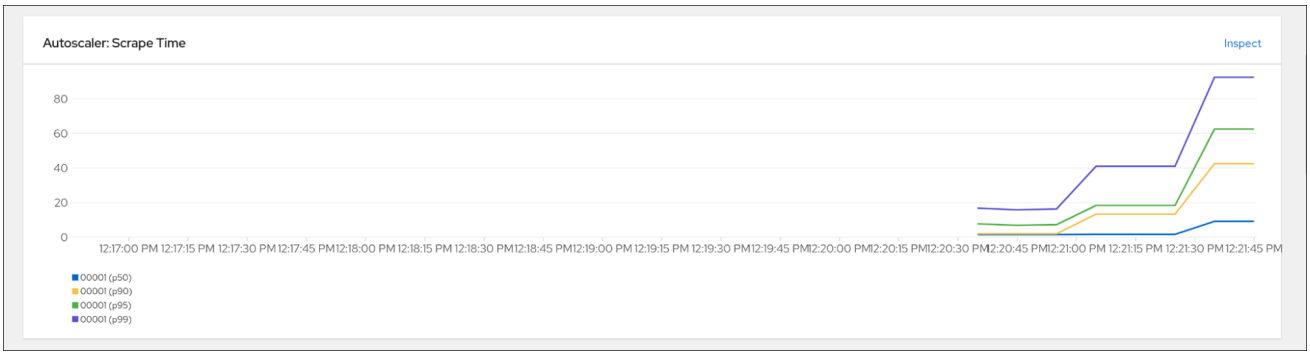
- request concurrency
- panic concurrency
- target concurrency
- excess burst capacity

Note that **ExcessBurstCapacity** is a negative number, **-200** by default, that increases when a bursty load appears. It is equal to the difference between spare capacity and the configured target burst capacity. If **ExcessBurstCapacity** is negative, then the activator is threaded in the request path by the **PodAutoscaler** controller.



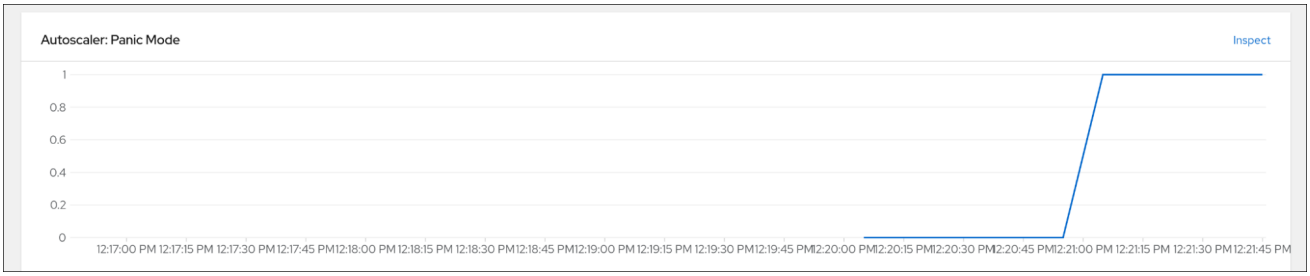
7.5.4. Scrape time

The **Scrape Time** graph shows the timeline of scrape times for each revision. Since autoscaling makes scaling decisions based on the metrics coming from service pods, high scrape times might cause delays in autoscaling when workload changes.



7.5.5. Panic mode

The **Panic Mode** graph shows the timeline of times when the Knative service faces a bursty load, which causes the autoscaler to quickly adapt the Service pod number.

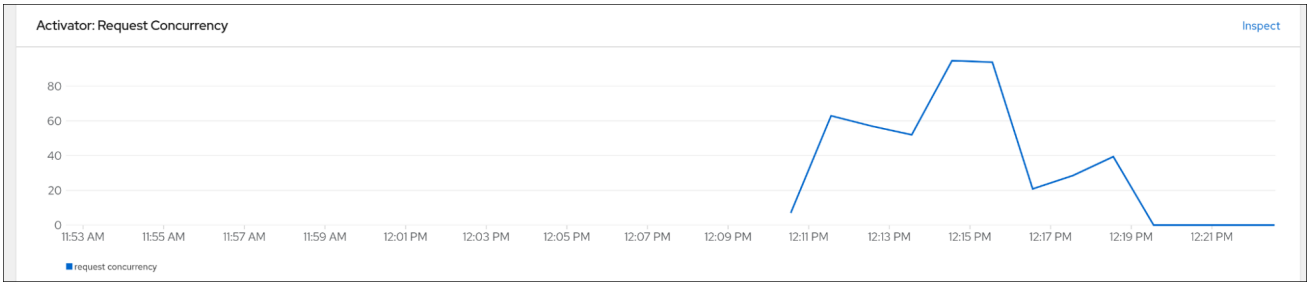


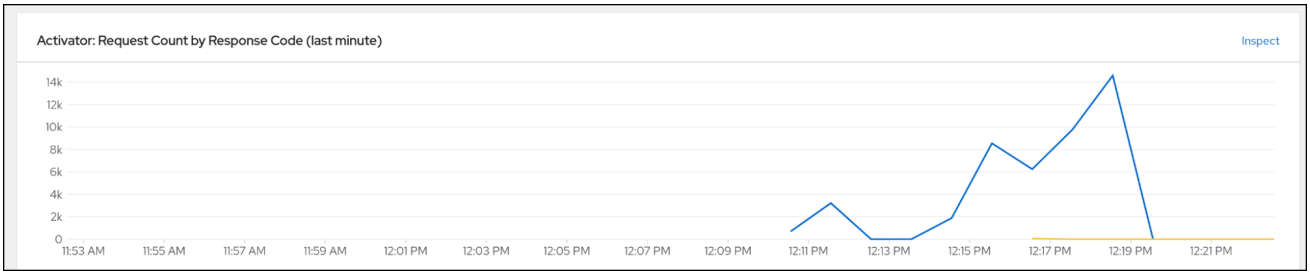
Additional resources

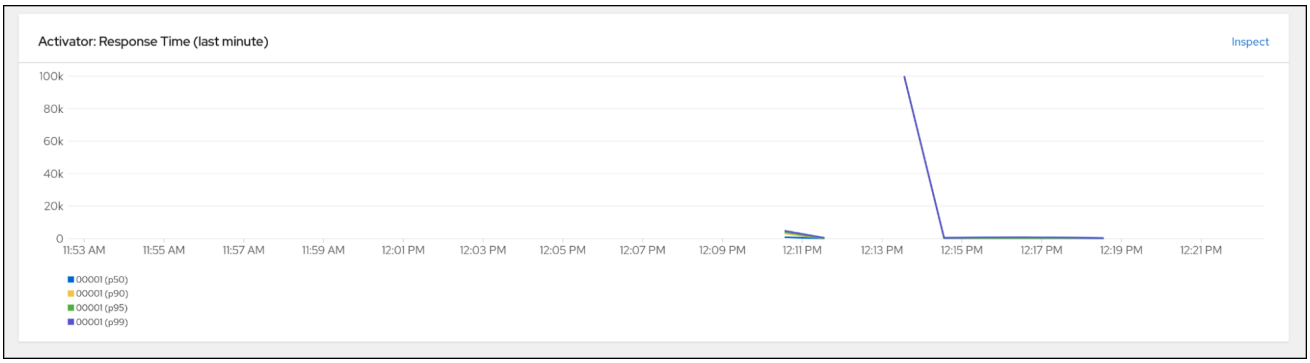
- See an overview of Knative Pod Autoscaling modes .

7.5.6. Activator metrics

The **Activator** graphs **Request Concurrency**, **Request Count by Response Code (last minute)**, and **Response Time (last minute)** show the timeline of requests going through the activator until the activator is removed from the request path. These graphs can be used, for example, to evaluate whether response count and the returned HTTP codes match expectations.







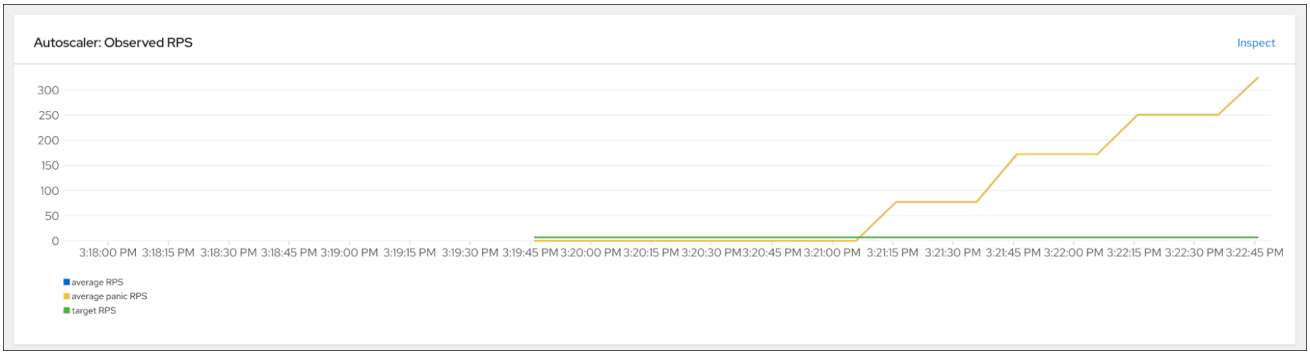
Additional resources

- See detailed information about activator metrics .

7.5.7. Requests per second

For requests-per-second (RPS) services, an additional **Observed RPS** dashboard is available, which visualizes different types of requests per second:

- **stable_requests_per_second**
- **panic_requests_per_second**
- **target_requests_per_second**



Note that the **Observed RPS** dashboard is visible only if the requests annotations are set, for example:

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: helloworld-go
  namespace: default
spec:
  template:
    metadata:
      annotations:
        autoscaling.knative.dev/target: "10"
        autoscaling.knative.dev/metric: "rps"
    spec:
      containers:
        - image: docker.io/openshift/hello-openshift
```

CHAPTER 8. OPENSHIFT SERVERLESS SUPPORT

8.1. GETTING SUPPORT

If you experience difficulty with a procedure described in this documentation, visit the Red Hat Customer Portal at http://access.redhat.com. Through the customer portal, you can:

- Search or browse through the Red Hat Knowledgebase of technical support articles about Red Hat products
- Submit a support case to Red Hat Global Support Services (GSS)
- Access other product documentation

If you have a suggestion for improving this guide or have found an error, please submit a Bugzilla report at http://bugzilla.redhat.com against **Product** for the **Documentation** component. Provide specific details, such as the section number, guide name, and OpenShift Serverless version so we can easily locate the content.

8.2. GATHERING DIAGNOSTIC INFORMATION FOR SUPPORT

When opening a support case, it is helpful to provide debugging information about your cluster to Red Hat Support.

The **must-gather** tool enables you to collect diagnostic information about your OpenShift Container Platform cluster, including data related to OpenShift Serverless.

For prompt support, supply diagnostic information for both OpenShift Container Platform and OpenShift Serverless.

8.2.1. About the must-gather tool

The **oc adm must-gather** CLI command collects the information from your cluster that is most likely needed for debugging issues, including:

- Resource definitions
- Service logs

By default, the **oc adm must-gather** command uses the default plug-in image and writes into **./must-gather.local**.

Alternatively, you can collect specific information by running the command with the appropriate arguments as described in the following sections:

- To collect data related to one or more specific features, use the **--image** argument with an image, as listed in a following section.
  For example:

  ```
  $ oc adm must-gather  --image=registry.redhat.io/container-native-virtualization/cnv-must-gather-rhel8:v4.9.0
  ```

- To collect the audit logs, use the **-- /usr/bin/gather_audit_logs** argument, as described in a following section.

For example:

```
$ oc adm must-gather -- /usr/bin/gather_audit_logs
```

NOTE

Audit logs are not collected as part of the default set of information to reduce the size of the files.

When you run **oc adm must-gather**, a new pod with a random name is created in a new project on the cluster. The data is collected on that pod and saved in a new directory that starts with **must-gather.local**. This directory is created in the current working directory.

For example:

```
NAMESPACE                  NAME              READY   STATUS      RESTARTS      AGE
...
openshift-must-gather-5drcj    must-gather-bklx4    2/2     Running     0          72s
openshift-must-gather-5drcj    must-gather-s8sdh    2/2     Running     0          72s
...
```

8.2.2. About collecting OpenShift Serverless data

You can use the **oc adm must-gather** CLI command to collect information about your cluster, including features and objects associated with OpenShift Serverless. To collect OpenShift Serverless data with **must-gather**, you must specify the OpenShift Serverless image and the image tag for your installed version of OpenShift Serverless.

Procedure

- Collect data by using the **oc adm must-gather** command:

```
$ oc adm must-gather --image=registry.redhat.io/openshift-serverless-1/svls-must-gather-rhel8:<image_version_tag>
```

Example command

```
$ oc adm must-gather --image=registry.redhat.io/openshift-serverless-1/svls-must-gather-rhel8:1.14.0
```

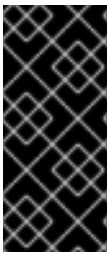
CHAPTER 9. SECURITY

9.1. CONFIGURING JSON WEB TOKEN AUTHENTICATION FOR KNATIVE SERVICES

After the Service Mesh integration with OpenShift Serverless and Kourier has been configured on your cluster, you can enable JSON Web Token (JWT) authentication for your Knative services.

9.1.1. Enabling sidecar injection for a Knative service

You can add the **sidecar.istio.io/inject="true"** annotation to a Knative service to enable sidecar injection for that service.



IMPORTANT

Adding sidecar injection to pods in system namespaces, such as **knative-serving** and **knative-serving-ingress**, is not supported when Kourier is enabled.

If you require sidecar injection for pods in these namespaces, see the OpenShift Serverless documentation on *Integrating Service Mesh with OpenShift Serverless natively* .

Procedure

1. Add the **sidecar.istio.io/inject="true"** annotation to your **Service** resource:

   Example service

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: <service_name>
spec:
  template:
    metadata:
      annotations:
        sidecar.istio.io/inject: "true" 1
        sidecar.istio.io/rewriteAppHTTPProbers: "true" 2
...
```

   1. Add the **sidecar.istio.io/inject="true"** annotation.
   2. You must set the annotation **sidecar.istio.io/rewriteAppHTTPProbers: "true"** in your Knative service as OpenShift Serverless versions 1.14.0 and higher use an HTTP probe as the readiness probe for Knative services by default.

2. Apply your **Service** resource YAML file:

```
$ oc apply -f <filename>
```

9.1.2. Using JSON Web Token authentication with Service Mesh 2.x and OpenShift Serverless

Procedure

1. Create a **RequestAuthentication** resource in each serverless application namespace that is a member in the **ServiceMeshMemberRoll** object:

```
apiVersion: security.istio.io/v1beta1
kind: RequestAuthentication
metadata:
  name: jwt-example
  namespace: <namespace>
spec:
  jwtRules:
  - issuer: testing@secure.istio.io
    jwksUri: https://raw.githubusercontent.com/istio/istio/release-
1.8/security/tools/jwt/samples/jwks.json
```

2. Apply the **RequestAuthentication** resource:

```
$ oc apply -f <filename>
```

3. Allow access to the **RequestAuthenticaton** resource from system pods for each serverless application namespace that is a member in the **ServiceMeshMemberRoll** object, by creating the following **AuthorizationPolicy** resource:

```
apiVersion: security.istio.io/v1beta1
kind: AuthorizationPolicy
metadata:
  name: allowlist-by-paths
  namespace: <namespace>
spec:
  action: ALLOW
  rules:
  - to:
    - operation:
        paths:
        - /metrics 1
        - /healthz 2
```

1. The path on your application to collect metrics by system pod.
2. The path on your application to probe by system pod.

4. Apply the **AuthorizationPolicy** resource:

```
$ oc apply -f <filename>
```

5. For each serverless application namespace that is a member in the **ServiceMeshMemberRoll** object, create the following **AuthorizationPolicy** resource:

```
apiVersion: security.istio.io/v1beta1
kind: AuthorizationPolicy
metadata:
  name: require-jwt
  namespace: <namespace>
```

```
spec:
  action: ALLOW
  rules:
  - from:
    - source:
       requestPrincipals: ["testing@secure.istio.io/testing@secure.istio.io"]
```

6. Apply the **AuthorizationPolicy** resource:

```
$ oc apply -f <filename>
```

Verification

1. If you try to use a **curl** request to get the Knative service URL, it is denied:

   Example command

   ```
   $ curl http://hello-example-1-default.apps.mycluster.example.com/
   ```

   Example output

   ```
   RBAC: access denied
   ```

2. Verify the request with a valid JWT.

   a. Get the valid JWT token:

   ```
   $ TOKEN=$(curl https://raw.githubusercontent.com/istio/istio/release-
   1.8/security/tools/jwt/samples/demo.jwt -s) && echo "$TOKEN" | cut -d '.' -f2 - | base64 --
   decode -
   ```

   b. Access the service by using the valid token in the **curl** request header:

   ```
   $ curl -H "Authorization: Bearer $TOKEN"  http://hello-example-1-
   default.apps.example.com
   ```

   The request is now allowed:

   Example output

   ```
   Hello OpenShift!
   ```

9.1.3. Using JSON Web Token authentication with Service Mesh 1.x and OpenShift Serverless

Procedure

1. Create a policy in a serverless application namespace which is a member in the **ServiceMeshMemberRoll** object, that only allows requests with valid JSON Web Tokens (JWT):

IMPORTANT

The paths **/metrics** and **/healthz** must be included in **excludedPaths** because they are accessed from system pods in the **knative-serving** namespace.

```
apiVersion: authentication.istio.io/v1alpha1
kind: Policy
metadata:
  name: default
  namespace: <namespace>
spec:
  origins:
  - jwt:
      issuer: testing@secure.istio.io
      jwksUri: "https://raw.githubusercontent.com/istio/istio/release-
1.6/security/tools/jwt/samples/jwks.json"
      triggerRules:
      - excludedPaths:
        - prefix: /metrics 1
        - prefix: /healthz 2
  principalBinding: USE_ORIGIN
```

1. The path on your application to collect metrics by system pod.
2. The path on your application to probe by system pod.

2. Apply the **Policy** resource:

```
$ oc apply -f <filename>
```

Verification

1. If you try to use a **curl** request to get the Knative service URL, it is denied:

```
$ curl http://hello-example-default.apps.mycluster.example.com/
```

Example output

```
Origin authentication failed.
```

2. Verify the request with a valid JWT.
   a. Get the valid JWT token:

```
$ TOKEN=$(curl https://raw.githubusercontent.com/istio/istio/release-
1.6/security/tools/jwt/samples/demo.jwt -s) && echo "$TOKEN" | cut -d '.' -f2 - | base64 --
decode -
```

   b. Access the service by using the valid token in the **curl** request header:

```
$ curl http://hello-example-default.apps.mycluster.example.com/ -H "Authorization:
Bearer $TOKEN"
```

The request is now allowed:

Example output

```
Hello OpenShift!
```

9.2. CONFIGURING A CUSTOM DOMAIN FOR A KNATIVE SERVICE

Knative services are automatically assigned a default domain name based on your cluster configuration. For example, **<service_name>.<namespace>.example.com**.

You can customize the domain for your Knative service by mapping a custom domain name that you own to a Knative service, by creating a **DomainMapping** resource for the service. You can also create multiple **DomainMapping** resources to map multiple domains and subdomains to a single service.

9.2.1. Creating a custom domain mapping

To map a custom domain name to a custom resource (CR), you must create a **DomainMapping** CR that maps to an Addressable target CR, such as a Knative service or a Knative route.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have created a Knative service and control a custom domain that you want to map to that service.

NOTE

Your custom domain must point to the IP address of the OpenShift Container Platform cluster.

Procedure

1. Create a YAML file containing the **DomainMapping** CR in the same namespace as the target CR you want to map to:

```
apiVersion: serving.knative.dev/v1alpha1
kind: DomainMapping
metadata:
 name: <domain_name> 1
 namespace: <namespace> 2
spec:
 ref:
   name: <target_name> 3
   kind: <target_type> 4
   apiVersion: serving.knative.dev/v1
```

1. The custom domain name that you want to map to the target CR.
2. The namespace of both the **DomainMapping** CR and the target CR.
3. The name of the target CR to map to the custom domain.

