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.

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CHAPTER 1. RELEASE NOTES

NOTE

For additional information about the OpenShift Serverless life cycle and supported platforms, refer to the Platform Life Cycle Policy .

Release notes contain information about new and deprecated features, breaking changes, and known issues. The following release notes apply for the most recent OpenShift Serverless releases 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

API versions are an important measure of the development status of certain features and custom resources in OpenShift Serverless. Creating resources on your cluster that do not use the correct API version can cause issues in your deployment.

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. GENERALLY AVAILABLE AND TECHNOLOGY PREVIEW FEATURES

Features which are Generally Available (GA) are fully supported and are suitable for production use. Technology Preview (TP) features are experimental features and are not intended for production use. See the Technology Preview scope of support on the Red Hat Customer Portal for more information about TP features.

The following table provides information about which OpenShift Serverless features are GA and which are TP:

Table 1.1. Generally Available and Technology Preview features tracker

Feature	1.26	1.27	1.28
kn func	GA	GA	GA

Feature	1.26	1.27	1.28
Quarkus functions	GA	GA	GA
Node.js functions	TP	TP	GA
TypeScript functions	TP	TP	GA
Python functions	-	-	TP
Service Mesh mTLS	GA	GA	GA
emptyDir volumes	GA	GA	GA
HTTPS redirection	GA	GA	GA
Kafka broker	GA	GA	GA
Kafka sink	GA	GA	GA
Init containers support for Knative services	GA	GA	GA
PVC support for Knative services	GA	GA	GA
TLS for internal traffic	TP	TP	TP
Namespace-scoped brokers	-	TP	TP
multi-container support	-	-	TP

1.3. DEPRECATED AND REMOVED FEATURES

Some features that were Generally Available (GA) or a Technology Preview (TP) in previous releases have been deprecated or removed. Deprecated functionality is still included in OpenShift Serverless and continues to be supported; however, it will be removed in a future release of this product and is not recommended for new deployments.

For the most recent list of major functionality deprecated and removed within OpenShift Serverless, refer to the following table:

Table 1.2. Deprecated and removed features tracker

Feature	1.20	1.21	1.22 to 1.26	1.27	1.28
KafkaBinding API	Deprecated	Deprecated	Removed	Removed	Removed

Feature	1.20	1.21	1.22 to 1.26	1.27	1.28
kn func emit (**kn func invoke** in 1.21+)	Deprecated	Removed	Removed	Removed	Removed
Serving and Eventing **v1alpha1** API	-	-	-	Deprecated	Deprecated
enable-secret-informer-filtering annotation	-	-	-	-	Deprecated

1.4. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.28

OpenShift Serverless 1.28 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 1.7.
- OpenShift Serverless now uses Knative Eventing 1.7.
- OpenShift Serverless now uses Kourier 1.7.
- OpenShift Serverless now uses Knative (**kn**) CLI 1.7.
- OpenShift Serverless now uses Knative Kafka 1.7.
- The **kn func** CLI plug-in now uses **func** 1.9.1 version.
- Node.js and TypeScript runtimes for OpenShift Serverless Functions are now Generally Available (GA).
- Python runtime for OpenShift Serverless Functions is now available as a Technology Preview.
- Multi-container support for Knative Serving is now available as a Technology Preview. This feature allows you to use a single Knative service to deploy a multi-container pod.
- In OpenShift Serverless 1.29 or later, the following components of Knative Eventing will be scaled down from two pods to one:
  - **imc-controller**
  - **imc-dispatcher**
  - **mt-broker-controller**
  - **mt-broker-filter**
  - **mt-broker-ingress**
- The **serverless.openshift.io/enable-secret-informer-filtering** annotation for the Serving CR is now deprecated. The annotation is valid only for Istio, and not for Kourier.

With OpenShift Serverless 1.28, the OpenShift Serverless Operator allows injecting the environment variable **ENABLE_SECRET_INFORMER_FILTERING_BY_CERT_UID** for both **net-istio** and **net-kourier**.

If you enable secret filtering, all of your secrets need to be labeled with **networking.internal.knative.dev/certificate-uid: "<id>"**. Otherwise, Knative Serving does not detect them, which leads to failures. You must label both new and existing secrets.

In one of the following OpenShift Serverless releases, secret filtering will become enabled by default. To prevent failures, label your secrets in advance.

1.4.2. Known issues

- Currently, runtimes for Python are not supported for OpenShift Serverless Functions on IBM Power, IBM zSystems, and IBM® LinuxONE.
  Node.js, TypeScript, and Quarkus functions are supported on these architectures.

- On the Windows platform, Python functions cannot be locally built, run, or deployed using the Source-to-Image builder due to the **app.sh** file permissions.
  To work around this problem, use the Windows Subsystem for Linux.

1.5. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.27

OpenShift Serverless 1.27 is now available. New features, changes, and known issues that pertain to OpenShift Serverless on OpenShift Container Platform are included in this topic.

IMPORTANT

OpenShift Serverless 1.26 is the earliest release that is fully supported on OpenShift Container Platform 4.12. OpenShift Serverless 1.25 and older does not deploy on OpenShift Container Platform 4.12.

For this reason, before upgrading OpenShift Container Platform to version 4.12, first upgrade OpenShift Serverless to version 1.26 or 1.27.

1.5.1. New features

- OpenShift Serverless now uses Knative Serving 1.6.

- OpenShift Serverless now uses Knative Eventing 1.6.

- OpenShift Serverless now uses Kourier 1.6.

- OpenShift Serverless now uses Knative (**kn**) CLI 1.6.

- OpenShift Serverless now uses Knative Kafka 1.6.

- The **kn func** CLI plug-in now uses **func** 1.8.1.

- Namespace-scoped brokers are now available as a Technology Preview. Such brokers can be used, for instance, to implement role-based access control (RBAC) policies.

- **KafkaSink** now uses the **CloudEvent** binary content mode by default. The binary content mode is more efficient than the structured mode because it uses headers in its body instead of a **CloudEvent**. For example, for the HTTP protocol, it uses HTTP headers.

- You can now use the gRPC framework over the HTTP/2 protocol for external traffic using the OpenShift Route on OpenShift Container Platform 4.10 and later. This improves efficiency and speed of the communications between the client and server.

- API version **v1alpha1** of the Knative Operator Serving and Eventings CRDs is deprecated in 1.27. It will be removed in future versions. Red Hat strongly recommends to use the **v1beta1** version instead. This does not affect the existing installations, because CRDs are updated automatically when upgrading the Serverless Operator.

- The delivery timeout feature is now enabled by default. It allows you to specify the timeout for each sent HTTP request. The feature remains a Technology Preview.

1.5.2. Fixed issues

- Previously, Knative services sometimes did not get into the **Ready** state, reporting waiting for the load balancer to be ready. This issue has been fixed.

1.5.3. Known issues

- Integrating OpenShift Serverless with Red Hat OpenShift Service Mesh causes the **net-kourier** pod to run out of memory on startup when too many secrets are present on the cluster.

- Namespace-scoped brokers might leave **ClusterRoleBindings** in the user namespace even after deletion of namespace-scoped brokers.
  If this happens, delete the **ClusterRoleBinding** named **rbac-proxy-reviews-prom-rb-knative-kafka-broker-data-plane-{{.Namespace}}** in the user namespace.

- If you use **net-istio** for Ingress and enable mTLS via SMCP using **security.dataPlane.mtls: true**, Service Mesh deploys **DestinationRules** for the ***.local** host, which does not allow **DomainMapping** for OpenShift Serverless.
  To work around this issue, enable mTLS by deploying **PeerAuthentication** instead of using **security.dataPlane.mtls: true**.

1.6. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.26

OpenShift Serverless 1.26 is now available. New features, changes, and known issues that pertain to OpenShift Serverless on OpenShift Container Platform are included in this topic.

1.6.1. New features

- OpenShift Serverless Functions with Quarkus is now GA.

- OpenShift Serverless now uses Knative Serving 1.5.

- OpenShift Serverless now uses Knative Eventing 1.5.

- OpenShift Serverless now uses Kourier 1.5.

- OpenShift Serverless now uses Knative (**kn**) CLI 1.5.

- OpenShift Serverless now uses Knative Kafka 1.5.

- OpenShift Serverless now uses Knative Operator 1.3.

- The **kn func** CLI plugin now uses **func** 1.8.1.

- Persistent volume claims (PVCs) are now GA. PVCs provide permanent data storage for your Knative services.
- The new trigger filters feature is now available as a Developer Preview. It allows users to specify a set of filter expressions, where each expression evaluates to either true or false for each event.
  To enable new trigger filters, add the **new-trigger-filters: enabled** entry in the section of the **KnativeEventing** type in the operator config map:

  ```
  apiVersion: operator.knative.dev/v1beta1
  kind: KnativeEventing
  ...
  ...
  spec:
    config:
      features:
        new-trigger-filters: enabled
  ...
  ```

- Knative Operator 1.3 adds the updated **v1beta1** version of the API for **operator.knative.dev**.
  To update from **v1alpha1** to **v1beta1** in your **KnativeServing** and **KnativeEventing** custom resource config maps, edit the **apiVersion** key:

  Example KnativeServing custom resource config map

  ```
  apiVersion: operator.knative.dev/v1beta1
  kind: KnativeServing
  ...
  ```

  Example KnativeEventing custom resource config map

  ```
  apiVersion: operator.knative.dev/v1beta1
  kind: KnativeEventing
  ...
  ```

1.6.2. Fixed issues

- Previously, Federal Information Processing Standards (FIPS) mode was disabled for Kafka broker, Kafka source, and Kafka sink. This has been fixed, and FIPS mode is now available.

1.6.3. Known issues

- If you use **net-istio** for Ingress and enable mTLS via SMCP using **security.dataPlane.mtls: true**, Service Mesh deploys **DestinationRules** for the ***.local** host, which does not allow **DomainMapping** for OpenShift Serverless.
  To work around this issue, enable mTLS by deploying **PeerAuthentication** instead of using **security.dataPlane.mtls: true**.

Additional resources

- Knative documentation on new trigger filters

1.7. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.25.0

OpenShift Serverless 1.25.0 is now available. New features, changes, and known issues that pertain to OpenShift Serverless on OpenShift Container Platform are included in this topic.

1.7.1. New features

- OpenShift Serverless now uses Knative Serving 1.4.
- OpenShift Serverless now uses Knative Eventing 1.4.
- OpenShift Serverless now uses Kourier 1.4.
- OpenShift Serverless now uses Knative (**kn**) CLI 1.4.
- OpenShift Serverless now uses Knative Kafka 1.4.
- The **kn func** CLI plugin now uses **func** 1.7.0.
- Integrated development environment (IDE) plugins for creating and deploying functions are now available for Visual Studio Code and IntelliJ.
- Knative Kafka broker is now GA. Knative Kafka broker is a highly performant implementation of the Knative broker API, directly targeting Apache Kafka.
  It is recommended to not use the MT-Channel-Broker, but the Knative Kafka broker instead.
- Knative Kafka sink is now GA. A **KafkaSink** takes a **CloudEvent** and sends it to an Apache Kafka topic. Events can be specified in either structured or binary content modes.
- Enabling TLS for internal traffic is now available as a Technology Preview.

1.7.2. Fixed issues

- Previously, Knative Serving had an issue where the readiness probe failed if the container was restarted after a liveness probe fail. This issue has been fixed.

1.7.3. Known issues

- The Federal Information Processing Standards (FIPS) mode is disabled for Kafka broker, Kafka source, and Kafka sink.
- The **SinkBinding** object does not support custom revision names for services.
- The Knative Serving Controller pod adds a new informer to watch secrets in the cluster. The informer includes the secrets in the cache, which increases memory consumption of the controller pod.
  If the pod runs out of memory, you can work around the issue by increasing the memory limit for the deployment.
- If you use **net-istio** for Ingress and enable mTLS via SMCP using **security.dataPlane.mtls: true**, Service Mesh deploys **DestinationRules** for the ***.local** host, which does not allow **DomainMapping** for OpenShift Serverless.
  To work around this issue, enable mTLS by deploying **PeerAuthentication** instead of using **security.dataPlane.mtls: true**.

Additional resources

- Configuring TLS authentication

1.8. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.24.0

OpenShift Serverless 1.24.0 is now available. New features, changes, and known issues that pertain to OpenShift Serverless on OpenShift Container Platform are included in this topic.