4 The type of CR being mapped to the custom domain.

Example service domain mapping

```
apiVersion: serving.knative.dev/v1alpha1
kind: DomainMapping
metadata:
 name: example-domain
 namespace: default
spec:
 ref:
   name: example-service
   kind: Service
   apiVersion: serving.knative.dev/v1
```

Example route domain mapping

```
apiVersion: serving.knative.dev/v1alpha1
kind: DomainMapping
metadata:
 name: example-domain
 namespace: default
spec:
 ref:
   name: example-route
   kind: Route
   apiVersion: serving.knative.dev/v1
```

2. Apply the **DomainMapping** CR as a YAML file:

```
$ oc apply -f <filename>
```

9.2.2. Creating a custom domain mapping by using the Knative CLI

You can use the **kn** CLI to create a **DomainMapping** custom resource (CR) that maps to an Addressable target CR, such as a Knative service or a Knative route.

The **--ref** flag specifies an Addressable target CR for domain mapping.

If a prefix is not provided when using the **--ref** flag, it is assumed that the target is a Knative service in the current namespace. The examples in the following procedure show the prefixes for mapping to a Knative service or a Knative route.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have created a Knative service or route, and control a custom domain that you want to map to that CR.

NOTE

Your custom domain must point to the DNS of the OpenShift Container Platform cluster.

- You have installed the **kn** CLI tool.

Procedure

- Map a domain to a CR in the current namespace:

```
$ kn domain create <domain_mapping_name> --ref <target_name>
```

Example command

```
$ kn domain create example-domain-map --ref example-service
```

- Map a domain to a Knative service in a specified namespace:

```
$ kn domain create <domain_mapping_name> --ref
<ksvc:service_name:service_namespace>
```

Example command

```
$ kn domain create example-domain-map --ref ksvc:example-service:example-namespace
```

- Map a domain to a Knative route:

```
$ kn domain create <domain_mapping_name> --ref <kroute:route_name>
```

Example command

```
$ kn domain create example-domain-map --ref kroute:example-route
```

9.2.3. Creating a custom domain mapping by using the web console

You can use the **Administrator** or **Developer** perspective of the OpenShift Container Platform web console to create a custom domain mapping for a Knative service.

9.2.3.1. Mapping a custom domain to a service by using the Administrator perspective

If you have cluster administrator permissions, you can create a **DomainMapping** custom resource (CR) by using the **Administrator** perspective in the OpenShift Container Platform web console.

Prerequisites

- You have logged in to the web console.
- You are in the **Administrator** perspective.
- You have installed the OpenShift Serverless Operator.

- You have installed Knative Serving.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.
- You have created a Knative service and control a custom domain that you want to map to that service.

NOTE

Your custom domain must point to the IP address of the OpenShift Container Platform cluster.

Procedure

1. Navigate to **CustomResourceDefinitions** and use the search box to find the **DomainMapping** custom resource definition (CRD).
2. Click the **DomainMapping** CRD, then navigate to the **Instances** tab.
3. Click **Create DomainMapping**.
4. Modify the YAML for the **DomainMapping** CR so that it includes the following information for your instance:

```
apiVersion: serving.knative.dev/v1alpha1
kind: DomainMapping
metadata:
 name: <domain_name> 1
 namespace: <namespace> 2
spec:
 ref:
   name: <target_name> 3
   kind: <target_type> 4
   apiVersion: serving.knative.dev/v1
```

1. The custom domain name that you want to map to the target CR.
2. The namespace of both the **DomainMapping** CR and the target CR.
3. The name of the target CR to map to the custom domain.
4. The type of CR being mapped to the custom domain.

Example domain mapping to a Knative service

```
apiVersion: serving.knative.dev/v1alpha1
kind: DomainMapping
metadata:
 name: custom-ksvc-domain.example.com
 namespace: default
spec:
 ref:
```

```
  name: example-service
  kind: Service
  apiVersion: serving.knative.dev/v1
```

Verification

- Access the custom domain by using a **curl** request. For example:

  Example command

  ```
  $ curl custom-ksvc-domain.example.com
  ```

  Example output

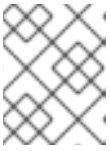
  ```
  Hello OpenShift!
  ```

9.2.3.2. Mapping a custom domain to a service by using the Developer perspective

You can use the **Developer** perspective of the OpenShift Container Platform web console to map a **DomainMapping** custom resource (CR) to a Knative service.

Prerequisites

- You have logged in to the web console.
- You are in the **Developer** perspective.
- The OpenShift Serverless Operator and Knative Serving are installed on your cluster. This must be completed by a cluster administrator.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.
- You have created a Knative service and control a custom domain that you want to map to that service.



NOTE

Your custom domain must point to the IP address of the OpenShift Container Platform cluster.

Procedure

1. Navigate to the **Topology** page.
2. Right-click on the service that you want to map to a domain, and select the **Edit** option that contains the service name. For example, if the service is named **example-service**, select the **Edit example-service** option.
3. In the **Advanced options** section, click **Show advanced Routing options**.
   a. If the domain mapping CR that you want to map to the service already exists, you can select it from the **Domain mapping** drop-down.

b. If you want to create a new domain mapping CR, type the domain name into the box, and select the **Create** option. For example, if you type in **example.com**, the **Create** option is **Create "example.com"**.

4. Click **Save** to save the changes to your service.

Verification

1. Navigate to the **Topology** page.
2. Click on the service that you have created.
3. In the **Resources** tab of the service information window, you can see the domain you have mapped to the service listed under **Domain mappings**.

9.3. USING A CUSTOM TLS CERTIFICATE FOR DOMAIN MAPPING

You can use an existing TLS certificate with a **DomainMapping** custom resource (CR) to secure the mapped service.

Prerequisites

- You have completed the steps in Configuring a custom domain for a Knative service and have a working **DomainMapping** CR.

9.3.1. Adding a custom TLS certificate to a DomainMapping CR

You can add an existing TLS certificate with a **DomainMapping** custom resource (CR) to secure the mapped service.

Prerequisites

- You configured a custom domain for a Knative service and have a working **DomainMapping** CR.
- You have a TLS certificate from your Certificate Authority provider or a self-signed certificate.
- You have obtained the **cert** and **key** files from your Certificate Authority provider, or a self-signed certificate.

Procedure

1. Create a Kubernetes TLS secret:

```
$ oc create secret tls <tls_secret_name> --cert=<path_to_certificate_file> --key=
<path_to_key_file>
```

2. Update the **DomainMapping** CR to use the TLS secret you have created:

```
apiVersion: serving.knative.dev/v1alpha1
kind: DomainMapping
metadata:
  name: <domain_name>
  namespace: <namespace>
spec:
```

```
  ref:
    name: <service_name>
    kind: Service
    apiVersion: serving.knative.dev/v1
# TLS block specifies the secret to be used
  tls:
    secretName: <tls_secret_name>
```

Verification

1. Verify that the **DomainMapping** CR status is **True**, and that the **URL** column of the output shows the mapped domain with the scheme **https**:

```
$ oc get domainmapping <domain_name>
```

Example output

```
NAME                URL                         READY   REASON
example.com         https://example.com         True
```

2. Optional: If the service is exposed publicly, verify that it is available by running the following command:

```
$ curl https://<domain_name>
```

If the certificate is self-signed, skip verification by adding the **-k** flag to the **curl** command.

9.4. SECURITY CONFIGURATION FOR KNATIVE KAFKA

In production, Kafka clusters are often secured using the TLS or SASL authentication methods. This section shows how to configure a Kafka channel to work against a protected Red Hat AMQ Streams cluster using TLS or SASL.

NOTE

If you choose to enable SASL, Red Hat recommends to also enable TLS.

9.4.1. Configuring TLS authentication

Prerequisites

- A Kafka cluster CA certificate as a **.pem** file.
- A Kafka cluster client certificate and key as **.pem** files.

Procedure

1. Create the certificate files as secrets in your chosen namespace:

```
$ kubectl create secret -n <namespace> generic <kafka_auth_secret> \
  --from-file=ca.crt=caroot.pem \
  --from-file=user.crt=certificate.pem \
```

```
--from-file=user.key=key.pem
```

IMPORTANT

Use the key names **ca.crt**, **user.crt**, and **user.key**. Do not change them.

2. Start editing the **KnativeKafka** custom resource:

```
$ oc edit knativekafka
```

3. Reference your secret and the namespace of the secret:

```
apiVersion: operator.serverless.openshift.io/v1alpha1
kind: KnativeKafka
metadata:
  namespace: knative-eventing
  name: knative-kafka
spec:
  channel:
    authSecretName: <kafka_auth_secret>
    authSecretNamespace: <kafka_auth_secret_namespace>
    bootstrapServers: <bootstrap_servers>
    enabled: true
  source:
    enabled: true
```

NOTE

Make sure to specify the matching port in the bootstrap server.

For example:

```
apiVersion: operator.serverless.openshift.io/v1alpha1
kind: KnativeKafka
metadata:
  namespace: knative-eventing
  name: knative-kafka
spec:
  channel:
    authSecretName: tls-user
    authSecretNamespace: kafka
    bootstrapServers: eventing-kafka-bootstrap.kafka.svc:9094
    enabled: true
  source:
    enabled: true
```

Additional resources

- TLS and SASL on Kafka

9.4.2. Configuring SASL authentication

Prerequisites

- A username and password for the Kafka cluster.
- Choose the SASL mechanism to use, for example **PLAIN**, **SCRAM-SHA-256**, or **SCRAM-SHA-512**.
- If TLS is enabled, you also need the **ca.crt** certificate file for the Kafka cluster.

NOTE

Red Hat recommends to enable TLS in addition to SASL.

Procedure

1. Create the certificate files as secrets in your chosen namespace:

```
$ oc create secret --namespace <namespace> generic <kafka_auth_secret> \
  --from-file=ca.crt=caroot.pem \
  --from-literal=password="SecretPassword" \
  --from-literal=saslType="SCRAM-SHA-512" \
  --from-literal=user="my-sasl-user"
```

IMPORTANT

Use the key names **ca.crt**, **password**, and **saslType**. Do not change them.

2. Start editing the **KnativeKafka** custom resource:

```
$ oc edit knativekafka
```

3. Reference your secret and the namespace of the secret:

```
apiVersion: operator.serverless.openshift.io/v1alpha1
kind: KnativeKafka
metadata:
  namespace: knative-eventing
  name: knative-kafka
spec:
  channel:
    authSecretName: <kafka_auth_secret>
    authSecretNamespace: <kafka_auth_secret_namespace>
    bootstrapServers: <bootstrap_servers>
    enabled: true
  source:
    enabled: true
```

NOTE

Make sure to specify the matching port in the bootstrap server.

For example:

```
apiVersion: operator.serverless.openshift.io/v1alpha1
kind: KnativeKafka
metadata:
  namespace: knative-eventing
  name: knative-kafka
spec:
  channel:
    authSecretName: scram-user
    authSecretNamespace: kafka
    bootstrapServers: eventing-kafka-bootstrap.kafka.svc:9093
    enabled: true
  source:
    enabled: true
```

Additional resources

- TLS and SASL on Kafka

9.4.3. Configuring SASL authentication using public CA certificates

If you want to use SASL with public CA certificates, you must use the **tls.enabled=true** flag, rather than the **ca.crt** argument, when creating the secret. For example:

```
$ oc create secret --namespace <namespace> generic <kafka_auth_secret> \
  --from-literal=tls.enabled=true \
  --from-literal=password="SecretPassword" \
  --from-literal=saslType="SCRAM-SHA-512" \
  --from-literal=user="my-sasl-user"
```

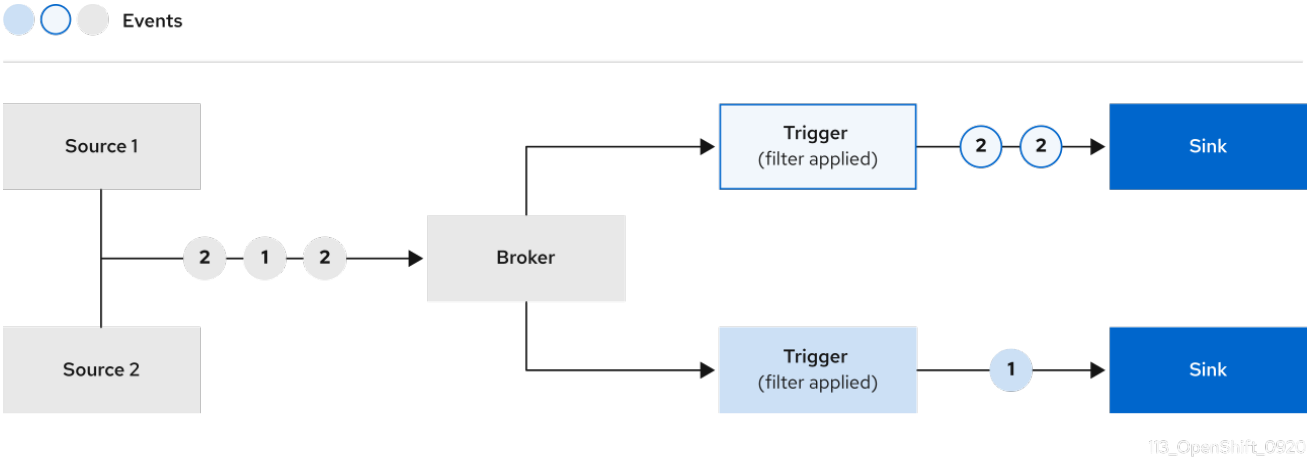
Additional resources

- TLS and SASL on Kafka

CHAPTER 10. KNATIVE EVENTING

10.1. BROKERS

Brokers can be used in combination with triggers to deliver events from an event source to an event sink.



Events can be sent from an event source to a broker as an HTTP POST request.

After events have entered the broker, they can be filtered by CloudEvent attributes using triggers, and sent as an HTTP POST request to an event sink.

10.1.1. Creating a broker

OpenShift Serverless provides a **default** Knative broker that you can create by using the **kn** CLI. You can also create the **default** broker by adding the **eventing.knative.dev/injection: enabled** annotation to a trigger, or by adding the **eventing.knative.dev/injection=enabled** label to a namespace.

10.1.1.1. Creating a broker by using the Knative CLI

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the **kn** CLI.

Procedure

- Create the **default** broker:

```
$ kn broker create default
```

Verification

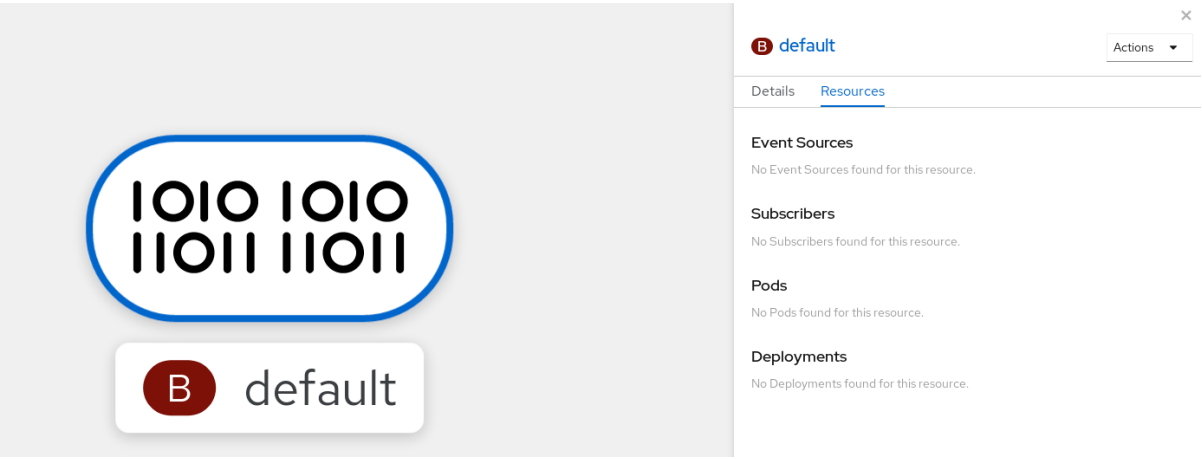
1. Use the **kn** command to list all existing brokers:

```
$ kn broker list
```

Example output

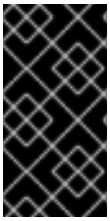
```
NAME      URL                                                        AGE   CONDITIONS   READY
REASON
default   http://broker-ingress.knative-eventing.svc.cluster.local/test/default   45s   5 OK / 5
True
```

2. Optional: If you are using the OpenShift Container Platform web console, you can navigate to the **Topology** view in the **Developer** perspective, and observe that the broker exists:



10.1.1.2. Creating a broker by annotating a trigger

You can create a broker by adding the **eventing.knative.dev/injection: enabled** annotation to a **Trigger** object.



IMPORTANT

If you create a broker by using the **eventing.knative.dev/injection: enabled** annotation, you cannot delete this broker without cluster administrator permissions. If you delete the broker without having a cluster administrator remove this annotation first, the broker is created again after deletion.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the **oc** CLI.

Procedure

1. Create a **Trigger** object as a YAML file that has the **eventing.knative.dev/injection: enabled** annotation:

```
apiVersion: eventing.knative.dev/v1
kind: Trigger
metadata:
  annotations:
    eventing.knative.dev/injection: enabled
  name: <trigger_name>
spec:
```

```
broker: default
subscriber: 1
  ref:
    apiVersion: serving.knative.dev/v1
    kind: Service
    name: <service_name>
```

1 Specify details about the event sink, or *subscriber*, that the trigger sends events to.

2. Apply the **Trigger** YAML file:

```
$ oc apply -f <filename>
```

Verification

You can verify that the broker has been created successfully by using the **oc** CLI, or by observing it in the **Topology** view in the web console.

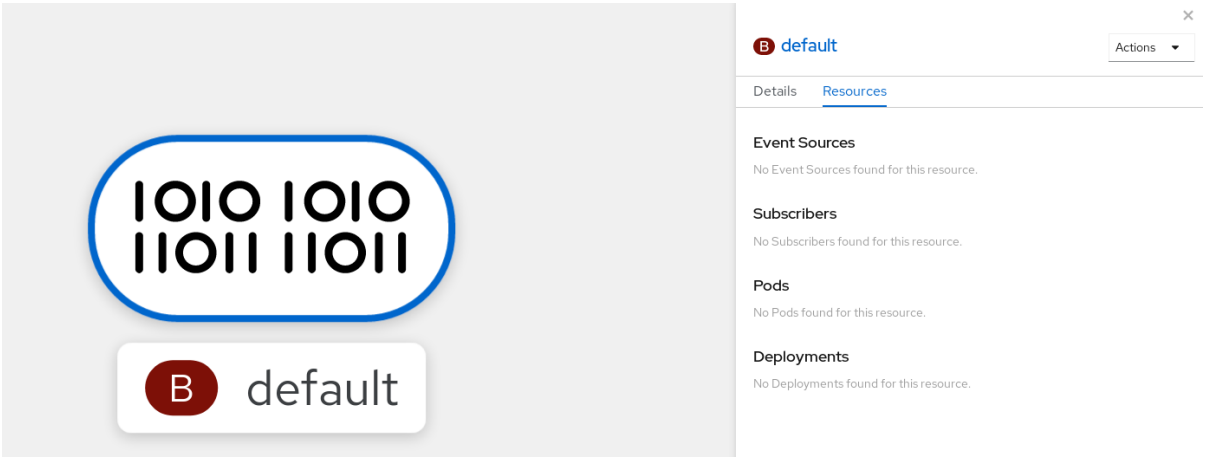
1. Enter the following **oc** command to get the broker:

```
$ oc -n <namespace> get broker default
```

Example output

```
NAME      READY     REASON    URL                                                                 AGE
default   True                http://broker-ingress.knative-eventing.svc.cluster.local/test/default   3m56s
```

2. Navigate to the **Topology** view in the web console, and observe that the broker exists:



10.1.1.3. Creating a broker by labeling a namespace

You can create the **default** broker automatically by labeling a namespace that you own or have write permissions for.

NOTE

Brokers created using this method will not be removed if you remove the label. You must manually delete them.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.

Procedure

- Label a namespace with **eventing.knative.dev/injection=enabled**:

```
$ oc label namespace <namespace> eventing.knative.dev/injection=enabled
```

Verification

You can verify that the broker has been created successfully by using the **oc** CLI, or by observing it in the **Topology** view in the web console.

1. Use the **oc** command to get the broker:

```
$ oc -n <namespace> get broker <broker_name>
```

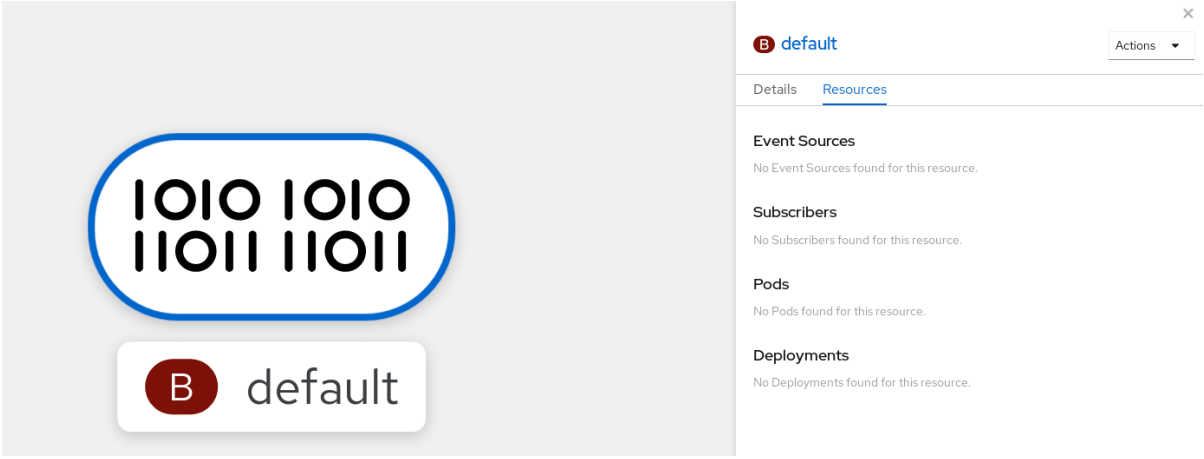
Example command

```
$ oc -n default get broker default
```

Example output

```
NAME      READY     REASON    URL                                                                 AGE
default   True                http://broker-ingress.knative-eventing.svc.cluster.local/test/default   3m56s
```

2. Navigate to the **Topology** view in the web console, and observe that the broker exists:



10.1.1.4. Deleting a broker that was created by injection

Brokers created by injection, by using a namespace label or trigger annotation, are not deleted permanently if a developer removes the label or annotation. You must manually delete these brokers.

Procedure

1. Remove the **eventing.knative.dev/injection=enabled** label from the namespace:

```
$ oc label namespace <namespace> eventing.knative.dev/injection-
```

Removing the annotation prevents Knative from recreating the broker after you delete it.

2. Delete the broker from the selected namespace:

```
$ oc -n <namespace> delete broker <broker_name>
```

Verification

- Use the **oc** command to get the broker:

```
$ oc -n <namespace> get broker <broker_name>
```

Example command

```
$ oc -n default get broker default
```

Example output

```
No resources found.
Error from server (NotFound): brokers.eventing.knative.dev "default" not found
```

10.1.2. Managing brokers

The **kn** CLI provides commands that can be used to list, describe, update, and delete brokers.

10.1.2.1. Listing existing brokers by using the Knative CLI

Prerequisites

- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the **kn** CLI.

Procedure

- List all existing brokers:

```
$ kn broker list
```

Example output

```
NAME      URL                                                    AGE   CONDITIONS   READY
REASON
default   http://broker-ingress.knative-eventing.svc.cluster.local/test/default   45s   5 OK / 5
True
```

10.1.2.2. Describing an existing broker by using the Knative CLI

Prerequisites

- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the **kn** CLI.

Procedure

- Describe an existing broker:

```
$ kn broker describe <broker_name>
```

Example command using default broker

```
$ kn broker describe default
```

Example output

```
Name:         default
Namespace:    default
Annotations:  eventing.knative.dev/broker.class=MTChannelBasedBroker,
eventing.knative.dev/creato ...
Age:          22s

Address:
  URL:    http://broker-ingress.knative-eventing.svc.cluster.local/default/default

Conditions:
  OK TYPE                  AGE REASON
  ++ Ready                 22s
  ++ Addressable           22s
  ++ FilterReady           22s
  ++ IngressReady          22s
  ++ TriggerChannelReady   22s
```

10.2. FILTERING EVENTS FROM A BROKER BY USING TRIGGERS

Using triggers enables you to filter events from the broker for delivery to event sinks.

10.2.1. Prerequisites

- You have installed Knative Eventing and the **kn** CLI.
- You have access to an available broker.
- You have access to an available event consumer, such as a Knative service.

10.2.2. Creating a trigger using the Developer perspective

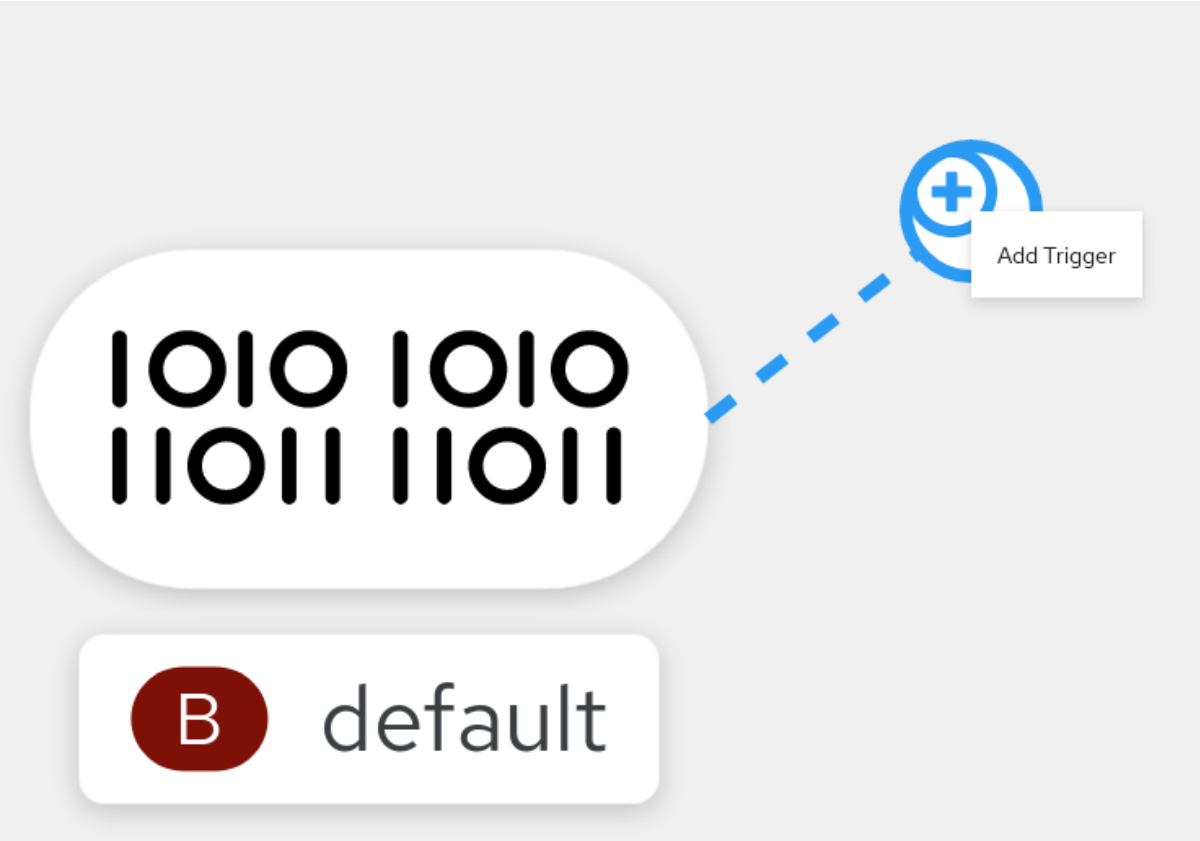
After you have created a broker, you can create a trigger in the web console **Developer** perspective.

Prerequisites

- The OpenShift Serverless Operator, Knative Serving, and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have logged in to the web console.
- You are in the **Developer** perspective.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.
- You have created a broker and a Knative service or other event sink to connect to the trigger.

Procedure

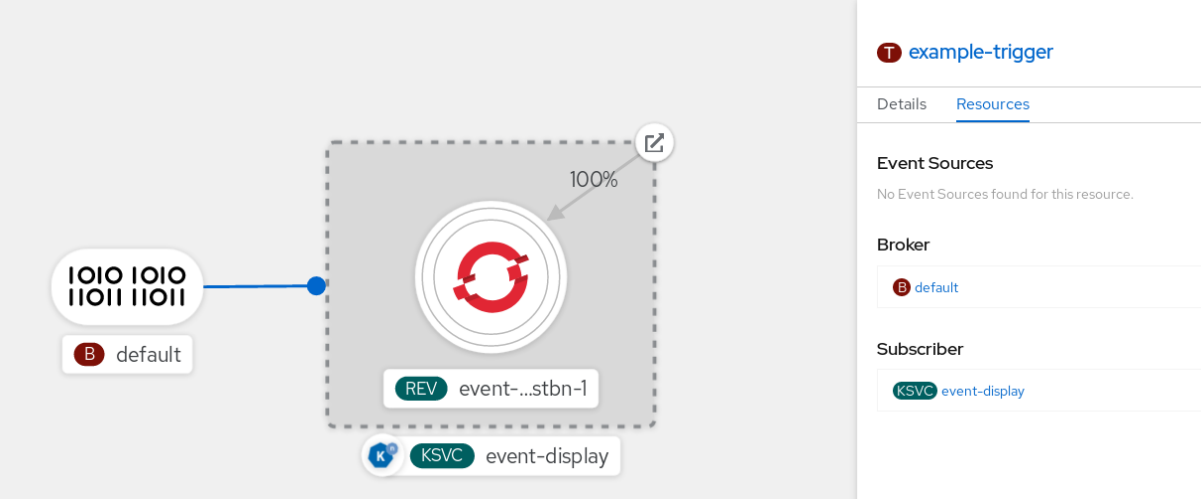
1. In the **Developer** perspective, navigate to the **Topology** page.
2. Hover over the broker that you want to create a trigger for, and drag the arrow. The **Add Trigger** option is displayed.



3. Click **Add Trigger**.
4. Select your sink as a **Subscriber** from the drop-down list.
5. Click **Add**.

Verification

- After the subscription has been created, it is represented as a line that connects the broker to the service in the **Topology** view:



10.2.3. Deleting a trigger using the Developer perspective

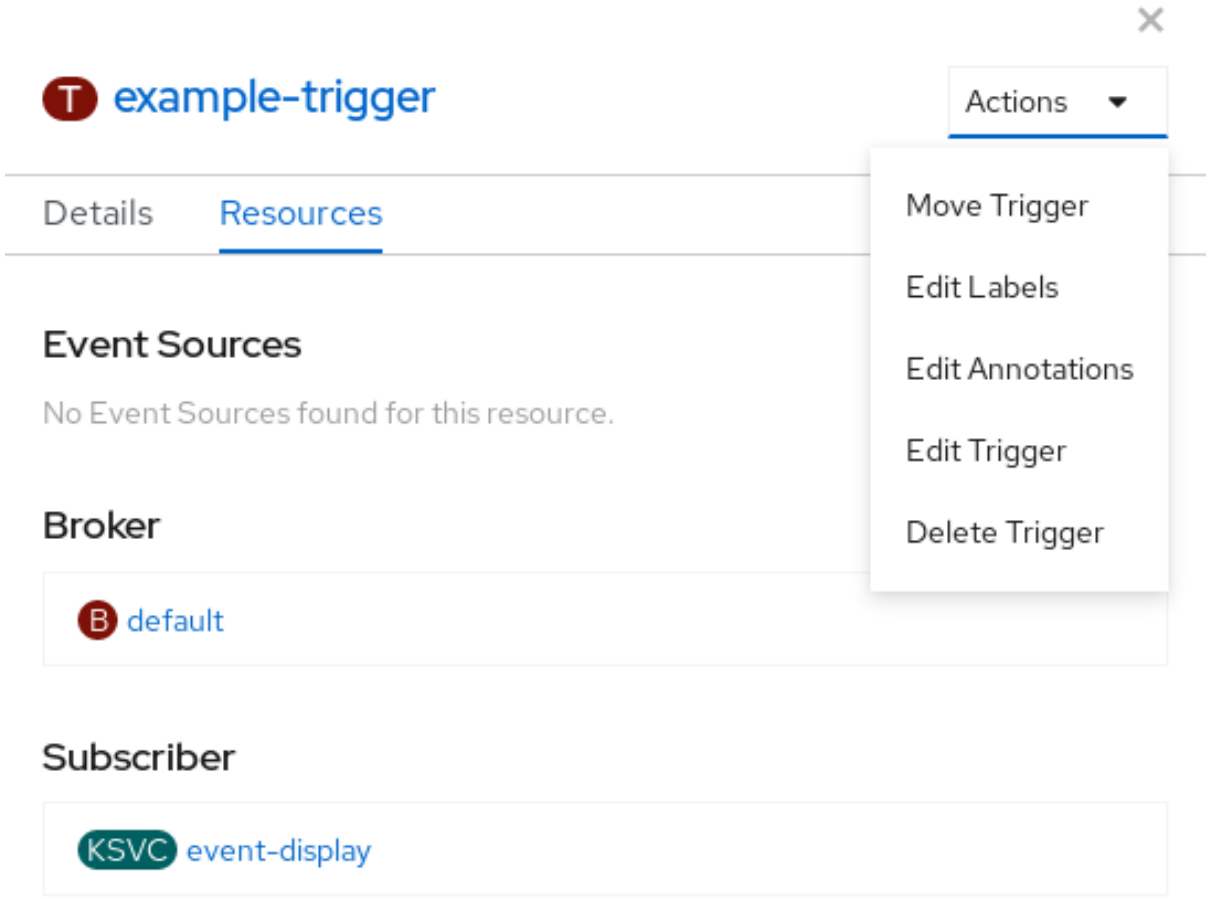
You can delete triggers in the web console **Developer** perspective.

Prerequisites

- To delete a trigger using the **Developer** perspective, ensure that you have logged in to the web console.

Procedure

1. In the **Developer** perspective, navigate to the **Topology** page.
2. Click on the trigger that you want to delete.
3. In the **Actions** context menu, select **Delete Trigger**.



10.2.4. Creating a trigger by using the Knative CLI

You can create a trigger by using the **kn trigger create** command.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the **kn** CLI.

Procedure

- Create a trigger:

```
$ kn trigger create <trigger_name> --broker <broker_name> --filter <key=value> --sink
<sink_name>
```

Alternatively, you can create a trigger and simultaneously create the **default** broker using broker injection:

```
$ kn trigger create <trigger_name> --inject-broker --filter <key=value> --sink <sink_name>
```

By default, triggers forward all events sent to a broker to sinks that are subscribed to that broker. Using the **--filter** attribute for triggers allows you to filter events from a broker, so that subscribers will only receive a subset of events based on your defined criteria.

10.2.5. Listing triggers by using the Knative CLI

The **kn trigger list** command prints a list of available triggers.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the **kn** CLI.

Procedure

1. Print a list of available triggers:

```
$ kn trigger list
```

Example output

```
NAME    BROKER    SINK          AGE   CONDITIONS   READY   REASON
email   default   ksvc:edisplay   4s    5 OK / 5     True
ping    default   ksvc:edisplay   32s   5 OK / 5     True
```

2. Optional: Print a list of triggers in JSON format:

```
$ kn trigger list -o json
```

10.2.6. Describing a trigger by using the Knative CLI

You can use the **kn trigger describe** command to print information about a trigger.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the **kn** CLI.

Procedure

- Enter the command:

```
$ kn trigger describe <trigger_name>
```

Example output

```
Name:         ping
Namespace:    default
Labels:       eventing.knative.dev/broker=default
Annotations:  eventing.knative.dev/creator=kube:admin,
eventing.knative.dev/lastModifier=kube:admin
Age:          2m
Broker:       default
```

```
Filter:
  type:       dev.knative.event

Sink:
  Name:       edisplay
  Namespace:  default
  Resource:   Service (serving.knative.dev/v1)

Conditions:
  OK TYPE                 AGE REASON
  ++ Ready                2m
  ++ BrokerReady          2m
  ++ DependencyReady      2m
  ++ Subscribed           2m
  ++ SubscriberResolved   2m
```

10.2.7. Filtering events with triggers by using the Knative CLI

In the following trigger example, only events with the attribute **type: dev.knative.samples.helloworld** will reach the event sink.

```
$ kn trigger create <trigger_name> --broker <broker_name> --filter
type=dev.knative.samples.helloworld --sink ksvc:<service_name>
```

You can also filter events using multiple attributes. The following example shows how to filter events using the type, source, and extension attributes.

```
$ kn trigger create <trigger_name> --broker <broker_name> --sink ksvc:<service_name> \
--filter type=dev.knative.samples.helloworld \
--filter source=dev.knative.samples/helloworldsource \
--filter myextension=my-extension-value
```

10.2.8. Updating a trigger by using the Knative CLI

You can use the **kn trigger update** command with certain flags to update attributes for a trigger.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the **kn** CLI.

Procedure

- Update a trigger:

```
$ kn trigger update <trigger_name> --filter <key=value> --sink <sink_name> [flags]
```

  - You can update a trigger to filter exact event attributes that match incoming events. For example, using the **type** attribute:

```
$ kn trigger update <trigger_name> --filter type=knative.dev.event
```

- You can remove a filter attribute from a trigger. For example, you can remove the filter attribute with key **type**:

```
$ kn trigger update <trigger_name> --filter type-
```

- You can use the **--sink** parameter to change the event sink of a trigger:

```
$ kn trigger update <trigger_name> --sink ksvc:my-event-sink
```

10.2.9. Deleting a trigger by using the Knative CLI

You can use the **kn trigger delete** command to delete a trigger.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the **kn** CLI.

Procedure

- Delete a trigger:

```
$ kn trigger delete <trigger_name>
```

Verification

1. List existing triggers:

```
$ kn trigger list
```

2. Verify that the trigger no longer exists:

Example output

```
No triggers found.
```

10.3. EVENT DELIVERY

You can configure event delivery parameters for Knative Eventing that are applied in cases where an event fails to be delivered by a subscription. Event delivery parameters are configured individually per subscription.

10.3.1. Event delivery behavior for Knative Eventing channels

Different Knative Eventing channel types have their own behavior patterns that are followed for event delivery. Developers can set event delivery parameters in the subscription configuration to ensure that any events that fail to be delivered from channels to an event sink are retried. You must also configure a dead letter sink for subscriptions if you want to provide a sink where events that are not eventually delivered can be stored, otherwise undelivered events are dropped.

10.3.1.1. Event delivery behavior for Knative Kafka channels

If an event is successfully delivered to a Kafka channel or broker receiver, the receiver responds with a **202** status code, which means that the event has been safely stored inside a Kafka topic and is not lost. If the receiver responds with any other status code, the event is not safely stored, and steps must be taken by the user to resolve this issue.

10.3.1.2. Delivery failure status codes

The channel or broker receiver can respond with the following status codes if an event fails to be delivered:

500

This is a generic status code which means that the event was not delivered successfully.

404

This status code means that the channel or broker the event is being delivered to does not exist, or that the **Host** header is incorrect.

400

This status code means that the event being sent to the receiver is invalid.

10.3.2. Configurable parameters

The following parameters can be configured for event delivery.

Dead letter sink

You can configure the **deadLetterSink** delivery parameter so that if an event fails to be delivered it is sent to the specified event sink.

Retries

You can set a minimum number of times that the delivery must be retried before the event is sent to the dead letter sink, by configuring the **retry** delivery parameter with an integer value.