1.8.1. New features

- OpenShift Serverless now uses Knative Serving 1.3.
- OpenShift Serverless now uses Knative Eventing 1.3.
- OpenShift Serverless now uses Kourier 1.3.
- OpenShift Serverless now uses Knative **kn** CLI 1.3.
- OpenShift Serverless now uses Knative Kafka 1.3.
- The **kn func** CLI plugin now uses **func** 0.24.
- Init containers support for Knative services is now generally available (GA).
- OpenShift Serverless logic is now available as a Developer Preview. It enables defining declarative workflow models for managing serverless applications.
- You can now use the cost management service with OpenShift Serverless.

1.8.2. Fixed issues

- Integrating OpenShift Serverless with Red Hat OpenShift Service Mesh causes the **net-istio-controller** pod to run out of memory on startup when too many secrets are present on the cluster.
  It is now possible to enable secret filtering, which causes **net-istio-controller** to consider only secrets with a **networking.internal.knative.dev/certificate-uid** label, thus reducing the amount of memory needed.
- The OpenShift Serverless Functions Technology Preview now uses Cloud Native Buildpacks by default to build container images.

1.8.3. Known issues

- The Federal Information Processing Standards (FIPS) mode is disabled for Kafka broker, Kafka source, and Kafka sink.
- In OpenShift Serverless 1.23, support for KafkaBindings and the **kafka-binding** webhook were removed. However, an existing **kafkabindings.webhook.kafka.sources.knative.dev MutatingWebhookConfiguration** might remain, pointing to the **kafka-source-webhook** service, which no longer exists.
  For certain specifications of KafkaBindings on the cluster, **kafkabindings.webhook.kafka.sources.knative.dev MutatingWebhookConfiguration** might be configured to pass any create and update events to various resources, such as Deployments, Knative Services, or Jobs, through the webhook, which would then fail.

To work around this issue, manually delete **kafkabindings.webhook.kafka.sources.knative.dev MutatingWebhookConfiguration** from the cluster after upgrading to OpenShift Serverless 1.23:

```
$ oc delete mutatingwebhookconfiguration kafkabindings.webhook.kafka.sources.knative.dev
```

- If you use **net-istio** for Ingress and enable mTLS via SMCP using **security.dataPlane.mtls: true**, Service Mesh deploys **DestinationRules** for the ***.local** host, which does not allow **DomainMapping** for OpenShift Serverless.
  To work around this issue, enable mTLS by deploying **PeerAuthentication** instead of using **security.dataPlane.mtls: true**.

1.9. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.23.0

OpenShift Serverless 1.23.0 is now available. New features, changes, and known issues that pertain to OpenShift Serverless on OpenShift Container Platform are included in this topic.

1.9.1. New features

- OpenShift Serverless now uses Knative Serving 1.2.
- OpenShift Serverless now uses Knative Eventing 1.2.
- OpenShift Serverless now uses Kourier 1.2.
- OpenShift Serverless now uses Knative (**kn**) CLI 1.2.
- OpenShift Serverless now uses Knative Kafka 1.2.
- The **kn func** CLI plugin now uses **func** 0.24.
- It is now possible to use the **kafka.eventing.knative.dev/external.topic** annotation with the Kafka broker. This annotation makes it possible to use an existing externally managed topic instead of the broker creating its own internal topic.
- The **kafka-ch-controller** and **kafka-webhook** Kafka components no longer exist. These components have been replaced by the **kafka-webhook-eventing** component.
- The OpenShift Serverless Functions Technology Preview now uses Source-to-Image (S2I) by default to build container images.

1.9.2. Known issues

- The Federal Information Processing Standards (FIPS) mode is disabled for Kafka broker, Kafka source, and Kafka sink.
- If you delete a namespace that includes a Kafka broker, the namespace finalizer may fail to be removed if the broker's **auth.secret.ref.name** secret is deleted before the broker.
- Running OpenShift Serverless with a large number of Knative services can cause Knative activator pods to run close to their default memory limits of 600MB. These pods might be restarted if memory consumption reaches this limit. Requests and limits for the activator deployment can be configured by modifying the **KnativeServing** custom resource:

```
apiVersion: operator.knative.dev/v1beta1
```

```
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
spec:
  deployments:
  - name: activator
    resources:
    - container: activator
      requests:
        cpu: 300m
        memory: 60Mi
      limits:
        cpu: 1000m
        memory: 1000Mi
```

- If you are using Cloud Native Buildpacks as the local build strategy for a function, **kn func** is unable to automatically start podman or use an SSH tunnel to a remote daemon. The workaround for these issues is to have a Docker or podman daemon already running on the local development computer before deploying a function.

- On-cluster function builds currently fail for Quarkus and Golang runtimes. They work correctly for Node, Typescript, Python, and Springboot runtimes.

- If you use **net-istio** for Ingress and enable mTLS via SMCP using **security.dataPlane.mtls: true**, Service Mesh deploys **DestinationRules** for the ***.local** host, which does not allow **DomainMapping** for OpenShift Serverless.
  To work around this issue, enable mTLS by deploying **PeerAuthentication** instead of using **security.dataPlane.mtls: true**.

Additional resources

- Source-to-Image

1.10. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.22.0

OpenShift Serverless 1.22.0 is now available. New features, changes, and known issues that pertain to OpenShift Serverless on OpenShift Container Platform are included in this topic.

1.10.1. New features

- OpenShift Serverless now uses Knative Serving 1.1.

- OpenShift Serverless now uses Knative Eventing 1.1.

- OpenShift Serverless now uses Kourier 1.1.

- OpenShift Serverless now uses Knative (**kn**) CLI 1.1.

- OpenShift Serverless now uses Knative Kafka 1.1.

- The **kn func** CLI plugin now uses **func** 0.23.

- Init containers support for Knative services is now available as a Technology Preview.

- Persistent volume claim (PVC) support for Knative services is now available as a Technology Preview.
- The **knative-serving**, **knative-serving-ingress**, **knative-eventing** and **knative-kafka** system namespaces now have the **knative.openshift.io/part-of: "openshift-serverless"** label by default.
- The **Knative Eventing - Kafka Broker/Trigger** dashboard has been added, which allows visualizing Kafka broker and trigger metrics in the web console.
- The **Knative Eventing - KafkaSink** dashboard has been added, which allows visualizing KafkaSink metrics in the web console.
- The **Knative Eventing - Broker/Trigger** dashboard is now called **Knative Eventing - Channel-based Broker/Trigger**.
- The **knative.openshift.io/part-of: "openshift-serverless"** label has substituted the **knative.openshift.io/system-namespace** label.
- Naming style in Knative Serving YAML configuration files changed from camel case (**ExampleName**) to hyphen style (**example-name**). Beginning with this release, use the hyphen style notation when creating or editing Knative Serving YAML configuration files.

1.10.2. Known issues

- The Federal Information Processing Standards (FIPS) mode is disabled for Kafka broker, Kafka source, and Kafka sink.

1.11. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.21.0

OpenShift Serverless 1.21.0 is now available. New features, changes, and known issues that pertain to OpenShift Serverless on OpenShift Container Platform are included in this topic.

1.11.1. New features

- OpenShift Serverless now uses Knative Serving 1.0
- OpenShift Serverless now uses Knative Eventing 1.0.
- OpenShift Serverless now uses Kourier 1.0.
- OpenShift Serverless now uses Knative (**kn**) CLI 1.0.
- OpenShift Serverless now uses Knative Kafka 1.0.
- The **kn func** CLI plugin now uses **func** 0.21.
- The Kafka sink is now available as a Technology Preview.
- The Knative open source project has begun to deprecate camel-cased configuration keys in favor of using kebab-cased keys consistently. As a result, the **defaultExternalScheme** key, previously mentioned in the OpenShift Serverless 1.18.0 release notes, is now deprecated and replaced by the **default-external-scheme** key. Usage instructions for the key remain the same.

1.11.2. Fixed issues

- In OpenShift Serverless 1.20.0, there was an event delivery issue affecting the use of **kn event send** to send events to a service. This issue is now fixed.
- In OpenShift Serverless 1.20.0 (**func** 0.20), TypeScript functions created with the **http** template failed to deploy on the cluster. This issue is now fixed.
- In OpenShift Serverless 1.20.0 (**func** 0.20), deploying a function using the **gcr.io** registry failed with an error. This issue is now fixed.
- In OpenShift Serverless 1.20.0 (**func** 0.20), creating a Springboot function project directory with the **kn func create** command and then running the **kn func build** command failed with an error message. This issue is now fixed.
- In OpenShift Serverless 1.19.0 (**func** 0.19), some runtimes were unable to build a function by using podman. This issue is now fixed.

1.11.3. Known issues

- Currently, the domain mapping controller cannot process the URI of a broker, which contains a path that is currently not supported.
  This means that, if you want to use a **DomainMapping** custom resource (CR) to map a custom domain to a broker, you must configure the **DomainMapping** CR with the broker's ingress service, and append the exact path of the broker to the custom domain:

  Example DomainMapping CR

  ```
  apiVersion: serving.knative.dev/v1alpha1
  kind: DomainMapping
  metadata:
    name: <domain-name>
    namespace: knative-eventing
  spec:
    ref:
      name: broker-ingress
      kind: Service
      apiVersion: v1
  ```

  The URI for the broker is then **<domain-name>/<broker-namespace>/<broker-name>**.

1.12. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.20.0

OpenShift Serverless 1.20.0 is now available. New features, changes, and known issues that pertain to OpenShift Serverless on OpenShift Container Platform are included in this topic.

1.12.1. New features

- OpenShift Serverless now uses Knative Serving 0.26.
- OpenShift Serverless now uses Knative Eventing 0.26.
- OpenShift Serverless now uses Kourier 0.26.
- OpenShift Serverless now uses Knative (**kn**) CLI 0.26.
- OpenShift Serverless now uses Knative Kafka 0.26.

- The **kn func** CLI plugin now uses **func** 0.20.
- The Kafka broker is now available as a Technology Preview.

  > IMPORTANT
  >
  > The Kafka broker, which is currently in Technology Preview, is not supported on FIPS.

- The **kn event** plugin is now available as a Technology Preview.
- The **--min-scale** and **--max-scale** flags for the **kn service create** command have been deprecated. Use the **--scale-min** and **--scale-max** flags instead.

1.12.2. Known issues

- OpenShift Serverless deploys Knative services with a default address that uses HTTPS. When sending an event to a resource inside the cluster, the sender does not have the cluster certificate authority (CA) configured. This causes event delivery to fail, unless the cluster uses globally accepted certificates.
  For example, an event delivery to a publicly accessible address works:

  ```
  $ kn event send --to-url https://ce-api.foo.example.com/
  ```

  On the other hand, this delivery fails if the service uses a public address with an HTTPS certificate issued by a custom CA:

  ```
  $ kn event send --to Service:serving.knative.dev/v1:event-display
  ```

  Sending an event to other addressable objects, such as brokers or channels, is not affected by this issue and works as expected.

- The Kafka broker currently does not work on a cluster with Federal Information Processing Standards (FIPS) mode enabled.
- If you create a Springboot function project directory with the **kn func create** command, subsequent running of the **kn func build** command fails with this error message:

  ```
  [analyzer] no stack metadata found at path ''
  [analyzer] ERROR: failed to : set API for buildpack 'paketo-buildpacks/ca-certificates@3.0.2':
  buildpack API version '0.7' is incompatible with the lifecycle
  ```

  As a workaround, you can change the **builder** property to **gcr.io/paketo-buildpacks/builder:base** in the function configuration file **func.yaml**.

- Deploying a function using the **gcr.io** registry fails with this error message:

  ```
  Error: failed to get credentials: failed to verify credentials: status code: 404
  ```

  As a workaround, use a different registry than **gcr.io**, such as **quay.io** or **docker.io**.

- TypeScript functions created with the **http** template fail to deploy on the cluster.
  As a workaround, in the **func.yaml** file, replace the following section:

```
buildEnvs: []
```

with this:

```
buildEnvs:
- name: BP_NODE_RUN_SCRIPTS
  value: build
```

- In **func** version 0.20, 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
    ```

1.13. 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.

1.13.1. 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 plugin 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.

1.13.2. 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.

1.13.3. 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
    ```

1.14. 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.

1.14.1. 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 plugin 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**.

1.14.2. 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.

1.14.3. 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.

CHAPTER 2. ABOUT SERVERLESS

2.1. OPENSHIFT SERVERLESS OVERVIEW

OpenShift Serverless provides Kubernetes native building blocks that enable developers to create and deploy serverless, event-driven applications on OpenShift Container Platform. 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.