Back off delay

You can set the **backoffDelay** delivery parameter to specify the time delay before an event delivery retry is attempted after a failure. The duration of the **backoffDelay** parameter is specified using the ISO 8601 format.

Back off policy

The **backoffPolicy** delivery parameter can be used to specify the retry back off policy. The policy can be specified as either **linear** or **exponential**. When using the **linear** back off policy, the back off delay is the time interval specified between retries. When using the **exponential** backoff policy, the back off delay is equal to **backoffDelay*2^<numberOfRetries>**.

10.3.3. Configuring event delivery failure parameters using subscriptions

Developers can configure event delivery parameters for individual subscriptions by modifying the **delivery** settings for a **Subscription** object.

Example subscription YAML

```
apiVersion: messaging.knative.dev/v1
kind: Subscription
metadata:
  name: <subscription_name>
```

```
  namespace: <subscription_namespace>
spec:
  delivery:
    deadLetterSink: 1
      ref:
        apiVersion: serving.knative.dev/v1
        kind: Service
        name: <sink_name>
    backoffDelay: <duration> 2
    backoffPolicy: <policy_type> 3
    retry: <integer> 4
```

1. Configuration settings to enable using a dead letter sink. This tells the subscription what happens to events that cannot be delivered to the subscriber.

   When this is configured, events that fail to be delivered are sent to the dead letter sink destination. The destination can be a Knative service or a URI.

2. You can set the **backoffDelay** delivery parameter to specify the time delay before an event delivery retry is attempted after a failure. The duration of the **backoffDelay** parameter is specified using the ISO 8601 format. For example, **PT1S** specifies a 1 second delay.

3. The **backoffPolicy** delivery parameter can be used to specify the retry back off policy. The policy can be specified as either **linear** or **exponential**. When using the **linear** back off policy, the back off delay is the time interval specified between retries. When using the **exponential** back off policy, the back off delay is equal to **backoffDelay*2^<numberOfRetries>**.

4. The number of times that event delivery is retried before the event is sent to the dead letter sink.

10.3.4. Additional resources

- See Creating subscriptions.

CHAPTER 11. FUNCTIONS

11.1. SETTING UP OPENSHIFT SERVERLESS FUNCTIONS

IMPORTANT

OpenShift Serverless Functions is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see https://access.redhat.com/support/offerings/techpreview/.

Before you can develop functions on OpenShift Serverless, you must complete the set up steps.

11.1.1. Prerequisites

To enable the use of OpenShift Serverless Functions on your cluster, you must complete the following steps:

- OpenShift Serverless is installed on your cluster.
- The **oc** CLI is installed on your cluster.
- The Knative (**kn**) CLI is installed on your cluster. Installing the **kn** CLI enables the use of **kn func** commands which you can use to create and manage functions.
- You have installed Docker Container Engine or podman, and have access to an available image registry.
- If you are using Quay.io as the image registry, you must ensure that either the repository is not private, or that you have followed the OpenShift Container Platform documentation on Allowing pods to reference images from other secured registries.
- If you are using the OpenShift Container Registry, a cluster administrator must expose the registry.

11.1.2. Using podman

If you are using podman, you must run the following commands before getting started with OpenShift Serverless Functions:

1. Start the podman service that serves the Docker API on a UNIX socket at **${XDG_RUNTIME_DIR}/podman/podman.sock**:

```
$ systemctl start --user podman.socket
```

NOTE

On most systems, this socket is located at **/run/user/$(id -u)/podman/podman.sock**.

2. Establish the environment variable that is used to build a function:

```
$ export DOCKER_HOST="unix://${XDG_RUNTIME_DIR}/podman/podman.sock"
```

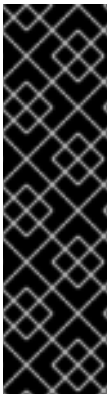
3. Run the build command with **-v** to see verbose output. You should see a connection to your local UNIX socket:

```
$ kn func build -v
```

11.1.3. Next steps

- For more information about Docker Container Engine or podman, see Container build tool options.
- See Getting started with functions.

11.2. GETTING STARTED WITH FUNCTIONS



IMPORTANT

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For more information about the support scope of Red Hat Technology Preview features, see https://access.redhat.com/support/offerings/techpreview/.

This guide explains how you can get started with creating, building, and deploying a function on an OpenShift Serverless installation.

11.2.1. Prerequisites

Before you can complete the following procedures, you must ensure that you have completed all of the prerequisite tasks in Setting up OpenShift Serverless Functions.

11.2.2. Creating functions

You can create a basic serverless function using the **kn** CLI.

You can specify the path, runtime, template, and repository with the template as flags on the command line, or use the **-c** flag to start the interactive experience in the terminal.

Procedure

- Create a function project:

```
$ kn func create -r <repository> -l <runtime> -t <template> <path>
```

  - Supported runtimes include **node**, **go**, **python**, **quarkus**, and **typescript**.
  - Supported templates include **http** and **events**.

    Example command

```
$ kn func create -l typescript -t events examplefunc
```

    Example output

```
Project path:  /home/user/demo/examplefunc
Function name: examplefunc
Runtime:       typescript
Template:      events
Writing events to /home/user/demo/examplefunc
```

  - Alternatively, you can specify a repository that contains a custom template.

    Example command

```
$ kn func create -r https://github.com/boson-project/templates/ -l node -t hello-world
examplefunc
```

    Example output

```
Project path:  /home/user/demo/examplefunc
Function name: examplefunc
Runtime:       node
Template:      hello-world
Writing events to /home/user/demo/examplefunc
```

11.2.3. Building functions

Before you can run a function, you must build the function project by using the **kn func build** command. The build command reads the **func.yaml** file from the function project directory to determine the image name and registry.

Example func.yaml

```
name: example-function
namespace: default
runtime: node
image: <image_from_registry>
imageDigest: ""
trigger: http
builder: default
builderMap:
  default: quay.io/boson/faas-nodejs-builder
envs: {}
```

-

If the image name and registry are not set in the **func.yaml** file, you must either specify the registry flag, **-r** when using the **kn func build** command, or you are prompted to provide a registry value in the terminal when building a function. An image name is then derived from the registry value that you have provided.

Example command using the -r registry flag

```
$ kn func build [-i <image> -r <registry> -p <path>]
```

Example output

```
Building function image
Function image has been built, image: quay.io/username/example-function:latest
```

This command creates an OCI container image that can be run locally on your computer, or on a Kubernetes cluster.

Example using the registy prompt

```
$ kn func build
A registry for function images is required (e.g. 'quay.io/boson').

Registry for function images: quay.io/username
Building function image
Function image has been built, image: quay.io/username/example-function:latest
```

The values for image and registry are persisted to the **func.yaml** file, so that subsequent invocations do not require the user to specify these again.

11.2.4. Deploying functions

You can deploy a function to your cluster as a Knative service by using the **kn func deploy** command.

If the targeted function is already deployed, it is updated with a new container image that is pushed to a container image registry, and the Knative service is updated.

Prerequisites

- You must have already initialized the function that you want to deploy.

Procedure

- Deploy a function:

  ```
  $ kn func deploy [-n <namespace> -p <path> -i <image> -r <registry>]
  ```

  #### Example output

  ```
  Function deployed at: http://func.example.com
  ```

  - If no **namespace** is specified, the function is deployed in the current namespace.

- The function is deployed from the current directory, unless a **path** is specified.
- The Knative service name is derived from the project name, and cannot be changed using this command.

11.2.5. Building and deploying functions with OpenShift Container Registry

When building and deploying functions, the resulting container image is stored in an image registry. Usually this will be a public registry, such as Quay. However, you can use the integrated OpenShift Container Registry instead if it has been exposed by a cluster administrator.

Procedure

- Run the **kn func build** command, or the **kn func deploy** command, with the OpenShift Container Registry and the namespace specified for the **-r** parameter:

  Example build command

  ```
  $ kn func build -r $(oc get route -n openshift-image-registry)/my-namespace
  ```

  Example deploy command

  ```
  $ kn func deploy -r $(oc get route -n openshift-image-registry)/my-namespace
  ```

  You can verify that the function deployed successfully by emitting a test event to it.

11.2.6. Additional resources

- See Exposing a default registry manually .

11.2.7. Emitting a test event to a deployed function

You can use the **kn func emit** CLI command to emit a CloudEvent to a function that is either deployed locally or deployed to your OpenShift Container Platform cluster. This command can be used to test that a function is working and able to receive events correctly.

Example command

```
$ kn func emit
```

The **kn func emit** command executes on the local directory by default, and assumes that this directory is a function project.

11.2.8. Next steps

- See Using functions with Knative Eventing .

11.3. DEVELOPING NODE.JS FUNCTIONS

IMPORTANT

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After you have created a Node.js function project , you can modify the template files provided to add business logic to your function.

11.3.1. Prerequisites

- Before you can develop functions, you must complete the steps in Setting up OpenShift Serverless Functions.

11.3.2. Node.js function template structure

When you create a Node.js function using the **kn** CLI, the project directory looks like a typical Node.js project, with the exception of an additional **func.yaml** configuration file.

Both **http** and **event** trigger functions have the same template structure:

Template structure

```
.
├── func.yaml 1
├── index.js 2
├── package.json 3
├── README.md
└── test 4
    ├── integration.js
    └── unit.js
```

1. The **func.yaml** configuration file is used to determine the image name and registry.
2. Your project must contain an **index.js** file which exports a single function.
3. You are not restricted to the dependencies provided in the template **package.json** file. You can add additional dependencies as you would in any other Node.js project.

   Example of adding npm dependencies

   ```
   npm install --save opossum
   ```

   When the project is built for deployment, these dependencies are included in the created runtime container image.
4. Integration and unit test scripts are provided as part of the function template.

11.3.3. About invoking Node.js functions

When using the **kn** CLI to create a function project, you can generate a project that responds to CloudEvents, or one that responds to simple HTTP requests. CloudEvents in Knative are transported over HTTP as a POST request, so both function types listen for and respond to incoming HTTP events.

Node.js functions can be invoked with a simple HTTP request. When an incoming request is received, functions are invoked with a **context** object as the first parameter.

11.3.3.1. Node.js context objects

Functions are invoked by providing a **context** object as the first parameter.

Example context object

```
function handle(context, data)
```

This object provides access to the incoming HTTP request information, including the HTTP request method, any query strings or headers sent with the request, the HTTP version, and the request body. Incoming requests that contain a CloudEvent attach the incoming instance of the CloudEvent to the context object so that it can be accessed by using **context.cloudevent**.

11.3.3.1.1. Context object methods

The **context** object has a single method, **cloudEventResponse()**, that accepts a data value and returns a CloudEvent.

In a Knative system, if a function deployed as a service is invoked by an event broker sending a CloudEvent, the broker examines the response. If the response is a CloudEvent, this event is handled by the broker.

Example context object method

```
// Expects to receive a CloudEvent with customer data
function handle(context, customer) {
  // process the customer
  const processed = handle(customer);
  return context.cloudEventResponse(customer)
    .source('/handle')
    .type('fn.process.customer')
    .response();
}
```

11.3.3.1.2. CloudEvent data

If the incoming request is a CloudEvent, any data associated with the CloudEvent is extracted from the event and provided as a second parameter. For example, if a CloudEvent is received that contains a JSON string in its data property that is similar to the following:

```
{
  "customerId": "0123456",
  "productId": "6543210"
}
```

When invoked, the second parameter to the function, after the **context** object, will be a JavaScript object that has **customerId** and **productId** properties.

Example signature

```
function handle(context, data)
```

The **data** parameter in this example is a JavaScript object that contains the **customerId** and **productId** properties.

11.3.4. Node.js function return values

Functions can return any valid JavaScript type or can have no return value. When a function has no return value specified, and no failure is indicated, the caller receives a **204 No Content** response.

Functions can also return a CloudEvent or a **Message** object in order to push events into the Knative Eventing system. In this case, the developer is not required to understand or implement the CloudEvent messaging specification. Headers and other relevant information from the returned values are extracted and sent with the response.

Example

```
function handle(context, customer) {
  // process customer and return a new CloudEvent
  return new CloudEvent({
    source: 'customer.processor',
    type: 'customer.processed'
  })
}
```

11.3.4.1. Returning headers

You can set a response header by adding a **headers** property to the **return** object. These headers are extracted and sent with the response to the caller.

Example response header

```
function handle(context, customer) {
  // process customer and return custom headers
  // the response will be '204 No content'
  return { headers: { customerid: customer.id } };
}
```

11.3.4.2. Returning status codes

You can set a status code that is returned to the caller by adding a **statusCode** property to the **return** object:

Example status code

```
function handle(context, customer) {
  // process customer
  if (customer.restricted) {
```

```
    return { statusCode: 451 }
  }
}
```

Status codes can also be set for errors that are created and thrown by the function:

Example error status code

```
function handle(context, customer) {
  // process customer
  if (customer.restricted) {
    const err = new Error('Unavailable for legal reasons');
    err.statusCode = 451;
    throw err;
  }
}
```

11.3.5. Testing Node.js functions

Node.js functions can be tested locally on your computer. In the default project that is created when you create a function using **kn func create**, there is a **test** folder that contains some simple unit and integration tests.

Procedure

- Run the tests:

```
$ npm test
```

11.3.6. Next steps

- See the Node.js context object reference documentation.
- Build and deploy a function.

11.4. DEVELOPING TYPESCRIPT FUNCTIONS

IMPORTANT

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After you have created a TypeScript function project, you can modify the template files provided to add business logic to your function.

11.4.1. Prerequisites

- Before you can develop functions, you must complete the steps in Setting up OpenShift Serverless Functions.

11.4.2. TypeScript function template structure

When you create a TypeScript function using the **kn** CLI, the project directory looks like a typical TypeScript project with the exception of an additional **func.yaml** configuration file.

Both **http** and **event** trigger functions have the same template structure:

Template structure

```
.
├── func.yaml 1
├── package.json 2
├── package-lock.json
├── README.md
├── src
│   └── index.ts 3
├── test 4
│   ├── integration.ts
│   └── unit.ts
└── tsconfig.json
```

1. The **func.yaml** configuration file is used to determine the image name and registry.
2. You are not restricted to the dependencies provided in the template **package.json** file. You can add additional dependencies as you would in any other TypeScript project.

   #### Example of adding npm dependencies

   ```
   npm install --save opossum
   ```

   When the project is built for deployment, these dependencies are included in the created runtime container image.
3. Your project must contain an **src/index.js** file which exports a function named **handle**.
4. Integration and unit test scripts are provided as part of the function template.

11.4.3. About invoking TypeScript functions

When using the **kn** CLI to create a function project, you can generate a project that responds to CloudEvents or one that responds to simple HTTP requests. CloudEvents in Knative are transported over HTTP as a POST request, so both function types listen for and respond to incoming HTTP events.

TypeScript functions can be invoked with a simple HTTP request. When an incoming request is received, functions are invoked with a **context** object as the first parameter.

11.4.3.1. TypeScript context objects

Functions are invoked with a **context** object as the first parameter.

Example context object

```
function handle(context:Context): string
```

This object provides access to the incoming HTTP request information, including the HTTP request method, any query strings or headers sent with the request, the HTTP version, and the request body. Incoming requests that contain a CloudEvent attach the incoming instance of the CloudEvent to the context object so that it can be accessed by using **context.cloudevent**.

11.4.3.1.1. Context object methods

The **context** object has a single method, **cloudEventResponse()**, that accepts a data value and returns a CloudEvent.

In a Knative system, if a function deployed as a service is invoked by an event broker sending a CloudEvent, the broker examines the response. If the response is a CloudEvent, this event is handled by the broker.

Example context object method

```
// Expects to receive a CloudEvent with customer data
export function handle(context: Context, cloudevent?: CloudEvent): CloudEvent {
  // process the customer
  const customer = cloudevent.data;
  const processed = processCustomer(customer);
  return context.cloudEventResponse(customer)
    .source('/customer/process')
    .type('customer.processed')
    .response();
}
```

11.4.3.1.2. Context types

The TypeScript type definition files export the following types for use in your functions.

Exported type definitions

```
// Invokable is the expeted Function signature for user functions
export interface Invokable {
    (context: Context, cloudevent?: CloudEvent): any
}

// Logger can be used for structural logging to the console
export interface Logger {
  debug: (msg: any) => void,
  info:  (msg: any) => void,
  warn:  (msg: any) => void,
  error: (msg: any) => void,
  fatal: (msg: any) => void,
  trace: (msg: any) => void,
}
```

```
// Context represents the function invocation context, and provides
// access to the event itself as well as raw HTTP objects.
export interface Context {
    log: Logger;
    req: IncomingMessage;
    query?: Record<string, any>;
    body?: Record<string, any>|string;
    method: string;
    headers: IncomingHttpHeaders;
    httpVersion: string;
    httpVersionMajor: number;
    httpVersionMinor: number;
    cloudevent: CloudEvent;
    cloudEventResponse(data: string|object): CloudEventResponse;
}

// CloudEventResponse is a convenience class used to create
// CloudEvents on function returns
export interface CloudEventResponse {
    id(id: string): CloudEventResponse;
    source(source: string): CloudEventResponse;
    type(type: string): CloudEventResponse;
    version(version: string): CloudEventResponse;
    response(): CloudEvent;
}
```

11.4.3.1.3. CloudEvent data

If the incoming request is a CloudEvent, any data associated with the CloudEvent is extracted from the event and provided as a second parameter. For example, if a CloudEvent is received that contains a JSON string in its data property that is similar to the following:

```
{
  "customerId": "0123456",
  "productId": "6543210"
}
```

When invoked, the second parameter to the function, after the **context** object, will be a JavaScript object that has **customerId** and **productId** properties.

Example signature

```
function handle(context: Context, cloudevent?: CloudEvent): CloudEvent
```

The **cloudevent** parameter in this example is a JavaScript object that contains the **customerId** and **productId** properties.

11.4.4. TypeScript function return values

Functions can return any valid JavaScript type or can have no return value. When a function has no return value specified, and no failure is indicated, the caller receives a **204 No Content** response.

Functions can also return a CloudEvent or a **Message** object in order to push events into the Knative Eventing system. In this case, the developer is not required to understand or implement the CloudEvent

messaging specification. Headers and other relevant information from the returned values are extracted and sent with the response.

Example

```
export const handle: Invokable = function (
  context: Context,
  cloudevent?: CloudEvent
): Message {
  // process customer and return a new CloudEvent
  const customer = cloudevent.data;
  return HTTP.binary(
    new CloudEvent({
      source: 'customer.processor',
      type: 'customer.processed'
    })
  );
};
```

11.4.4.1. Returning headers

You can set a response header by adding a **headers** property to the **return** object. These headers are extracted and sent with the response to the caller.

Example response header

```
export function handle(context: Context, cloudevent?: CloudEvent): Record<string, any> {
  // process customer and return custom headers
  const customer = cloudevent.data as Record<string, any>;
  return { headers: { 'customer-id': customer.id } };
}
```

11.4.4.2. Returning status codes

You can set a status code that is returned to the caller by adding a **statusCode** property to the **return** object:

Example status code

```
export function handle(context: Context, cloudevent?: CloudEvent): Record<string, any> {
  // process customer
  const customer = cloudevent.data as Record<string, any>;
  if (customer.restricted) {
    return {
      statusCode: 451
    }
  }
  // business logic, then
  return {
    statusCode: 240
  }
}
```

Status codes can also be set for errors that are created and thrown by the function:

Example error status code

```
export function handle(context: Context, cloudevent?: CloudEvent): Record<string, string> {
  // process customer
  const customer = cloudevent.data as Record<string, any>;
  if (customer.restricted) {
    const err = new Error('Unavailable for legal reasons');
    err.statusCode = 451;
    throw err;
  }
}
```

11.4.5. Testing TypeScript functions

TypeScript functions can be tested locally on your computer. In the default project that is created when you create a function using **kn func create**, there is a **test** folder that contains some simple unit and integration tests.

Procedure

1. If you have not previously run tests, install the dependencies first:

```
$ npm install
```

2. Run the tests:

```
$ npm test
```

11.4.6. Next steps

- See the TypeScript context object reference documentation.
- Build and deploy a function.
- See the Pino API documentation for more information on logging with functions.