NOTE

Because OpenShift Serverless releases on a different cadence from OpenShift Container Platform, the OpenShift Serverless documentation does not maintain separate documentation sets for minor versions of the product. The current documentation set applies to all currently supported versions of OpenShift Serverless unless version-specific limitations are called out in a particular topic or for a particular feature.

For additional information about the OpenShift Serverless life cycle and supported platforms, refer to the Platform Life Cycle Policy .

2.1.1. Additional resources

- Extending the Kubernetes API with custom resource definitions
- Managing resources from custom resource definitions
- What is serverless?

2.2. KNATIVE SERVING

Knative Serving supports developers who want to create, deploy, and manage 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.

2.2.1. Knative Serving resources

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.

2.3. 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.

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.

2.3.1. Using Knative Kafka

Knative Kafka provides integration options for you to use supported versions of the Apache Kafka message streaming platform with OpenShift Serverless. Kafka provides options for event source, channel, broker, and event sink capabilities.

NOTE

Knative Kafka is not currently supported for IBM Z and IBM Power.

Knative Kafka provides additional options, such as:

- Kafka source
- Kafka channel
- Kafka broker
- Kafka sink

2.3.2. Additional resources

- Installing the **KnativeKafka** custom resource.
- Red Hat AMQ Streams documentation
- Red Hat AMQ Streams TLS and SASL on Kafka documentation
- Event delivery

2.4. ABOUT OPENSHIFT SERVERLESS FUNCTIONS

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 plugin for the Knative **kn** CLI. You can use the **kn func** CLI to create, build, and deploy the container image as a Knative service on the cluster.

2.4.1. Included runtimes

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

- Quarkus
- Node.js
- TypeScript

2.4.2. Next steps

- Getting started with functions.

CHAPTER 3. INSTALLING SERVERLESS

3.1. PREPARING TO INSTALL OPENSHIFT SERVERLESS

Read the following information about supported configurations and prerequisites before you install OpenShift Serverless.

- OpenShift Serverless is supported for installation in a restricted network environment.
- OpenShift Serverless currently cannot be used in a multi-tenant configuration on a single cluster.

3.1.1. Supported configurations

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

3.1.2. Scalability and performance

OpenShift Serverless has been tested with a configuration of 3 main nodes and 3 worker nodes, each of which has 64 CPUs, 457 GB of memory, and 394 GB of storage each.

The maximum number of Knative services that can be created using this configuration is 3,000. This corresponds to the OpenShift Container Platform Kubernetes services limit of 10,000 , since 1 Knative service creates 3 Kubernetes services.

The average scale from zero response time was approximately 3.4 seconds, with a maximum response time of 8 seconds, and a 99.9th percentile of 4.5 seconds for a simple Quarkus application. These times might vary depending on the application and the runtime of the application.

3.1.3. Defining cluster size requirements

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 minimum requirement to use OpenShift Serverless is a cluster with 10 CPUs and 40GB memory. By default, each pod requests ~400m of CPU, so the minimum requirements are based on this value.

The total size requirements to run OpenShift Serverless are dependent on the components that are installed and the applications that are deployed, and might vary depending on your deployment.

3.1.4. Scaling your cluster using compute 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 compute machine sets by two additional machines. See Manually scaling a compute machine set .

3.1.4.1. Additional requirements for advanced use-cases

For more advanced use-cases such as logging or metering on OpenShift Container Platform, you must deploy more resources. Recommended requirements for such use-cases are 24 CPUs and 96GB of memory.

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".

3.1.5. Additional resources

- Using Operator Lifecycle Manager on restricted networks
- Understanding OperatorHub

3.2. INSTALLING THE OPENSHIFT SERVERLESS OPERATOR

Installing the OpenShift Serverless Operator enables you to install and use Knative Serving, Knative Eventing, and Knative Kafka on a OpenShift Container Platform cluster. The OpenShift Serverless Operator manages Knative custom resource definitions (CRDs) for your cluster and enables you to configure them without directly modifying individual config maps for each component.

3.2.1. Installing the OpenShift Serverless Operator from the web console

You can install the OpenShift Serverless Operator from the OperatorHub by using the OpenShift Container Platform web console. Installing this Operator enables you to install and use Knative components.

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- You have logged in to the OpenShift Container Platform web console.

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** is **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.

IMPORTANT

If you want to use Red Hat OpenShift distributed tracing with OpenShift Serverless , you must install and configure Red Hat OpenShift distributed tracing before you install Knative Serving or Knative Eventing.

3.2.2. Installing the OpenShift Serverless Operator from the CLI

You can install the OpenShift Serverless Operator from the OperatorHub by using the CLI. Installing this Operator enables you to install and use Knative components.

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- Your cluster has the Marketplace capability enabled or the Red Hat Operator catalog source configured manually.
- You have logged in to the OpenShift Container Platform cluster.

Procedure

1. Create a YAML file containing **Namespace**, **OperatorGroup**, and **Subscription** objects to subscribe a namespace to the OpenShift Serverless Operator. For example, create the file **serverless-subscription.yaml** with the following content:

Example subscription

```
---
apiVersion: v1
kind: Namespace
metadata:
  name: openshift-serverless
---
apiVersion: operators.coreos.com/v1
kind: OperatorGroup
metadata:
  name: serverless-operators
  namespace: openshift-serverless
spec: {}
---
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: serverless-operator
  namespace: openshift-serverless
spec:
  channel: stable 1
  name: serverless-operator 2
  source: redhat-operators 3
  sourceNamespace: openshift-marketplace 4
```

1 The channel name of the Operator. The **stable** channel enables installation of the most recent stable version of the OpenShift Serverless Operator.

2 The name of the Operator to subscribe to. For the OpenShift Serverless Operator, this is always **serverless-operator**.

3 The name of the CatalogSource that provides the Operator. Use **redhat-operators** for the default OperatorHub catalog sources.

4 The namespace of the CatalogSource. Use **openshift-marketplace** for the default OperatorHub catalog sources.

2. Create the **Subscription** object:

```
$ oc apply -f serverless-subscription.yaml
```

Verification

Check that the cluster service version (CSV) has reached the **Succeeded** phase:

Example command

```
$ oc get csv
```

Example output

```
NAME                        DISPLAY                        VERSION   REPLACES                      PHASE
serverless-operator.v1.25.0   Red Hat OpenShift Serverless   1.25.0    serverless-operator.v1.24.0
Succeeded
```

IMPORTANT

If you want to use Red Hat OpenShift distributed tracing with OpenShift Serverless , you must install and configure Red Hat OpenShift distributed tracing before you install Knative Serving or Knative Eventing.

3.2.3. Global configuration

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**.

3.2.4. Additional resources

- Managing resources from custom resource definitions
- Understanding persistent storage
- Configuring a custom PKI

3.2.5. Next steps

- After the OpenShift Serverless Operator is installed, you can install Knative Serving or install Knative Eventing.

3.3. INSTALLING THE KNATIVE CLI

The Knative (**kn**) CLI does not have its own login mechanism. To log in to the cluster, you must install the OpenShift CLI (**oc**) and use the **oc login** command. Installation options for the CLIs may vary depending on your operating system.

For more information on installing the OpenShift CLI (**oc**) for your operating system and logging in with **oc**, see the OpenShift CLI getting started documentation.

OpenShift Serverless cannot be installed using the Knative (**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 1.23.0 release of the Knative (**kn**) CLI, which uses version 1.2, with the 1.24.0 OpenShift Serverless release, which uses the 1.3 versions of the Knative Serving and Knative Eventing APIs, the CLI does not work because it continues to look for the outdated 1.2 API versions.

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

3.3.1. Installing the Knative CLI using the OpenShift Container Platform web console

Using the OpenShift Container Platform web console provides a streamlined and intuitive user interface to install the Knative (**kn**) CLI. After the OpenShift Serverless Operator is installed, you will see a link to download the Knative (**kn**) CLI for Linux (amd64, s390x, ppc64le), macOS, or Windows from the **Command Line Tools** page in the OpenShift Container Platform web console.

Prerequisites

- You have logged in to the OpenShift Container Platform web console.
- The OpenShift Serverless Operator and Knative Serving are installed on your OpenShift Container Platform cluster.

  IMPORTANT

  If **libc** is not available, you might see the following error when you run CLI commands:

  ```
  $ kn: No such file or directory
  ```

- If you want to use the verification steps for this procedure, you must install the OpenShift (**oc**) CLI.

Procedure

1. Download the Knative (**kn**) CLI from the **Command Line Tools** page. 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 list.
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
   ```

Verification

- Run the following commands to check that the correct Knative CLI resources and route have been created:

```
$ oc get ConsoleCLIDownload
```

Example output

```
NAME               DISPLAY NAME                                AGE
kn                 kn - OpenShift Serverless Command Line Interface (CLI)   2022-09-
20T08:41:18Z
oc-cli-downloads   oc - OpenShift Command Line Interface (CLI)              2022-09-
20T08:00:20Z
```

```
$ oc get route -n openshift-serverless
```

Example output

```
NAME   HOST/PORT                               PATH   SERVICES                  PORT
TERMINATION     WILDCARD
kn     kn-openshift-serverless.apps.example.com        knative-openshift-metrics-3   http-cli
edge/Redirect   None
```

3.3.2. Installing the Knative CLI for Linux by using an RPM package manager

For Red Hat Enterprise Linux (RHEL), you can install the Knative (**kn**) CLI as an RPM by using a package manager, such as **yum** or **dnf**. This allows the Knative CLI version to be automatically managed by the system. For example, using a command like **dnf upgrade** upgrades all packages, including **kn**, if a new version is available.

Prerequisites

- You have an active OpenShift Container Platform subscription on your Red Hat account.

Procedure

1. Register with Red Hat Subscription Manager:

```
# subscription-manager register
```

2. Pull the latest subscription data:

```
# subscription-manager refresh
```

3. Attach the subscription to the registered system:

```
# subscription-manager attach --pool=<pool_id> 1
```

1 Pool ID for an active OpenShift Container Platform subscription

4. Enable the repositories required by the Knative (**kn**) CLI:
    - Linux (x86_64, amd64)

      ```
      # subscription-manager repos --enable="openshift-serverless-1-for-rhel-8-x86_64-rpms"
      ```

    - Linux on IBM Z and LinuxONE (s390x)

      ```
      # subscription-manager repos --enable="openshift-serverless-1-for-rhel-8-s390x-rpms"
      ```

    - Linux on IBM Power (ppc64le)

      ```
      # subscription-manager repos --enable="openshift-serverless-1-for-rhel-8-ppc64le-rpms"
      ```

5. Install the Knative (**kn**) CLI as an RPM by using a package manager:

   Example yum command

   ```
   # yum install openshift-serverless-clients
   ```

3.3.3. Installing the Knative CLI for Linux

If you are using a Linux distribution that does not have RPM or another package manager installed, you can install the Knative (**kn**) CLI as a binary file. To do this, you must download and unpack a **tar.gz** archive and add the binary to a directory on your **PATH**.

Prerequisites

- If you are not using RHEL or Fedora, ensure that **libc** is installed in a directory on your library path.

  IMPORTANT

  If **libc** is not available, you might see the following error when you run CLI commands:

  ```
  $ kn: No such file or directory
  ```

Procedure

1. Download the relevant Knative (**kn**) CLI **tar.gz** archive:
    - Linux (x86_64, amd64)
    - Linux on IBM Z and LinuxONE (s390x)
    - Linux on IBM Power (ppc64le)

   You can also download any version of **kn** by navigating to that version's corresponding directory in the Serverless client download mirror .

2. Unpack the archive:

```
$ tar -xf <filename>
```

3. Move the **kn** binary to a directory on your **PATH**.

4. To check your **PATH**, run:

```
$ echo $PATH
```

3.3.4. Installing the Knative CLI for macOS

If you are using macOS, you can install the Knative (**kn**) CLI as a binary file. To do this, you must download and unpack a **tar.gz** archive and add the binary to a directory on your **PATH**.

Procedure

1. Download the Knative (**kn**) CLI **tar.gz** archive.
   You can also download any version of **kn** by navigating to that version's corresponding directory in the Serverless client download mirror .

2. Unpack and extract 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
```

3.3.5. Installing the Knative CLI for Windows

If you are using Windows, you can install the Knative (**kn**) CLI as a binary file. To do this, you must download and unpack a ZIP archive and add the binary to a directory on your **PATH**.