11.5. DEVELOPING GOLANG FUNCTIONS

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After you have created a Golang function project , you can modify the template files provided to add business logic to your function.

11.5.1. Prerequisites

- Before you can develop functions, you must complete the steps in Setting up OpenShift Serverless Functions.

11.5.2. Golang function template structure

When you create a Golang function using the **kn** CLI, the project directory looks like a typical Go project, with the exception of an additional **func.yaml** configuration file.

Golang functions have few restrictions. The only requirements are that your project must be defined in a **function** module, and must export the function **Handle()**.

Both **http** and **event** trigger functions have the same template structure:

Template structure

```
fn
├── README.md
├── func.yaml 1
├── go.mod 2
├── go.sum
├── handle.go
└── handle_test.go
```

1. The **func.yaml** configuration file is used to determine the image name and registry.
2. You can add any required dependencies to the **go.mod** file, which can include additional local Golang files. When the project is built for deployment, these dependencies are included in the resulting runtime container image.

Example of adding dependencies

```
$ go get gopkg.in/yaml.v2@v2.4.0
```

11.5.3. About invoking Golang functions

Golang functions are invoked by using different methods, depending on whether they are triggered by an HTTP request or a CloudEvent.

11.5.3.1. Functions triggered by an HTTP request

When an incoming HTTP request is received, your function is invoked with a standard Golang Context as the first parameter, followed by two more parameters:

- **http.ResponseWriter**
- **http.Request**

You can use standard Golang techniques to access the request, and set a proper HTTP response of your function.

Example HTTP response

```
func Handle(ctx context.Context, res http.ResponseWriter, req *http.Request) {
  // Read body
  body, err := ioutil.ReadAll(req.Body)
  defer req.Body.Close()
  if err != nil {
 http.Error(res, err.Error(), 500)
 return
  }
  // Process body and function logic
  // ...
}
```

11.5.3.2. Functions triggered by a cloud event

When an incoming cloud event is received, the event is invoked by the CloudEvents Golang SDK and the **Event** type as a parameter.

You can leverage the Golang Context as an optional parameter in the function contract, as shown in the list of supported function signatures:

Supported function signatures

```
Handle()
Handle() error
Handle(context.Context)
Handle(context.Context) error
Handle(cloudevents.Event)
Handle(cloudevents.Event) error
Handle(context.Context, cloudevents.Event)
Handle(context.Context, cloudevents.Event) error
Handle(cloudevents.Event) *cloudevents.Event
Handle(cloudevents.Event) (*cloudevents.Event, error)
Handle(context.Context, cloudevents.Event) *cloudevents.Event
Handle(context.Context, cloudevents.Event) (*cloudevents.Event, error)
```

11.5.3.2.1. CloudEvent trigger example

A cloud event is received which contains a JSON string in the data property:

```
{
  "customerId": "0123456",
  "productId": "6543210"
}
```

To access this data, a structure must be defined which maps properties in the cloud event data, and retrieves the data from the incoming event. The following example uses the **Purchase** structure:

```
type Purchase struct {
  CustomerId string `json:"customerId"`
  ProductId  string `json:"productId"`
}
func Handle(ctx context.Context, event cloudevents.Event) (err error) {

  purchase := &Purchase{}
```

```
 if err = event.DataAs(purchase); err != nil {
 fmt.Fprintf(os.Stderr, "failed to parse incoming CloudEvent %s\n", err)
 return
 }
 // ...
}
```

Alternatively, a Golang **encoding/json** package could be used to access the cloud event directly as JSON in the form of a bytes array:

```
func Handle(ctx context.Context, event cloudevents.Event) {
 bytes, err := json.Marshal(event)
 // ...
}
```

11.5.4. Golang function return values

HTTP triggered functions can set the response directly by using the Golang http.ResponseWriter.

Example HTTP response

```
func Handle(ctx context.Context, res http.ResponseWriter, req *http.Request) {
 // Set response
 res.Header().Add("Content-Type", "text/plain")
 res.Header().Add("Content-Length", "3")
 res.WriteHeader(200)
 _, err := fmt.Fprintf(res, "OK\n")
 if err != nil {
 fmt.Fprintf(os.Stderr, "error or response write: %v", err)
 }
}
```

Functions triggered by a cloud event might return nothing, **error**, or **CloudEvent** in order to push events into the Knative Eventing system. In this case, you must set a unique **ID**, proper **Source**, and a **Type** for the cloud event. The data can be populated from a defined structure, or from a **map**.

Example CloudEvent response

```
func Handle(ctx context.Context, event cloudevents.Event) (resp *cloudevents.Event, err error) {
 // ...
 response := cloudevents.NewEvent()
 response.SetID("example-uuid-32943bac6fea")
 response.SetSource("purchase/getter")
 response.SetType("purchase")
 // Set the data from Purchase type
 response.SetData(cloudevents.ApplicationJSON, Purchase{
 CustomerId: custId,
 ProductId:  prodId,
 })
 // OR set the data directly from map
 response.SetData(cloudevents.ApplicationJSON, map[string]string{"customerId": custId, "productId":
prodId})
 // Validate the response
 resp = &response
```

```
  if err = resp.Validate(); err != nil {
 fmt.Printf("invalid event created. %v", err)
  }
  return
}
```

11.5.5. Testing Golang functions

Golang functions can be tested locally on your computer. In the default project that is created when you create a function using **kn func create**, there is a **handle_test.go** file which contains some basic tests. These tests can be extended as needed.

Procedure

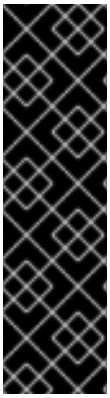
- Run the tests:

```
$ go test
```

11.5.6. Next steps

- Build and deploy a function.

11.6. DEVELOPING PYTHON FUNCTIONS



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After you have created a Python function project, you can modify the template files provided to add business logic to your function.

11.6.1. Prerequisites

- Before you can develop functions, you must complete the steps in Setting up OpenShift Serverless Functions.

11.6.2. Python function template structure

When you create a Python function by using the **kn** CLI, the project directory looks similar to a typical Python project.

Python functions have very few restrictions. The only requirements are that your project contains a **func.py** file that contains a **main()** function, and a **func.yaml** configuration file.

Developers are not restricted to the dependencies provided in the template **requirements.txt** file. Additional dependencies can be added as they would be in any other Python project. When the project is built for deployment, these dependencies will be included in the created runtime container image.

Both **http** and **event** trigger functions have the same template structure:

Template structure

```
fn
├── func.py 1
├── func.yaml 2
├── requirements.txt 3
└── test_func.py 4
```

1. Contains a **main()** function.
2. Used to determine the image name and registry.
3. Additional dependencies can be added to the **requirements.txt** file as they are in any other Python project.
4. Contains a simple unit test that can be used to test your function locally.

11.6.3. About invoking Python functions

Python functions can be invoked with a simple HTTP request. When an incoming request is received, functions are invoked with a **context** object as the first parameter. The **context** object is a Python class with two attributes:

- The **request** attribute is always present, and contains the Flask **request** object.
- The second attribute, **cloud_event**, is populated if the incoming request is a **CloudEvent** object.

Developers can access any **CloudEvent** data from the context object.

Example context object

```
def main(context: Context):
    """
    The context parameter contains the Flask request object and any
    CloudEvent received with the request.
    """
    print(f"Method: {context.request.method}")
    print(f"Event data {context.cloud_event.data}")
    # ... business logic here
```

11.6.4. Python function return values

Functions can return any value supported by Flask because the invocation framework proxies these values directly to the Flask server.

Example

```
def main(context: Context):
    body = { "message": "Howdy!" }
    headers = { "content-type": "application/json" }
    return body, 200, headers
```

Functions can set both headers and response codes as secondary and tertiary response values from function invocation.

11.6.4.1. Returning CloudEvents

Developers can use the **@event** decorator to tell the invoker that the function return value must be converted to a CloudEvent before sending the response.

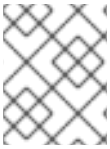
Example

```
@event("event_source"="/my/function", "event_type"="my.type")
def main(context):
    # business logic here
    data = do_something()
    # more data processing
    return data
```

This example sends a CloudEvent as the response value, with a type of **"my.type"** and a source of **"/my/function"**. The CloudEvent **data** property is set to the returned **data** variable. The **event_source** and **event_type** decorator attributes are both optional.

11.6.5. Testing Python functions

You can test Python functions locally on your computer. The default project contains a **test_func.py** file, which provides a simple unit test for functions.



NOTE

The default test framework for Python functions is **unittest**. You can use a different test framework if you prefer.

Prerequisites

- To run Python functions tests locally, you must install the required dependencies:

```
$ pip install -r requirements.txt
```

Procedure

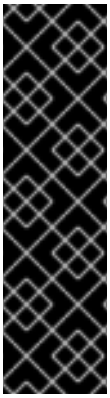
- After you have installed the dependencies, run the tests:

```
$ python3 test_func.py
```

11.6.6. Next steps

- Build and deploy a function.

11.7. DEVELOPING QUARKUS FUNCTIONS



IMPORTANT

OpenShift Serverless Functions is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see https://access.redhat.com/support/offerings/techpreview/.

After you have created a Quarkus function project , you can modify the template files provided to add business logic to your function.

11.7.1. Prerequisites

- Before you can develop functions, you must complete the setup steps in Setting up OpenShift Serverless Functions.

11.7.2. Quarkus function template structure

When you create a Quarkus function by using the **kn** CLI, the project directory looks similar to a typical Maven project.

Both **http** and **event** trigger functions have the same template structure:

Template structure

```
.
├── func.yaml 1
├── mvnw
├── mvnw.cmd
├── pom.xml 2
├── README.md
└── src
    ├── main
    │   ├── java
    │   │   └── functions
    │   │       ├── Function.java 3
    │   │       ├── Input.java
    │   │       └── Output.java
    │   └── resources
    │       └── application.properties
    └── test
        └── java
            └── functions 4
                ├── FunctionTest.java
                └── NativeFunctionIT.java
```

1 Used to determine the image name and registry.

2 The Project Object Model (POM) file contains project configuration, such as information about dependencies. You can add additional dependencies by modifying this file.

Example of additional dependencies

```
...
  <dependencies>
    <dependency>
      <groupId>junit</groupId>
      <artifactId>junit</artifactId>
      <version>4.11</version>
      <scope>test</scope>
    </dependency>
    <dependency>
      <groupId>org.assertj</groupId>
      <artifactId>assertj-core</artifactId>
      <version>3.8.0</version>
      <scope>test</scope>
    </dependency>
  </dependencies>
...
```

Dependencies are downloaded during the first compilation.

3 The function project must contain a Java method annotated with **@Funq**. You can place this method in the **Function.java** class.

4 Contains simple test cases that can be used to test your function locally.

11.7.3. About invoking Quarkus functions

You can create a Quarkus project that responds to cloud events, or one that responds to simple HTTP requests. Cloud events in Knative are transported over HTTP as a POST request, so either function type can listen and respond to incoming HTTP requests.

When an incoming request is received, Quarkus functions are invoked with an instance of a permitted type.

Table 11.1. Function invocation options

Invocation method	Data type contained in the instance	Example of data
HTTP POST request	JSON object in the body of the request	**{ "customerId": "0123456", "productId": "6543210" }**
HTTP GET request	Data in the query string	**?customerId=0123456&productId=6543210**
CloudEvent	JSON object in the **data** property	**{ "customerId": "0123456", "productId": "6543210" }**

The following example shows a function that receives and processes the **customerId** and **productId** purchase data that is listed in the previous table:

Example Quarkus function

```
public class Functions {
    @Funq
    public void processPurchase(Purchase purchase) {
        // process the purchase
    }
}
```

The corresponding **Purchase** JavaBean class that contains the purchase data looks as follows:

Example class

```
public class Purchase {
    private long customerId;
    private long productId;
    // getters and setters
}
```

11.7.3.1. Invocation examples

The following example code defines three functions named **withBeans**, **withCloudEvent**, and **withBinary**;

Example

```
import io.quarkus.funqy.Funq;
import io.quarkus.funqy.knative.events.CloudEvent;

public class Input {
    private String message;

    // getters and setters
}

public class Output {
    private String message;

    // getters and setters
}

public class Functions {
    @Funq
    public Output withBeans(Input in) {
        // function body
    }

    @Funq
    public CloudEvent<Output> withCloudEvent(CloudEvent<Input> in) {
        // function body
    }
```

```
    @Funq
    public void withBinary(byte[] in) {
        // function body
    }
}
```

The **withBeans** function of the **Functions** class can be invoked by:

- An HTTP POST request with a JSON body:

```
$ curl "http://localhost:8080/withBeans" -X POST \
    -H "Content-Type: application/json" \
    -d '{"message": "Hello there."}'
```

- An HTTP GET request with query parameters:

```
$ curl "http://localhost:8080/withBeans?message=Hello%20there." -X GET
```

- A **CloudEvent** object in binary encoding:

```
$ curl "http://localhost:8080/" -X POST \
  -H "Content-Type: application/json" \
  -H "Ce-SpecVersion: 1.0" \
  -H "Ce-Type: withBeans" \
  -H "Ce-Source: cURL" \
  -H "Ce-Id: 42" \
  -d '{"message": "Hello there."}'
```

- A **CloudEvent** object in structured encoding:

```
$ curl http://localhost:8080/ \
    -H "Content-Type: application/cloudevents+json" \
    -d '{ "data": {"message":"Hello there."},
          "datacontenttype": "application/json",
          "id": "42",
          "source": "curl",
          "type": "withBeans",
          "specversion": "1.0"}'
```

The **withCloudEvent** function of the **Functions** class can be invoked by using a **CloudEvent** object, similarly to the **withBeans** function. However, unlike **withBeans**, **withCloudEvent** cannot be invoked with a plain HTTP request.

The **withBinary** function of the **Functions** class can be invoked by:

- A **CloudEvent** object in binary encoding:

```
$ curl "http://localhost:8080/" -X POST \
  -H "Content-Type: application/octet-stream" \
  -H "Ce-SpecVersion: 1.0"\
  -H "Ce-Type: withBinary" \
```

```
    -H "Ce-Source: cURL" \
    -H "Ce-Id: 42" \
    --data-binary '@img.jpg'
```

- A **CloudEvent** object in structured encoding:

```
$ curl http://localhost:8080/ \
  -H "Content-Type: application/cloudevents+json" \
  -d "{ \"data_base64\": \"$(base64 --wrap=0 img.jpg)\",
       \"datacontenttype\": \"application/octet-stream\",
       \"id\": \"42\",
       \"source\": \"curl\",
       \"type\": \"withBinary\",
       \"specversion\": \"1.0\"}"
```

11.7.4. CloudEvent attributes

If you need to read or write the attributes of a CloudEvent, such as **type** or **subject**, you can use the **CloudEvent<T>** generic interface and the **CloudEventBuilder** builder. The **<T>** type parameter must be one of the permitted types.

In the following example, **CloudEventBuilder** is used to return success or failure of processing the purchase:

```
public class Functions {

    private boolean _processPurchase(Purchase purchase) {
        // do stuff
    }

    public CloudEvent<Void> processPurchase(CloudEvent<Purchase> purchaseEvent) {
        System.out.println("subject is: " + purchaseEvent.subject());

        if (!_processPurchase(purchaseEvent.data())) {
            return CloudEventBuilder.create()
                    .type("purchase.error")
                    .build();
        }
        return CloudEventBuilder.create()
                .type("purchase.success")
                .build();
    }
}
```

11.7.5. Quarkus function return values

Functions can return an instance of:

- Any type from the list of permitted types.
- The **Uni<T>** type, where the **<T>** type parameter can be of any type from the permitted types.

The **Uni<T>** type is useful if a function calls asynchronous APIs, because the returned object is serialized in the same format as the received object. For example:

- If a function receives an HTTP request, then the returned object is sent in the body of an HTTP response.
- If a function receives a **CloudEvent** object in binary encoding, then the returned object is sent in the data property of a binary-encoded **CloudEvent** object.

The following example shows a function that fetches a list of purchases:

Example command

```
public class Functions {
    @Funq
    public List<Purchase> getPurchasesByName(String name) {
      // logic to retrieve purchases
    }
}
```

- Invoking this function through an HTTP request produces an HTTP response that contains a list of purchases in the body of the response.
- Invoking this function through an incoming **CloudEvent** object produces a **CloudEvent** response with a list of purchases in the **data** property.

11.7.5.1. Permitted types

The input and output types of a function can be any of the following:

- **void**
- **String**
- **byte[]**
- Primitive types and their wrappers (for example, **int** and **Integer**).
- A JavaBean, if its attributes are of types listed here.
- A map, list, or array of the types in this list.
- The special **CloudEvents<T>** type, where the **<T>** type parameter is of a type in this list.

Example

```
public class Functions {
    public List<Integer> getIds();
    public Purchase[] getPurchasesByName(String name);
    public String getNameById(int id);
    public Map<String,Integer> getNameIdMapping();
    public void processImage(byte[] img);
}
```

11.7.6. Testing Quarkus functions

You can test Quarkus functions locally on your computer by running the Maven tests that are included in the project template.

Procedure

- Run the Maven tests:

```
$ ./mvnw test
```

11.7.7. Next steps

- Build and deploy a function.

11.8. USING FUNCTIONS WITH KNATIVE EVENTING

IMPORTANT

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Functions are deployed as a Knative service on an OpenShift Container Platform cluster, and can be connected as a sink to Knative Eventing components.

11.8.1. Connect an event source to a sink using the Developer perspective

You can create multiple event source types in OpenShift Container Platform that can be connected to sinks.

Prerequisites

To connect an event source to a sink using the **Developer** perspective, ensure that:

- The OpenShift Serverless Operator, Knative Serving, and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have created a sink.
- You have logged in to the web console and are in the **Developer** perspective.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.

Procedure

1. Create an event source of any type, by navigating to **+Add → Event Sources** and then selecting the event source type that you want to create.
2. In the **Sink** section of the **Event Sources** form view, select **Resource**. Then use the drop-down list to select your sink.

3. Click **Create**.

Verification

You can verify that the event source was created and is connected to the sink by viewing the **Topology** page.

1. In the **Developer** perspective, navigate to **Topology**.
2. View the event source and click on the connected sink to see the sink details in the side panel.

11.9. FUNCTION PROJECT CONFIGURATION IN FUNC.YAML

The **func.yaml** file contains the configuration for your function project.

Generally, these values are used when you execute a **kn func** command. For example, when you run the **kn func build** command, the value in the **builder** field is used.

NOTE

In many cases, you can override these values with command line flags or environment variables.

11.9.1. Configurable fields in func.yaml

Many of the fields in **func.yaml** are generated automatically when you create, build, and deploy your function. However, there are also fields that you modify manually to change things, such as the function name or the image name.

11.9.1.1. builder

The **builder** field specifies the Buildpack builder image to use when building the function. In most cases, this value should not be changed. When you do change it, use a value that is listed in the **builders** field.

11.9.1.2. builders

Some function runtimes can be built in multiple ways. For example, a Quarkus function can be built for the JVM or as a native binary. The **builders** field contains all of the builders available for a given runtime.

11.9.1.3. buildEnvs

The **buildEnvs** field enables you to set environment variables to be available to the environment that builds your function. Unlike variables set using **envs**, a variable set using **buildEnv** is not available during function runtime.

You can set a **buildEnv** variable directly from a value. In the following example, the **buildEnv** variable named **EXAMPLE1** is directly assigned the **one** value:

```
buildEnvs:
- name: EXAMPLE1
  value: one
```

You can also set a **buildEnv** variable from a local environment variable. In the following example, the **buildEnv** variable named **EXAMPLE2** is assigned the value of the **LOCAL_ENV_VAR** local environment variable:

```
buildEnvs:
- name: EXAMPLE1
  value: '{{ env:LOCAL_ENV_VAR }}'
```

11.9.1.4. envs

The **envs** field enables you to set environment variables to be available to your function at runtime. You can set an environment variable in several different ways:

1. Directly from a value.
2. From a value assigned to a local environment variable. See the section "Referencing local environment variables from func.yaml fields" for more information.
3. From a key-value pair stored in a secret or config map.
4. You can also import all key-value pairs stored in a secret or config map, with keys used as names of the created environment variables.