Procedure

1. Download the Knative (**kn**) CLI ZIP archive.
   You can also download any version of **kn** by navigating to that version's corresponding directory in the Serverless client download mirror .

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
```

3.4. INSTALLING KNATIVE SERVING

Installing Knative Serving allows you to create Knative services and functions on your cluster. It also allows you to use additional functionality such as autoscaling and networking options for your applications.

After you install the OpenShift Serverless Operator, you can install Knative Serving by using the default settings, or configure more advanced settings in the **KnativeServing** custom resource (CR). For more information about configuration options for the **KnativeServing** CR, see Global configuration.

IMPORTANT

If you want to use Red Hat OpenShift distributed tracing with OpenShift Serverless , you must install and configure Red Hat OpenShift distributed tracing before you install Knative Serving.

3.4.1. Installing Knative Serving by using the web console

After you install the OpenShift Serverless Operator, install Knative Serving by using the OpenShift Container Platform web console. You can install Knative Serving by using the default settings or configure more advanced settings in the **KnativeServing** custom resource (CR).

Prerequisites

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

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

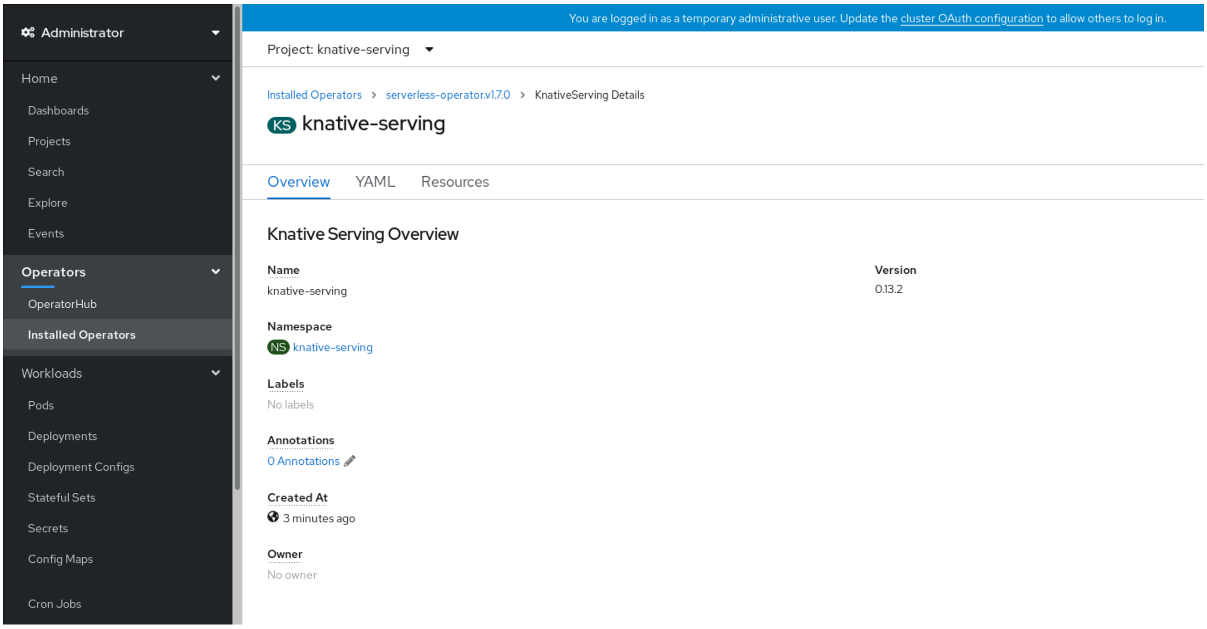
   For more information about configuration options for the KnativeServing custom resource definition, see the documentation on *Advanced installation configuration options*.

6. After you have installed Knative Serving, the **KnativeServing** object is created, and you are automatically 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.



You are logged in as a temporary administrative user. Update the cluster OAuth configuration to allow others to log in.

Knative Serving Overview

Name
knative-serving

Version
0.13.2

Namespace
NS knative-serving

Labels
No labels

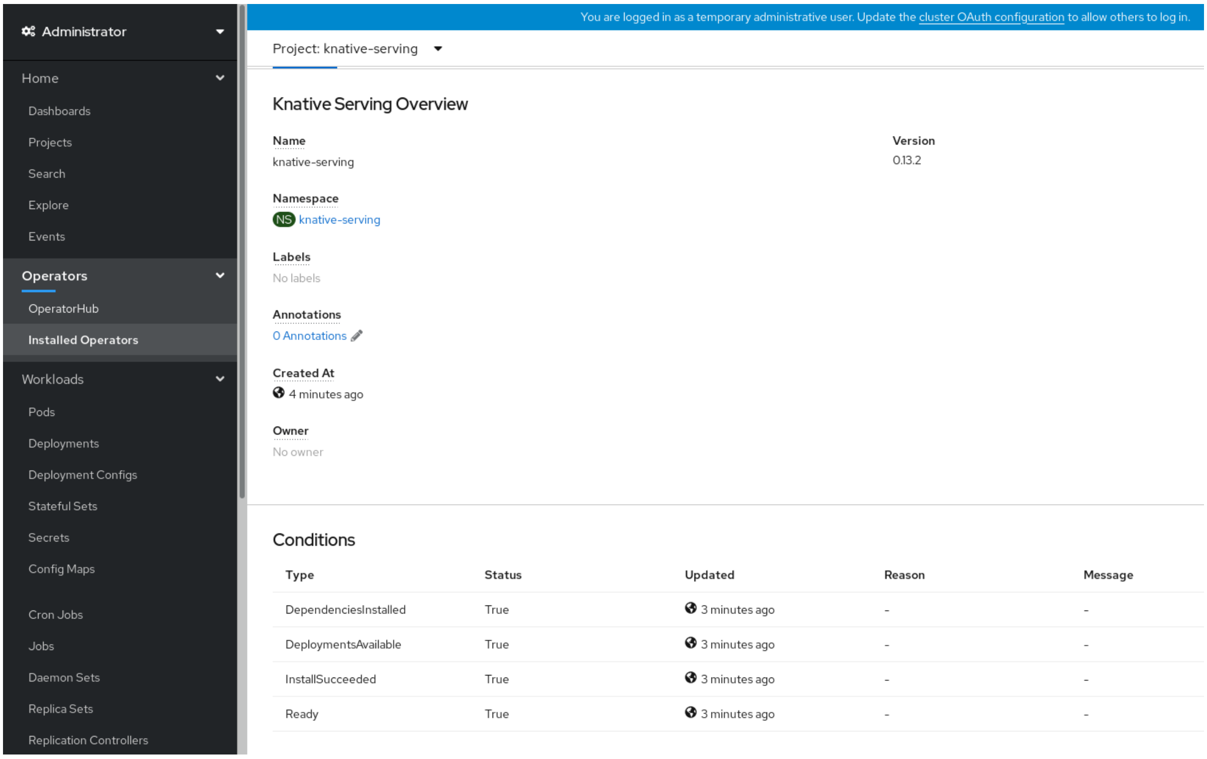
Annotations
0 Annotations

Created At
3 minutes ago

Owner
No owner

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.



You are logged in as a temporary administrative user. Update the cluster OAuth configuration to allow others to log in.

Knative Serving Overview

Name
knative-serving

Version
0.13.2

Namespace
NS knative-serving

Labels
No labels

Annotations
0 Annotations

Created At
4 minutes ago

Owner
No owner

Conditions

Type	Status	Updated	Reason	Message
DependenciesInstalled	True	3 minutes ago	-	-
DeploymentsAvailable	True	3 minutes ago	-	-
InstallSucceeded	True	3 minutes ago	-	-
Ready	True	3 minutes ago	-	-

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.

3.4.2. Installing Knative Serving by using YAML

After you install the OpenShift Serverless Operator, you can install Knative Serving by using the default settings, or configure more advanced settings in the **KnativeServing** custom resource (CR). You can use the following procedure to install Knative Serving by using YAML files and the **oc** CLI.

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- You have installed the OpenShift Serverless Operator.
- Install the OpenShift CLI (**oc**).

Procedure

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