This examples demonstrates the different ways to set an environment variable:

```
name: test
namespace: ""
runtime: go
...
envs:
- name: EXAMPLE1 (1)
  value: value
- name: EXAMPLE2 (2)
  value: '{{ env:LOCAL_ENV_VALUE }}'
- name: EXAMPLE3 (3)
  value: '{{ secret:mysecret:key }}'
- name: EXAMPLE4 (4)
  value: '{{ configMap:myconfigmap:key }}'
- value: '{{ secret:mysecret2 }}' (5)
- value: '{{ configMap:myconfigmap2 }}' (6)
```

1. An environment variable set directly from a value.
2. An environment variable set from a value assigned to a local environment variable.
3. An environment variable assigned from a key-value pair stored in a secret.
4. An environment variable assigned from a key-value pair stored in a config map.
5. A set of environment variables imported from key-value pairs of a secret.
6. A set of environment variables imported from key-value pairs of a config map.

11.9.1.5. volumes

The **volumes** field enables you to mount secrets and config maps as a volume accessible to the function at the specified path, as shown in the following example:

```
name: test
namespace: ""
runtime: go
...
volumes:
- secret: mysecret (1)
  path: /workspace/secret
- configMap: myconfigmap (2)
  path: /workspace/configmap
```

1. The **mysecret** secret is mounted as a volume residing at **/workspace/secret**.
2. The **myconfigmap** config map is mounted as a volume residing at **/workspace/configmap**.

11.9.1.6. options

The **options** field enables you to modify Knative Service properties for the deployed function, such as autoscaling. If these options are not set, the default ones are used.

These options are available:

- **scale**
  - **min**: The minimum number of replicas. Must be a non-negative integer. The default is 0.
  - **max**: The maximum number of replicas. Must be a non-negative integer. The default is 0, which means no limit.
  - **metric**: Defines which metric type is watched by the Autoscaler. It can be set to **concurrency**, which is the default, or **rps**.
  - **target**: Recommendation for when to scale up based on the number of concurrently incoming requests. The **target** option can be a float value greater than 0.01. The default is 100, unless the **options.resources.limits.concurrency** is set, in which case **target** defaults to its value.
  - **utilization**: Percentage of concurrent requests utilization allowed before scaling up. It can be a float value between 1 and 100. The default is 70.
- **resources**
  - **requests**
    - **cpu**: A CPU resource request for the container with deployed function.
    - **memory**: A memory resource request for the container with deployed function.
  - **limits**
    - **cpu**: A CPU resource limit for the container with deployed function.

- **memory**: A memory resource limit for the container with deployed function.
- **concurrency**: Hard Limit of concurrent requests to be processed by a single replica. It can be integer value greater than or equal to 0, default is 0 - meaning no limit.

This is an example configuration of the **scale** options:

```
name: test
namespace: ""
runtime: go
...
options:
  scale:
    min: 0
    max: 10
    metric: concurrency
    target: 75
    utilization: 75
  resources:
    requests:
      cpu: 100m
      memory: 128Mi
    limits:
      cpu: 1000m
      memory: 256Mi
      concurrency: 100
```

11.9.1.7. image

The **image** field sets the image name for your function after it has been built. You can modify this field. If you do, the next time you run **kn func build** or **kn func deploy**, the function image will be created with the new name.

11.9.1.8. imageDigest

The **imageDigest** field contains the SHA256 hash of the image manifest when the function is deployed. Do not modify this value.

11.9.1.9. labels

The **labels** field enables you to set labels on a deployed function.

You can set a label directly from a value. In the following example, the label with the **role** key is directly assigned the value of **backend**:

```
labels:
- key: role
  value: backend
```

You can also set a label from a local environment variable. In the following example, the label with the **author** key is assigned the value of the **USER** local environment variable:

```
labels:
- key: author
  value: '{{ env:USER }}'
```

11.9.1.10. name

The **name** field defines the name of your function. This value is used as the name of your Knative service when it is deployed. You can change this field to rename the function on subsequent deployments.

11.9.1.11. namespace

The **namespace** field specifies the namespace in which your function is deployed.

11.9.1.12. runtime

The **runtime** field specifies the language runtime for your function, for example, **python**.

11.9.2. Referencing local environment variables from func.yaml fields

In the **envs** field in the **func.yaml**, you can put a reference to an environment variable available in the local environment. This can be useful for avoiding storing sensitive information, such as an API key in the function configuration.

Procedure

- To refer to a local environment variable, use the following syntax:

  ```
  {{ env:ENV_VAR }}
  ```

  Substitute **ENV_VAR** with the name of the variable in the local environment that you want to use.

  For example, you might have the **API_KEY** variable available in the local environment. You can assign its value to the **MY_API_KEY** variable, which you can then directly use within your function:

  ```
  name: test
  namespace: ""
  runtime: go
  ...
  envs:
  - name: MY_API_KEY
    value: '{{ env:API_KEY }}'
  ```

Additional resources

- For information on overriding values in the **func.yaml** file, see Getting started with functions.
- For more information on accessing data in secrets and config maps, see Accessing secrets and config maps from Serverless functions.
- For more information on the **scale** set of options, see the Knative documentation on Autoscaling.

- For more information on the **resources** set of options, see the Kubernetes documentation on managing resources for containers and the Knative documentation on configuring concurrency .

11.10. ACCESSING SECRETS AND CONFIG MAPS FROM SERVERLESS FUNCTIONS

Your functions, after deployed to the cluster, can access data stored in secrets and config maps. This data can be mounted as volumes, or assigned to environment variables. You can configure this access interactively by using the Knative CLI **kn func** commands or manually by editing the function configuration file.

IMPORTANT

To access secrets and config maps, the function needs to be deployed on the cluster. This functionality is not available to a function running locally.

If a secret or config map value cannot be accessed, the deployment fails with an error message specifying the inaccessible values.

11.10.1. Modifying function access to secrets and config maps interactively

You can manage the secrets and config maps accessed by your function by using the **kn func config** interactive utility.

Procedure

1. Run the following command in the function project directory:

```
$ kn func config
```

   Alternatively, you can specify the function project directory using the **--path** or **-p** option.

2. Use the interactive interface to perform the necessary operation. For example, using the utility to list configured volumes produces an output similar to this:

```
$ kn func config
? What do you want to configure? Volumes
? What operation do you want to perform? List
Configured Volumes mounts:
- Secret "mysecret" mounted at path: "/workspace/secret"
- Secret "mysecret2" mounted at path: "/workspace/secret2"
```

   This scheme shows all operations available in the interactive utility and how to navigate to them:

```
kn func config
   ├─> Environment variables
   │            ├─> Add
   │            │    ├─> ConfigMap: Add all key-value pairs from a config map
   │            │    ├─> ConfigMap: Add value from a key in a config map
   │            │    ├─> Secret: Add all key-value pairs from a secret
   │            │    └─> Secret: Add value from a key in a secret
   │            ├─> List: List all configured environment variables
   │            └─> Remove: Remove a configured environment variable
   └─> Volumes
```

```
        ├─> Add
        │   ├─> ConfigMap: Mount a config map as a volume
        │   └─> Secret: Mount a secret as a volume
        ├─> List: List all configured volumes
        └─> Remove: Remove a configured volume
```

3. Optional. Deploy the function to make the changes take effect:

```
$ kn func deploy -p test
```

11.10.2. Modifying function access to secrets and config maps interactively with specialized commands

Every time you run the **kn func config** utility, you need to navigate the entire dialogue to select the operation you need, as shown in the previous section. To save steps, you can directly execute a specific operation by running a more specific form of the **kn func config** command:

- To list configured environment variables:

```
$ kn func config envs [-p <function-project-path>]
```

- To add environment variables to the function configuration:

```
$ kn func config envs add [-p <function-project-path>]
```

- To remove environment variables from the function configuration:

```
$ kn func config envs remove [-p <function-project-path>]
```

- To list configured volumes:

```
$ kn func config volumes [-p <function-project-path>]
```

- To add a volume to the function configuration:

```
$ kn func config volumes add [-p <function-project-path>]
```

- To remove a volume from the function configuration:

```
$ kn func config volumes remove [-p <function-project-path>]
```

11.10.3. Adding function access to secrets and config maps manually

You can manually add configuration for accessing secrets and config maps to your function.

11.10.3.1. Mounting a secret as a volume

1. Open the **func.yaml** file for your function.
2. For each secret you want to mount as a volume, add the following YAML to the **volumes** section:

```
name: test
namespace: ""
runtime: go
...
volumes:
- secret: mysecret
  path: /workspace/secret
```

- Substitute **mysecret** with the name of the target secret.
- Substitute /**workspace**/**secret** with the path where you want to mount the secret.

3. Save the configuration.

11.10.3.2. Mounting a config map as a volume

1. Open the **func.yaml** file for your function.
2. For each config map you want to mount as a volume, add the following YAML to the **volumes** section:

```
name: test
namespace: ""
runtime: go
...
volumes:
- configMap: myconfigmap
  path: /workspace/configmap
```

- Substitute **myconfigmap** with the name of the target config map.
- Substitute /**workspace**/**configmap** with the path where you want to mount the config map.

3. Save the configuration.

11.10.3.3. Setting environment variable from a key value defined in a secret

1. Open the **func.yaml** file for your function.
2. For each value from a secret key-value pair that you want to assign to an environment variable, add the following YAML to the **envs** section:

```
name: test
namespace: ""
runtime: go
...
envs:
- name: EXAMPLE
  value: '{{ secret:mysecret:key }}'
```

- Substitute **EXAMPLE** with the name of the environment variable.
- Substitute **mysecret** with the name of the target secret.
- Substitute **key** with the key mapped to the target value.

3. Save the configuration.

11.10.3.4. Setting environment variable from a key value defined in a config map

1. Open the **func.yaml** file for your function.
2. For each value from a config map key-value pair that you want to assign to an environment variable, add the following YAML to the **envs** section:

```
name: test
namespace: ""
runtime: go
...
envs:
- name: EXAMPLE
  value: '{{ configMap:myconfigmap:key }}'
```

   - Substitute **EXAMPLE** with the name of the environment variable.
   - Substitute **myconfigmap** with the name of the target config map.
   - Substitute **key** with the key mapped to the target value.

3. Save the configuration.

11.10.3.5. Setting environment variables from all values defined in a secret

1. Open the **func.yaml** file for your function.
2. For every secret for which you want to import all key-value pairs as environment variables, add the following YAML to the **envs** section:

```
name: test
namespace: ""
runtime: go
...
envs:
- value: '{{ secret:mysecret }}' (1)
```

   (1) Substitute **mysecret** with the name of the target secret.

3. Save the configuration.

11.10.3.6. Setting environment variables from all values defined in a config map

1. Open the **func.yaml** file for your function.
2. For every config map for which you want to import all key-value pairs as environment variables, add the following YAML to the **envs** section:

```
name: test
namespace: ""
runtime: go
```

```
...
envs:
- value: '{{ configMap:myconfigmap }}' (1)
```

(1) Substitute **myconfigmap** with the name of the target config map.

3. Save the file.

11.11. ADDING ANNOTATIONS TO FUNCTIONS

You can add Kubernetes annotations to a deployed Serverless function by adding them to the **annotations** section in the **func.yaml** configuration file.

IMPORTANT

There are two limitations of the function annotation feature:

- Once a function annotation propagates to the corresponding Knative service on the cluster, it cannot be removed from the service by deleting it from the **func.yaml** file. You can remove the annotation from the Knative service by modifying the YAML file of the service directly, or by using the Developer Console.
- You cannot set annotations that are set by Knative, for example, the **autoscaling** annotations.

11.11.1. Adding annotations to a function

Procedure

1. Open the **func.yaml** file for your function.
2. For every annotation that you want to add, add the following YAML to the **annotations** section:

```
name: test
namespace: ""
runtime: go
...
annotations:
  <annotation_name>: "<annotation_value>" (1)
```

(1) Substitute **<annotation_name>: "<annotation_value>"** with your annotation.

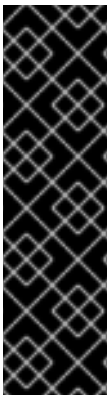
For example, to indicate that a function was authored by Alice, you might include the following annotation:

```
name: test
namespace: ""
runtime: go
...
annotations:
  author: "alice@example.com"
```

3. Save the configuration.

The next time you deploy your function to the cluster, the annotations are added to the corresponding Knative service.

11.12. FUNCTIONS DEVELOPMENT REFERENCE GUIDE



IMPORTANT

OpenShift Serverless Functions is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

For more information about the support scope of Red Hat Technology Preview features, see https://access.redhat.com/support/offerings/techpreview/.

OpenShift Serverless Functions provides templates that can be used to create basic functions for the following runtimes:

- Node.js
- Python
- Golang
- Quarkus
- TypeScript

This guide provides reference information that you can use to develop functions.

11.12.1. Node.js context object reference

The **context** object has several properties that can be accessed by the function developer.

11.12.1.1. log

Provides a logging object that can be used to write output to the cluster logs. The log adheres to the Pino logging API.

Example log

```
function handle(context) {
  context.log.info("Processing customer");
}
```

You can access the function by using the **kn func emit** command to invoke it:

Example command

```
$ kn func emit --sink 'http://example.function.com'
```

-

Example output

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"Processing customer"}
```

You can change the log level to one of **fatal**, **error**, **warn**, **info**, **debug**, **trace**, or **silent**. To do that, change the value of **logLevel** by assigning one of these values to the environment variable **FUNC_LOG_LEVEL** using the **config** command.

11.12.1.2. query

Returns the query string for the request, if any, as key-value pairs. These attributes are also found on the context object itself.

Example query

```
function handle(context) {
  // Log the 'name' query parameter
  context.log.info(context.query.name);
  // Query parameters are also attached to the context
  context.log.info(context.name);
}
```

You can access the function by using the **curl** command to invoke it:

Example command

```
$ curl http://example.com?name=tiger
```

Example output

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"tiger"}
```

11.12.1.3. body

Returns the request body if any. If the request body contains JSON code, this will be parsed so that the attributes are directly available.

Example body

```
function handle(context) {
  // log the incoming request body's 'hello' parameter
  context.log.info(context.body.hello);
}
```

You can access the function by using the **curl** command to invoke it:

Example command

```
$ kn func emit -d '{"Hello": "world"}'
```

Example output

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"world"}
```

11.12.1.4. headers

Returns the HTTP request headers as an object.

Example header

```
function handle(context) {
  context.log.info(context.headers["custom-header"]);
}
```

You can access the function by using the **kn func emit** command to invoke it:

Example command

```
$ kn func emit --sink 'http://example.function.com'
```

Example output

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"some-value"}
```

11.12.1.5. HTTP requests

method

Returns the HTTP request method as a string.

httpVersion

Returns the HTTP version as a string.

httpVersionMajor

Returns the HTTP major version number as a string.

httpVersionMinor

Returns the HTTP minor version number as a string.

11.12.2. TypeScript context object reference

The **context** object has several properties that can be accessed by the function developer.

11.12.2.1. log

Provides a logging object that can be used to write output to the cluster logs. The log adheres to the Pino logging API.

Example log

```
export function handle(context: Context): string {
    // log the incoming request body's 'hello' parameter
```

```
    if (context.body) {
      context.log.info((context.body as Record<string, string>).hello);
    } else {
      context.log.info('No data received');
    }
    return 'OK';
}
```

You can access the function by using the **kn func emit** command to invoke it:

Example command

```
$ kn func emit --sink 'http://example.function.com'
```

Example output

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"Pr
ocessing customer"}
```

You can change the log level to one of **fatal**, **error**, **warn**, **info**, **debug**, **trace**, or **silent**. To do that, change the value of **logLevel** by assigning one of these values to the environment variable **FUNC_LOG_LEVEL** using the **config** command.

11.12.2.2. query

Returns the query string for the request, if any, as key-value pairs. These attributes are also found on the context object itself.

Example query

```
export function handle(context: Context): string {
    // log the 'name' query parameter
    if (context.query) {
      context.log.info((context.query as Record<string, string>).name);
    } else {
      context.log.info('No data received');
    }
    return 'OK';
}
```

You can access the function by using the **kn func emit** command to invoke it:

Example command

```
$ kn func emit --sink 'http://example.function.com' --data '{"name": "tiger"}'
```

Example output

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"tig
er"}
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"tig
er"}
```

11.12.2.3. body

Returns the request body, if any. If the request body contains JSON code, this will be parsed so that the attributes are directly available.

Example body

```
export function handle(context: Context): string {
  // log the incoming request body's 'hello' parameter
  if (context.body) {
    context.log.info((context.body as Record<string, string>).hello);
  } else {
    context.log.info('No data received');
  }
  return 'OK';
}
```

You can access the function by using the **kn func emit** command to invoke it:

Example command

```
$ kn func emit --sink 'http://example.function.com' --data '{"hello": "world"}'
```

Example output

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"world"}
```

11.12.2.4. headers

Returns the HTTP request headers as an object.

Example header

```
export function handle(context: Context): string {
  // log the incoming request body's 'hello' parameter
  if (context.body) {
    context.log.info((context.headers as Record<string, string>)['custom-header']);
  } else {
    context.log.info('No data received');
  }
  return 'OK';
}
```

You can access the function by using the **curl** command to invoke it:

Example command

```
$ curl -H'x-custom-header: some-value" http://example.function.com
```

Example output

{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"some-value"}

11.12.2.5. HTTP requests

method

Returns the HTTP request method as a string.

httpVersion

Returns the HTTP version as a string.

httpVersionMajor

Returns the HTTP major version number as a string.

httpVersionMinor

Returns the HTTP minor version number as a string.

CHAPTER 12. INTEGRATIONS

12.1. USING NVIDIA GPU RESOURCES WITH SERVERLESS APPLICATIONS

NVIDIA supports experimental use of GPU resources on OpenShift Container Platform. See OpenShift Container Platform on NVIDIA GPU accelerated clusters for more information about setting up GPU resources on OpenShift Container Platform.

12.1.1. Specifying GPU requirements for a service

After GPU resources are enabled for your OpenShift Container Platform cluster, you can specify GPU requirements for a Knative service using the **kn** CLI.

NOTE

Using NVIDIA GPU resources is not supported for IBM Z and IBM Power Systems.

Procedure

1. Create a Knative service and set the GPU resource requirement limit to **1** by using the **--limit nvidia.com/gpu=1** flag:

```
$ kn service create hello --image <service-image> --limit nvidia.com/gpu=1
```

   A GPU resource requirement limit of **1** means that the service has 1 GPU resource dedicated. Services do not share GPU resources. Any other services that require GPU resources must wait until the GPU resource is no longer in use.

   A limit of 1 GPU also means that applications exceeding usage of 1 GPU resource are restricted. If a service requests more than 1 GPU resource, it is deployed on a node where the GPU resource requirements can be met.

2. Optional. For an existing service, you can change the GPU resource requirement limit to **3** by using the **--limit nvidia.com/gpu=3** flag:

```
$ kn service update hello --limit nvidia.com/gpu=3
```

12.1.2. Additional resources

- For more information about limits, see Setting resource quotas for extended resources .

CHAPTER 13. CLI TOOLS

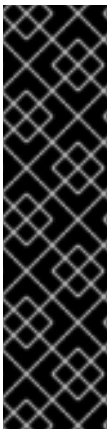
13.1. INSTALLING THE KNATIVE CLI

Installation options for the **oc** CLI may vary depending on your operating system.

The Knative CLI (**kn**) does not have its own login mechanism. To log in to the cluster, you must install the **oc** CLI and use the **oc login** command.

For more information on installing the **oc** CLI for your operating system and logging in with **oc**, see the OpenShift CLI getting started documentation.

OpenShift Serverless cannot be installed using the **kn** CLI. A cluster administrator must install the OpenShift Serverless Operator and set up the Knative components, as described in the Installing the OpenShift Serverless Operator documentation.



IMPORTANT

If you try to use an older version of the Knative **kn** CLI with a newer OpenShift Serverless release, the API is not found and an error occurs.

For example, if you use the 1.16.0 release of the **kn** CLI, which uses version 0.22.0, with the 1.17.0 OpenShift Serverless release, which uses the 0.23.0 versions of the Knative Serving and Knative Eventing APIs, the CLI does not work because it continues to look for the outdated 0.22.0 API versions.

Ensure that you are using the latest **kn** CLI version for your OpenShift Serverless release to avoid issues.

13.1.1. Installing the Knative CLI using the OpenShift Container Platform web console

Once the OpenShift Serverless Operator is installed, you will see a link to download the Knative CLI (**kn**) for Linux (x86_64, amd64, s390x, ppc64le), macOS, or Windows from the **Command Line Tools** page in the OpenShift Container Platform web console.

You can access the **Command Line Tools** page by clicking the  icon in the top right corner of the web console and selecting **Command Line Tools** in the drop down menu.

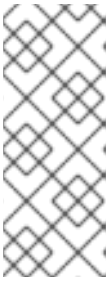
Procedure

1. Download the **kn** CLI from the **Command Line Tools** page.
2. Unpack the archive:

```
$ tar -xf <file>
```

3. Move the **kn** binary to a directory on your **PATH**.
4. To check your **PATH**, run:

```
$ echo $PATH
```



NOTE

If you do not use RHEL or Fedora, ensure that **libc** is installed in a directory on your library path. If **libc** is not available, you might see the following error when you run CLI commands:

```
$ kn: No such file or directory
```

13.1.2. Installing the Knative CLI for Linux using an RPM

For Red Hat Enterprise Linux (RHEL), you can install the Knative CLI (**kn**) as an RPM if you have an active OpenShift Container Platform subscription on your Red Hat account.

Procedure

1. Enter the command:

```
# subscription-manager register
```

2. Enter the command:

```
# subscription-manager refresh
```

3. Enter the command:

```
# subscription-manager attach --pool=<pool_id> 1
```

1 Pool ID for an active OpenShift Container Platform subscription

4. Enter the command:

```
# subscription-manager repos --enable="openshift-serverless-1-for-rhel-8-x86_64-rpms"
```

5. Enter the command:

```
# yum install openshift-serverless-clients
```

13.1.3. Installing the Knative CLI for Linux

For Linux distributions, you can download the Knative CLI (**kn**) directly as a **tar.gz** archive.

Procedure

1. Download the **kn** CLI.

2. Unpack the archive:

```
$ tar -xf <file>
```

3. Move the **kn** binary to a directory on your **PATH**.

4. To check your **PATH**, run:

```
$ echo $PATH
```

NOTE

If you do not use RHEL or Fedora, ensure that **libc** is installed in a directory on your library path. If **libc** is not available, you might see the following error when you run CLI commands:

```
$ kn: No such file or directory
```

13.1.4. Installing the Knative CLI for Linux on IBM Power Systems using an RPM

For Red Hat Enterprise Linux (RHEL), you can install the Knative CLI (**kn**) as an RPM if you have an active OpenShift Container Platform subscription on your Red Hat account.

Procedure

1. Register with a Red Hat Subscription Management (RHSM) service during the firstboot process:

```
# subscription-manager register
```

2. Refresh the RHSM:

```
# subscription-manager refresh
```

3. Attach the subscription to a system by specifying ID of the subscription pool, using the **--pool** option:

```
# subscription-manager attach --pool=<pool_id> 1
```

1 Pool ID for an active OpenShift Container Platform subscription

4. Enable the repository using Red Hat Subscription Manager:

```
# subscription-manager repos --enable="openshift-serverless-1-for-rhel-8-ppc64le-rpms"
```

5. Install the **openshift-serverless-clients** on the system:

```
# yum install openshift-serverless-clients
```

13.1.5. Installing the Knative CLI for Linux on IBM Power Systems

For Linux distributions, you can download the Knative CLI (**kn**) directly as a **tar.gz** archive.

Procedure

1. Download the **kn** CLI.

2. Unpack the archive:

```
$ tar -xf <file>
```

3. Move the **kn** binary to a directory on your **PATH**.

4. To check your **PATH**, run:

```
$ echo $PATH
```

NOTE

If you do not use RHEL, ensure that **libc** is installed in a directory on your library path.

If **libc** is not available, you might see the following error when you run CLI commands:

```
$ kn: No such file or directory
```

13.1.6. Installing the Knative CLI for Linux on IBM Z and LinuxONE using an RPM

For Red Hat Enterprise Linux (RHEL), you can install the Knative CLI (**kn**) as an RPM if you have an active OpenShift Container Platform subscription on your Red Hat account.

Procedure

1. Register with a Red Hat Subscription Management (RHSM) service during the firstboot process:

```
# subscription-manager register
```

2. Refresh the RHSM:

```
# subscription-manager refresh
```

3. Attach the subscription to a system by specifying ID of the subscription pool, using the **--pool** option:

```
# subscription-manager attach --pool=<pool_id> 1
```

1 Pool ID for an active OpenShift Container Platform subscription

4. Enable the repository using Red Hat Subscription Manager:

```
# subscription-manager repos --enable="openshift-serverless-1-for-rhel-8-s390x-rpms"
```

5. Install the **openshift-serverless-clients** on the system:

```
# yum install openshift-serverless-clients
```

13.1.7. Installing the Knative CLI for Linux on IBM Z and LinuxONE

For Linux distributions, you can download the Knative CLI (**kn**) directly as a **tar.gz** archive.

Procedure

1. Download the **kn** CLI.
2. Unpack the archive:

```
$ tar -xf <file>
```

3. Move the **kn** binary to a directory on your **PATH**.
4. To check your **PATH**, run:

```
$ echo $PATH
```

NOTE

If you do not use RHEL, ensure that **libc** is installed in a directory on your library path.

If **libc** is not available, you might see the following error when you run CLI commands:

```
$ kn: No such file or directory
```

13.1.8. Installing the Knative CLI for macOS

The Knative CLI (**kn**) for macOS is provided as a **tar.gz** archive.

Procedure

1. Download the **kn** CLI.
2. Unpack and unzip the archive.
3. Move the **kn** binary to a directory on your **PATH**.
4. To check your **PATH**, open a terminal window and run:

```
$ echo $PATH
```

13.1.9. Installing the Knative CLI for Windows

The Knative CLI (**kn**) for Windows is provided as a zip archive.

Procedure

1. Download the **kn** CLI.
2. Extract the archive with a ZIP program.

3. Move the **kn** binary to a directory on your **PATH**.
4. To check your **PATH**, open the command prompt and run the command:

```
C:\> path
```

13.1.10. Customizing the Knative CLI

You can customize your **kn** CLI setup by creating a **config.yaml** configuration file. You can provide this configuration by using the **--config** flag, otherwise the configuration is picked up from a default location. The default configuration location conforms to the XDG Base Directory Specification, and is different for Unix systems and Windows systems.

For Unix systems:

- If the **XDG_CONFIG_HOME** environment variable is set, the default configuration location that the **kn** CLI looks for is **$XDG_CONFIG_HOME/kn**.
- If the **XDG_CONFIG_HOME** environment variable is not set, the **kn** CLI looks for the configuration in the home directory of the user at **$HOME/.config/kn/config.yaml**.

For Windows systems, the default **kn** CLI configuration location is **%APPDATA%\kn**.

Example configuration file

```
plugins:
  path-lookup: true (1)
  directory: ~/.config/kn/plugins (2)
eventing:
  sink-mappings: (3)
  - prefix: svc (4)
    group: core (5)
    version: v1 (6)
    resource: services (7)
```

(1) Specifies whether the **kn** CLI should look for plug-ins in the **PATH** environment variable. This is a boolean configuration option. The default value is **false**.

(2) Specifies the directory where the **kn** CLI will look for plug-ins. The default path depends on the operating system, as described above. This can be any directory that is visible to the user.

(3) The **sink-mappings** spec defines the Kubernetes addressable resource that is used when you use the **--sink** flag with a **kn** CLI command.

(4) The prefix you want to use to describe your sink. **svc** for a service, **channel**, and **broker** are predefined prefixes in **kn**.

(5) The API group of the Kubernetes resource.

(6) The version of the Kubernetes resource.

(7) The plural name of the Kubernetes resource type. For example, **services** or **brokers**.

13.1.11. Knative CLI plug-ins

The **kn** CLI supports the use of plug-ins, which enable you to extend the functionality of your **kn** installation by adding custom commands and other shared commands that are not part of the core distribution. **kn** CLI plug-ins are used in the same way as the main **kn** functionality.

Currently, Red Hat supports the **kn-source-kafka** plug-in.

13.2. KNATIVE CLI ADVANCED CONFIGURATION

You can customize and extend the **kn** CLI by using advanced features, such as configuring a **config.yaml** file for **kn** or using plug-ins.

13.2.1. Customizing the Knative CLI

You can customize your **kn** CLI setup by creating a **config.yaml** configuration file. You can provide this configuration by using the **--config** flag, otherwise the configuration is picked up from a default location. The default configuration location conforms to the XDG Base Directory Specification, and is different for Unix systems and Windows systems.

For Unix systems:

- If the **XDG_CONFIG_HOME** environment variable is set, the default configuration location that the **kn** CLI looks for is **$XDG_CONFIG_HOME/kn**.
- If the **XDG_CONFIG_HOME** environment variable is not set, the **kn** CLI looks for the configuration in the home directory of the user at **$HOME/.config/kn/config.yaml**.

For Windows systems, the default **kn** CLI configuration location is **%APPDATA%\kn**.

Example configuration file

```
plugins:
  path-lookup: true (1)
  directory: ~/.config/kn/plugins (2)
eventing:
  sink-mappings: (3)
  - prefix: svc (4)
    group: core (5)
    version: v1 (6)
    resource: services (7)
```

(1) Specifies whether the **kn** CLI should look for plug-ins in the **PATH** environment variable. This is a boolean configuration option. The default value is **false**.

(2) Specifies the directory where the **kn** CLI will look for plug-ins. The default path depends on the operating system, as described above. This can be any directory that is visible to the user.

(3) The **sink-mappings** spec defines the Kubernetes addressable resource that is used when you use the **--sink** flag with a **kn** CLI command.

(4) The prefix you want to use to describe your sink. **svc** for a service, **channel**, and **broker** are predefined prefixes in **kn**.

5 The API group of the Kubernetes resource.

6 The version of the Kubernetes resource.

7 The plural name of the Kubernetes resource type. For example, **services** or **brokers**.

13.2.2. Knative CLI plug-ins

The **kn** CLI supports the use of plug-ins, which enable you to extend the functionality of your **kn** installation by adding custom commands and other shared commands that are not part of the core distribution. **kn** CLI plug-ins are used in the same way as the main **kn** functionality.

Currently, Red Hat supports the **kn-source-kafka** plug-in.

CHAPTER 14. REFERENCE

14.1. KN FLAGS REFERENCE

14.1.1. Knative CLI --sink flag

When you create an event-producing custom resource by using the Knative (**kn**) CLI, you can specify a sink where events are sent to from that resource, by using the **--sink** flag.

The following example creates a sink binding that uses a service, **http://event-display.svc.cluster.local**, as the sink:

Example command using the --sink flag

```
$ kn source binding create bind-heartbeat \
  --namespace sinkbinding-example \
  --subject "Job:batch/v1:app=heartbeat-cron" \
  --sink http://event-display.svc.cluster.local \ 1
  --ce-override "sink=bound"
```

1 **svc** in **http://event-display.svc.cluster.local** determines that the sink is a Knative service. Other default sink prefixes include **channel**, and **broker**.

14.2. KNATIVE SERVING CLI COMMANDS

You can use the following **kn** CLI commands to complete Knative Serving tasks on the cluster.

14.2.1. kn service commands

You can use the following commands to create and manage Knative services.

14.2.1.1. Creating serverless applications by using the Knative CLI

The following procedure describes how you can create a basic serverless application using the **kn** CLI.

Prerequisites

- OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have installed the **kn** CLI.

Procedure

- Create a Knative service:

```
$ kn service create <service-name> --image <image> --env <key=value>
```

Example command

```
$ kn service create event-display \
    --image quay.io/openshift-knative/knative-eventing-sources-event-display:latest
```

Example output

```
Creating service 'event-display' in namespace 'default':

  0.271s The Route is still working to reflect the latest desired specification.
  0.580s Configuration "event-display" is waiting for a Revision to become ready.
  3.857s ...
  3.861s Ingress has not yet been reconciled.
  4.270s Ready to serve.

Service 'event-display' created with latest revision 'event-display-bxshg-1' and URL:
http://event-display-default.apps-crc.testing
```

14.2.1.2. Updating serverless applications by using the Knative CLI

You can use the **kn service update** command for interactive sessions on the command line as you build up a service incrementally. In contrast to the **kn service apply** command, when using the **kn service update** command you only have to specify the changes that you want to update, rather than the full configuration for the Knative service.

Example commands

- Update a service by adding a new environment variable:

```
$ kn service update <service_name> --env <key>=<value>
```

- Update a service by adding a new port:

```
$ kn service update <service_name> --port 80
```

- Update a service by adding new request and limit parameters:

```
$ kn service update <service_name> --request cpu=500m --limit memory=1024Mi --limit
cpu=1000m
```

- Assign the **latest** tag to a revision:

```
$ kn service update <service_name> --tag <revision_name>=latest
```

- Update a tag from **testing** to **staging** for the latest **READY** revision of a service:

```
$ kn service update <service_name> --untag testing --tag @latest=staging
```

- Add the **test** tag to a revision that receives 10% of traffic, and send the rest of the traffic to the latest **READY** revision of a service:

```
$ kn service update <service_name> --tag <revision_name>=test --traffic test=10,@latest=90
```

14.2.1.3. Applying service declarations

You can declaratively configure a Knative service by using the **kn service apply** command. If the service does not exist it is created, otherwise the existing service is updated with the options that have been changed.

The **kn service apply** command is especially useful for shell scripts or in a continuous integration pipeline, where users typically want to fully specify the state of the service in a single command to declare the target state.

When using **kn service apply** you must provide the full configuration for the Knative service. This is different from the **kn service update** command, which only requires you to specify in the command the options that you want to update.

Example commands

- Create a service:

```
$ kn service apply <service_name> --image <image>
```

- Add an environment variable to a service:

```
$ kn service apply <service_name> --image <image> --env <key>=<value>
```

- Read the service declaration from a JSON or YAML file:

```
$ kn service apply <service_name> -f <filename>
```

14.2.1.4. Describing serverless applications by using the Knative CLI

You can describe a Knative service by using the **kn service describe** command.

Example commands

- Describe a service:

```
$ kn service describe --verbose <service_name>
```

The **--verbose** flag is optional but can be included to provide a more detailed description. The difference between a regular and verbose output is shown in the following examples:

Example output without --verbose flag

```
Name:       hello
Namespace:  default
Age:        2m
URL:        http://hello-default.apps.ocp.example.com

Revisions:
  100%  @latest (hello-00001) [1] (2m)
        Image:  docker.io/openshift/hello-openshift (pinned to aaea76)

Conditions:
  OK TYPE                  AGE REASON
```

```
  ++ Ready                 1m
  ++ ConfigurationsReady   1m
  ++ RoutesReady           1m
```

Example output with --verbose flag

```
Name:         hello
Namespace:    default
Annotations:  serving.knative.dev/creator=system:admin
              serving.knative.dev/lastModifier=system:admin
Age:          3m
URL:          http://hello-default.apps.ocp.example.com
Cluster:      http://hello.default.svc.cluster.local

Revisions:
  100%  @latest (hello-00001) [1] (3m)
        Image:  docker.io/openshift/hello-openshift (pinned to aaea76)
        Env:    RESPONSE=Hello Serverless!

Conditions:
  OK TYPE                  AGE REASON
  ++ Ready                 3m
  ++ ConfigurationsReady   3m
  ++ RoutesReady           3m
```

- Describe a service in YAML format:

```
$ kn service describe <service_name> -o yaml
```

- Describe a service in JSON format:

```
$ kn service describe <service_name> -o json
```

- Print the service URL only:

```
$ kn service describe <service_name> -o url
```

14.2.2. kn container commands

You can use the following commands to create and manage multiple containers in a Knative service spec.

14.2.2.1. Knative client multi-container support

You can use the **kn container add** command to print YAML container spec to standard output. This command is useful for multi-container use cases because it can be used along with other standard **kn** flags to create definitions. The **kn container add** command accepts all container-related flags that are supported for use with the **kn service create** command. The **kn container add** command can also be chained by using UNIX pipes (|) to create multiple container definitions at once.

14.2.2.1.1. Example commands

- Add a container from an image and print it to standard output:

```
$ kn container add <container_name> --image <image_uri>
```

Example command

```
$ kn container add sidecar --image docker.io/example/sidecar
```

Example output

```
containers:
- image: docker.io/example/sidecar
  name: sidecar
  resources: {}
```

- Chain two **kn container add** commands together, and then pass them to a **kn service create** command to create a Knative service with two containers:

```
$ kn container add <first_container_name> --image <image_uri> | \
kn container add <second_container_name> --image <image_uri> | \
kn service create <service_name> --image <image_uri> --extra-containers -
```

--extra-containers - specifies a special case where **kn** reads the pipe input instead of a YAML file.

Example command

```
$ kn container add sidecar --image docker.io/example/sidecar:first | \
kn container add second --image docker.io/example/sidecar:second | \
kn service create my-service --image docker.io/example/my-app:latest --extra-containers -
```

The **--extra-containers** flag can also accept a path to a YAML file:

```
$ kn service create <service_name> --image <image_uri> --extra-containers <filename>
```

Example command

```
$ kn service create my-service --image docker.io/example/my-app:latest --extra-containers
my-extra-containers.yaml
```

14.2.3. kn domain commands

You can use the following commands to create and manage domain mappings.

14.2.3.1. Creating a custom domain mapping by using the Knative CLI

You can use the **kn** CLI to create a **DomainMapping** custom resource (CR) that maps to an Addressable target CR, such as a Knative service or a Knative route.

The **--ref** flag specifies an Addressable target CR for domain mapping.

If a prefix is not provided when using the **--ref** flag, it is assumed that the target is a Knative service in the current namespace. The examples in the following procedure show the prefixes for mapping to a Knative service or a Knative route.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have created a Knative service or route, and control a custom domain that you want to map to that CR.

NOTE

Your custom domain must point to the DNS of the OpenShift Container Platform cluster.

- You have installed the **kn** CLI tool.

Procedure

- Map a domain to a CR in the current namespace:

```
$ kn domain create <domain_mapping_name> --ref <target_name>
```

Example command

```
$ kn domain create example-domain-map --ref example-service
```

- Map a domain to a Knative service in a specified namespace:

```
$ kn domain create <domain_mapping_name> --ref
<ksvc:service_name:service_namespace>
```

Example command

```
$ kn domain create example-domain-map --ref ksvc:example-service:example-namespace
```

- Map a domain to a Knative route:

```
$ kn domain create <domain_mapping_name> --ref <kroute:route_name>
```

Example command

```
$ kn domain create example-domain-map --ref kroute:example-route
```

14.2.3.2. Managing custom domain mappings by using the Knative CLI

After you have created a **DomainMapping** custom resource (CR), you can list existing CRs, view information about an existing CR, update CRs, or delete CRs by using the **kn** CLI.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have created at least one **DomainMapping** CR.

- You have installed the **kn** CLI tool.

Procedure

- List existing **DomainMapping** CRs:

```
$ kn domain list -n <domain_mapping_namespace>
```

- View details of an existing **DomainMapping** CR:

```
$ kn domain describe <domain_mapping_name>
```

- Update a **DomainMapping** CR to point to a new target:

```
$ kn domain update --ref <target>
```

- Delete a **DomainMapping** CR:

```
$ kn domain delete <domain_mapping_name>
```

14.3. KNATIVE EVENTING CLI COMMANDS

You can use the following **kn** CLI commands to complete Knative Eventing tasks on the cluster.

14.3.1. kn source commands

You can use the following commands to list, create, and manage Knative event sources.

14.3.1.1. Listing available event source types by using the Knative CLI

Procedure

1. List the available event source types in the terminal:

```
$ kn source list-types
```

Example output

```
TYPE              NAME                                DESCRIPTION
ApiServerSource   apiserversources.sources.knative.dev  Watch and send Kubernetes
API events to a sink
PingSource        pingsources.sources.knative.dev      Periodically send ping events to
a sink
SinkBinding       sinkbindings.sources.knative.dev     Binding for connecting a
PodSpecable to a sink
```

2. Optional: You can also list the available event source types in YAML format:

```
$ kn source list-types -o yaml
```

14.3.1.2. Creating and managing container sources by using the Knative CLI

You can use the following **kn** commands to create and manage container sources:

Create a container source

```
$ kn source container create <container_source_name> --image <image_uri> --sink <sink>
```

Delete a container source

```
$ kn source container delete <container_source_name>
```

Describe a container source

```
$ kn source container describe <container_source_name>
```

List existing container sources

```
$ kn source container list
```

List existing container sources in YAML format

```
$ kn source container list -o yaml
```

Update a container source

This command updates the image URI for an existing container source:

```
$ kn source container update <container_source_name> --image <image_uri>
```

14.3.1.3. Creating an API server source by using the Knative CLI

This section describes the steps required to create an API server source using **kn** commands.

Prerequisites

- You must have OpenShift Serverless, the Knative Serving and Eventing components, and the **kn** CLI installed.

Procedure

1. Create an API server source that uses a broker as a sink:

```
$ kn source apiserver create <event_source_name> --sink broker:<broker_name> --
resource "event:v1" --service-account <service_account_name> --mode Resource
```

2. To check that the API server source is set up correctly, create a Knative service that dumps incoming messages to its log:

```
$ kn service create <service_name> --image quay.io/openshift-knative/knative-eventing-
sources-event-display:latest
```

3. Create a trigger to filter events from the **default** broker to the service:

```
$ kn trigger create <trigger_name> --sink ksvc:<service_name>
```

4. Create events by launching a pod in the default namespace:

```
$ oc create deployment hello-node --image quay.io/openshift-knative/knative-eventing-sources-event-display:latest
```

5. Check that the controller is mapped correctly by inspecting the output generated by the following command:

```
$ kn source apiserver describe <source_name>
```

Example output

```
Name:                mysource
Namespace:           default
Annotations:         sources.knative.dev/creator=developer,
sources.knative.dev/lastModifier=developer
Age:                 3m
ServiceAccountName:  events-sa
Mode:                Resource
Sink:
  Name:       default
  Namespace:  default
  Kind:       Broker (eventing.knative.dev/v1)
Resources:
  Kind:        event (v1)
  Controller:  false
Conditions:
  OK TYPE                   AGE REASON
  ++ Ready                  3m
  ++ Deployed               3m
  ++ SinkProvided           3m
  ++ SufficientPermissions  3m
  ++ EventTypesProvided     3m
```

Verification

You can verify that the Kubernetes events were sent to Knative by looking at the message dumper function logs.

1. Get the pods:

```
$ oc get pods
```

2. View the message dumper function logs for the pods:

```
$ oc logs $(oc get pod -o name | grep event-display) -c user-container
```

Example output

```
☁  cloudevents.Event
Validation: valid
Context Attributes,
  specversion: 1.0
  type: dev.knative.apiserver.resource.update
  datacontenttype: application/json
  ...
Data,
  {
    "apiVersion": "v1",
    "involvedObject": {
      "apiVersion": "v1",
      "fieldPath": "spec.containers{hello-node}",
      "kind": "Pod",
      "name": "hello-node",
      "namespace": "default",
       .....
    },
    "kind": "Event",
    "message": "Started container",
    "metadata": {
      "name": "hello-node.159d7608e3a3572c",
      "namespace": "default",
      ....
    },
    "reason": "Started",
    ...
  }
```

14.3.1.4. Deleting the API server source by using the Knative CLI

This section describes the steps used to delete the API server source, trigger, service account, cluster role, and cluster role binding using **kn** and **oc** commands.

Prerequisites

- You must have the **kn** CLI installed.

Procedure

1. Delete the trigger:

```
$ kn trigger delete <trigger_name>
```

2. Delete the event source:

```
$ kn source apiserver delete <source_name>
```

3. Delete the service account, cluster role, and cluster binding:

```
$ oc delete -f authentication.yaml
```

14.3.1.5. Creating a ping source by using the Knative CLI

The following procedure describes how to create a basic ping source by using the **kn** CLI.

Prerequisites

- You have Knative Serving and Eventing installed.
- You have the **kn** CLI installed.

Procedure

1. To verify that the ping source is working, create a simple Knative service that dumps incoming messages to the service logs:

```
$ kn service create event-display \
    --image quay.io/openshift-knative/knative-eventing-sources-event-display:latest
```

2. For each set of ping events that you want to request, create a ping source in the same namespace as the event consumer:

```
$ kn source ping create test-ping-source \
    --schedule "*/2 * * * *" \
    --data '{"message": "Hello world!"}' \
    --sink ksvc:event-display
```

3. Check that the controller is mapped correctly by entering the following command and inspecting the output:

```
$ kn source ping describe test-ping-source
```

Example output

```
Name:         test-ping-source
Namespace:    default
Annotations:  sources.knative.dev/creator=developer,
sources.knative.dev/lastModifier=developer
Age:          15s
Schedule:     */2 * * * *
Data:         {"message": "Hello world!"}

Sink:
  Name:       event-display
  Namespace:  default
  Resource:   Service (serving.knative.dev/v1)

Conditions:
  OK TYPE               AGE REASON
  ++ Ready              8s
  ++ Deployed             8s
  ++ SinkProvided         15s
  ++ ValidSchedule        15s
  ++ EventTypeProvided    15s
  ++ ResourcesCorrect     15s
```

Verification

You can verify that the Kubernetes events were sent to the Knative event sink by looking at the logs of the sink pod.

By default, Knative services terminate their pods if no traffic is received within a 60 second period. The example shown in this guide creates a ping source that sends a message every 2 minutes, so each message should be observed in a newly created pod.

1. Watch for new pods created:

```
$ watch oc get pods
```

2. Cancel watching the pods using Ctrl+C, then look at the logs of the created pod:

```
$ oc logs $(oc get pod -o name | grep event-display) -c user-container
```

Example output

```
☁  cloudevents.Event
Validation: valid
Context Attributes,
  specversion: 1.0
  type: dev.knative.sources.ping
  source: /apis/v1/namespaces/default/pingsources/test-ping-source
  id: 99e4f4f6-08ff-4bff-acf1-47f61ded68c9
  time: 2020-04-07T16:16:00.000601161Z
  datacontenttype: application/json
Data,
  {
    "message": "Hello world!"
  }
```

14.3.1.6. Deleting a ping source by using the Knative CLI

The following procedure describes how to delete a ping source using the **kn** CLI.

- Delete the ping source:

```
$ kn delete pingsources.sources.knative.dev <ping_source_name>
```

14.3.1.7. Creating a Kafka event source by using the Knative CLI

This section describes how to create a Kafka event source by using the **kn** command.

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, Knative Serving, and the **KnativeKafka** custom resource (CR) are installed on your cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.
- You have access to a Red Hat AMQ Streams (Kafka) cluster that produces the Kafka messages you want to import.

Procedure

1. To verify that the Kafka event source is working, create a Knative service that dumps incoming events into the service logs:

```
$ kn service create event-display \
    --image quay.io/openshift-knative/knative-eventing-sources-event-display
```

2. Create a **KafkaSource** CR:

```
$ kn source kafka create <kafka_source_name> \
    --servers <cluster_kafka_bootstrap>.kafka.svc:9092 \
    --topics <topic_name> --consumergroup my-consumer-group \
    --sink event-display
```

NOTE

Replace the placeholder values in this command with values for your source name, bootstrap servers, and topics.

The **--servers**, **--topics**, and **--consumergroup** options specify the connection parameters to the Kafka cluster. The **--consumergroup** option is optional.

3. Optional: View details about the **KafkaSource** CR you created:

```
$ kn source kafka describe <kafka_source_name>
```

Example output

```
Name:              example-kafka-source
Namespace:         kafka
Age:               1h
BootstrapServers:  example-cluster-kafka-bootstrap.kafka.svc:9092
Topics:            example-topic
ConsumerGroup:     example-consumer-group

Sink:
  Name:       event-display
  Namespace:  default
  Resource:   Service (serving.knative.dev/v1)

Conditions:
  OK TYPE           AGE REASON
  ++ Ready          1h
  ++ Deployed       1h
  ++ SinkProvided   1h
```

Verification steps

1. Trigger the Kafka instance to send a message to the topic:

```
$ oc -n kafka run kafka-producer \
    -ti --image=quay.io/strimzi/kafka:latest-kafka-2.7.0 --rm=true \
```

```
    --restart=Never -- bin/kafka-console-producer.sh \
    --broker-list <cluster_kafka_bootstrap>:9092 --topic my-topic
```

Enter the message in the prompt. This command assumes that:

- The Kafka cluster is installed in the **kafka** namespace.
- The **KafkaSource** object has been configured to use the **my-topic** topic.

2. Verify that the message arrived by viewing the logs:

```
$ oc logs $(oc get pod -o name | grep event-display) -c user-container
```

Example output

```
☁  cloudevents.Event
Validation: valid
Context Attributes,
  specversion: 1.0
  type: dev.knative.kafka.event
  source: /apis/v1/namespaces/default/kafkasources/example-kafka-source#example-topic
  subject: partition:46#0
  id: partition:46/offset:0
  time: 2021-03-10T11:21:49.4Z
Extensions,
  traceparent: 00-161ff3815727d8755848ec01c866d1cd-7ff3916c44334678-00
Data,
  Hello!
```

14.4. LISTING EVENT SOURCES AND EVENT SOURCE TYPES

You can use the **kn** CLI or the **Developer** perspective in the OpenShift Container Platform web console to list and manage available event sources or event source types.

14.4.1. Listing available event source types by using the Knative CLI

Procedure

1. List the available event source types in the terminal:

```
$ kn source list-types
```

Example output

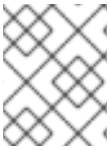
```
TYPE              NAME                                DESCRIPTION
ApiServerSource   apiserversources.sources.knative.dev   Watch and send Kubernetes API events to a sink
PingSource        pingsources.sources.knative.dev       Periodically send ping events to a sink
SinkBinding       sinkbindings.sources.knative.dev      Binding for connecting a PodSpecable to a sink
```

2. Optional: You can also list the available event source types in YAML format:

```
$ kn source list-types -o yaml
```

14.4.2. Viewing available event source types within the Developer perspective

You can use the web console to view available event source types.



NOTE

Additional event source types can be added by cluster administrators by installing Operators on OpenShift Container Platform.

Procedure

1. Access the **Developer** perspective.
2. Click **+Add**.
3. Click **Event source**.

14.4.3. Listing available event sources by using the Knative CLI

- List the available event sources:

```
$ kn source list
```

Example output

```
NAME   TYPE             RESOURCE                          SINK         READY
a1     ApiServerSource   apiserversources.sources.knative.dev   ksvc:eshow2   True
b1     SinkBinding       sinkbindings.sources.knative.dev       ksvc:eshow3   False
p1     PingSource        pingsources.sources.knative.dev        ksvc:eshow1   True
```

14.4.3.1. Listing event sources of a specific type only

You can list event sources of a specific type only, by using the **--type** flag.

- List the available ping sources:

```
$ kn source list --type PingSource
```

Example output

```
NAME   TYPE             RESOURCE                          SINK         READY
p1     PingSource        pingsources.sources.knative.dev        ksvc:eshow1   True
```

14.5. KN FUNC

14.5.1. Creating functions

You can create a basic serverless function using the **kn** CLI.

You can specify the path, runtime, template, and repository with the template as flags on the command line, or use the **-c** flag to start the interactive experience in the terminal.

Procedure

- Create a function project:

```
$ kn func create -r <repository> -l <runtime> -t <template> <path>
```

  - Supported runtimes include **node**, **go**, **python**, **quarkus**, and **typescript**.
  - Supported templates include **http** and **events**.

    Example command

```
$ kn func create -l typescript -t events examplefunc
```

    Example output

```
Project path:  /home/user/demo/examplefunc
Function name: examplefunc
Runtime:       typescript
Template:      events
Writing events to /home/user/demo/examplefunc
```

  - Alternatively, you can specify a repository that contains a custom template.

    Example command

```
$ kn func create -r https://github.com/boson-project/templates/ -l node -t hello-world
examplefunc
```

    Example output

```
Project path:  /home/user/demo/examplefunc
Function name: examplefunc
Runtime:       node
Template:      hello-world
Writing events to /home/user/demo/examplefunc
```

14.5.2. Building functions

Before you can run a function, you must build the function project by using the **kn func build** command. The build command reads the **func.yaml** file from the function project directory to determine the image name and registry.

Example func.yaml

```
name: example-function
namespace: default
runtime: node
image: <image_from_registry>
imageDigest: ""
```

```
trigger: http
builder: default
builderMap:
  default: quay.io/boson/faas-nodejs-builder
envs: {}
```

If the image name and registry are not set in the **func.yaml** file, you must either specify the registry flag, **-r** when using the **kn func build** command, or you are prompted to provide a registry value in the terminal when building a function. An image name is then derived from the registry value that you have provided.

Example command using the -r registry flag

```
$ kn func build [-i <image> -r <registry> -p <path>]
```

Example output

```
Building function image
Function image has been built, image: quay.io/username/example-function:latest
```

This command creates an OCI container image that can be run locally on your computer, or on a Kubernetes cluster.

Example using the registy prompt

```
$ kn func build
A registry for function images is required (e.g. 'quay.io/boson').

Registry for function images: quay.io/username
Building function image
Function image has been built, image: quay.io/username/example-function:latest
```

The values for image and registry are persisted to the **func.yaml** file, so that subsequent invocations do not require the user to specify these again.

14.5.3. Deploying functions

You can deploy a function to your cluster as a Knative service by using the **kn func deploy** command.

If the targeted function is already deployed, it is updated with a new container image that is pushed to a container image registry, and the Knative service is updated.

Prerequisites

- You must have already initialized the function that you want to deploy.

Procedure

- Deploy a function:

  ```
  $ kn func deploy [-n <namespace> -p <path> -i <image> -r <registry>]
  ```

  #### Example output

```
Function deployed at: http://func.example.com
```

- If no **namespace** is specified, the function is deployed in the current namespace.
- The function is deployed from the current directory, unless a **path** is specified.
- The Knative service name is derived from the project name, and cannot be changed using this command.

14.5.4. Listing existing functions

You can list existing functions by using **kn func list**. If you want to list functions that have been deployed as Knative services, you can also use **kn service list**.

Procedure

- List existing functions:

```
$ kn func list [-n <namespace> -p <path>]
```

Example output

```
NAME            NAMESPACE  RUNTIME  URL
READY
example-function default    node     http://example-function.default.apps.ci-ln-g9f36hb-
d5d6b.origin-ci-int-aws.dev.rhcloud.com  True
```

- List functions deployed as Knative services:

```
$ kn service list -n <namespace>
```

Example output

```
NAME            URL                                                                LATEST
AGE   CONDITIONS   READY   REASON
example-function   http://example-function.default.apps.ci-ln-g9f36hb-d5d6b.origin-ci-int-
aws.dev.rhcloud.com   example-function-gzl4c   16m   3 OK / 3      True
```

14.5.5. Describing a function

The **kn func info** command prints information about a deployed function, such as the function name, image, namespace, Knative service information, route information, and event subscriptions.

Procedure

- Describe a function:

```
$ kn func info [-f <format> -n <namespace> -p <path>]
```

Example command

```
$ kn func info -p function/example-function
```

-

Example output

```
Function name:
  example-function
Function is built in image:
  docker.io/user/example-function:latest
Function is deployed as Knative Service:
  example-function
Function is deployed in namespace:
  default
Routes:
  http://example-function.default.apps.ci-ln-g9f36hb-d5d6b.origin-ci-int-aws.dev.rhcloud.com
```

14.5.6. Emitting a test event to a deployed function

You can use the **kn func emit** CLI command to emit a CloudEvent to a function that is either deployed locally or deployed to your OpenShift Container Platform cluster. This command can be used to test that a function is working and able to receive events correctly.

Example command

```
$ kn func emit
```

The **kn func emit** command executes on the local directory by default, and assumes that this directory is a function project.

14.5.6.1. kn func emit optional parameters

You can specify optional parameters for the emitted CloudEvent by using the **kn func emit** CLI command flags.

List of flags from --help command output

```
Flags:
  -c, --content-type string   The MIME Content-Type for the CloudEvent data  (Env:
$FUNC_CONTENT_TYPE) (default "application/json")
  -d, --data string           Any arbitrary string to be sent as the CloudEvent data. Ignored if --file is
provided  (Env: $FUNC_DATA)
  -f, --file string           Path to a local file containing CloudEvent data to be sent  (Env: $FUNC_FILE)
  -h, --help                  help for emit
  -i, --id string             CloudEvent ID (Env: $FUNC_ID) (default "306bd6a0-0b0a-48ba-b187-
b633571d072a")
  -p, --path string           Path to the project directory. Ignored when --sink is provided (Env:
$FUNC_PATH) (default "/home/lanceball/src/github.com/nodeshift/opossum")
  -k, --sink string           Send the CloudEvent to the function running at [sink]. The special value
"local" can be used to send the event to a function running on the local host. When provided, the --
path flag is ignored  (Env: $FUNC_SINK)
  -s, --source string         CloudEvent source (Env: $FUNC_SOURCE) (default "/boson/fn")
  -t, --type string           CloudEvent type  (Env: $FUNC_TYPE) (default "boson.fn")
```

In particular, you might find it useful to specify the following parameters:

Event type

The type of event being emitted. You can find information about the **type** parameter that is set for events from a certain event producer in the documentation for that event producer. For example, the API server source may set the **type** parameter of produced events as **dev.knative.apiserver.resource.update**.

Event source

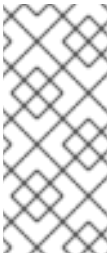
The unique event source that produced the event. This may be a URI for the event source, for example **https://10.96.0.1/**, or the name of the event source.

Event ID

A random, unique ID that is created by the event producer.

Event data

Allows you to specify a **data** value for the event sent by the **kn func emit** command. For example, you can specify a **--data** value such as **"Hello world!"** so that the event contains this data string. By default, no data is included in the events created by **kn func emit**.



NOTE

Functions that have been deployed to a cluster can respond to events from an existing event source that provides values for properties such as **source** and **type**. These events often have a **data** value in JSON form, which captures the domain specific context of the event. Using the CLI flags noted in this document, developers can simulate those events for local testing.

You can also send event data using the **--file** flag to provide a local file containing data for the event.

Data content type

If you are using the **--data** flag to add data for events, you can also specify what type of data is carried by the event, by using the **--content-type** flag. In the previous example, the data is plain text, so you might specify **kn func emit --data "Hello world!" --content-type "text/plain"**.

Example commands specifying event parameters by using flags

```
$ kn func emit --type <event_type> --source <event_source> --data <event_data> --content-type <content_type> -i <event_ID>
```

```
$ kn func emit --type ping --source example-ping --data "Hello world!" --content-type "text/plain" -i example-ID
```

Example commands specifying a file on disk that contains the event parameters

```
$ kn func emit --file <path>
```

```
$ kn func emit --file ./test.json
```

Example commands specifying a path to the function

You can specify a path to the function project by using the **--path** flag, or specify an endpoint for the function by using the **--sink** flag:

```
$ kn func emit --path <path_to_function>
```

```
$ kn func emit --path ./example/example-function
```

Example commands specifying a function deployed as a Knative service (sink)

```
$ kn func emit --sink <service_URL>
```

```
$ kn func emit --sink "http://example.function.com"
```

The **--sink** flag also accepts the special value **local** to send an event to a function running locally:

```
$ kn func emit --sink local
```

14.5.7. Deleting a function

You can delete a function from your cluster by using the **kn func delete** command.

Procedure

- Delete a function:

  ```
  $ kn func delete [<function_name> -n <namespace> -p <path>]
  ```

  - If the name or path of the function to delete is not specified, the current directory is searched for a **func.yaml** file that is used to determine the function to delete.
  - If the namespace is not specified, it defaults to the **namespace** value in the **func.yaml** file.