```
apiVersion: operator.knative.dev/v1beta1
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
```

3.4.3. Next steps

- If you want to use Knative event-driven architecture you can install Knative Eventing.

3.5. INSTALLING KNATIVE EVENTING

To use event-driven architecture on your cluster, install Knative Eventing. You can create Knative components such as event sources, brokers, and channels and then use them to send events to applications or external systems.

After you install the OpenShift Serverless Operator, you can install Knative Eventing by using the default settings, or configure more advanced settings in the **KnativeEventing** custom resource (CR). For more information about configuration options for the **KnativeEventing** CR, see Global configuration.

IMPORTANT

If you want to use Red Hat OpenShift distributed tracing with OpenShift Serverless , you must install and configure Red Hat OpenShift distributed tracing before you install Knative Eventing.

3.5.1. Installing Knative Eventing by using the web console

After you install the OpenShift Serverless Operator, install Knative Eventing by using the OpenShift Container Platform web console. You can install Knative Eventing by using the default settings or configure more advanced settings in the **KnativeEventing** custom resource (CR).

Prerequisites

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

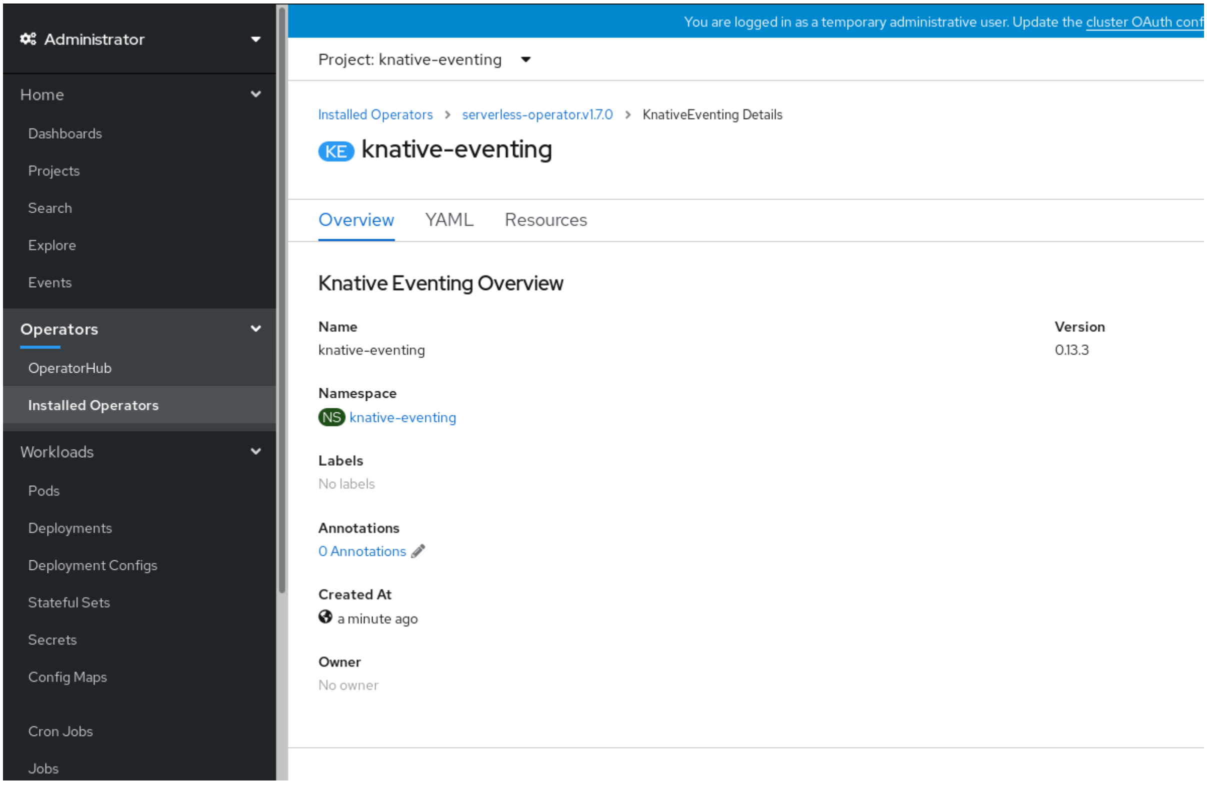
Procedure

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 automatically 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.



You are logged in as a temporary administrative user. Update the cluster OAuth conf

Knative Eventing Overview

Name
knative-eventing

Version
0.13.3

Namespace
NS knative-eventing

Labels
No labels

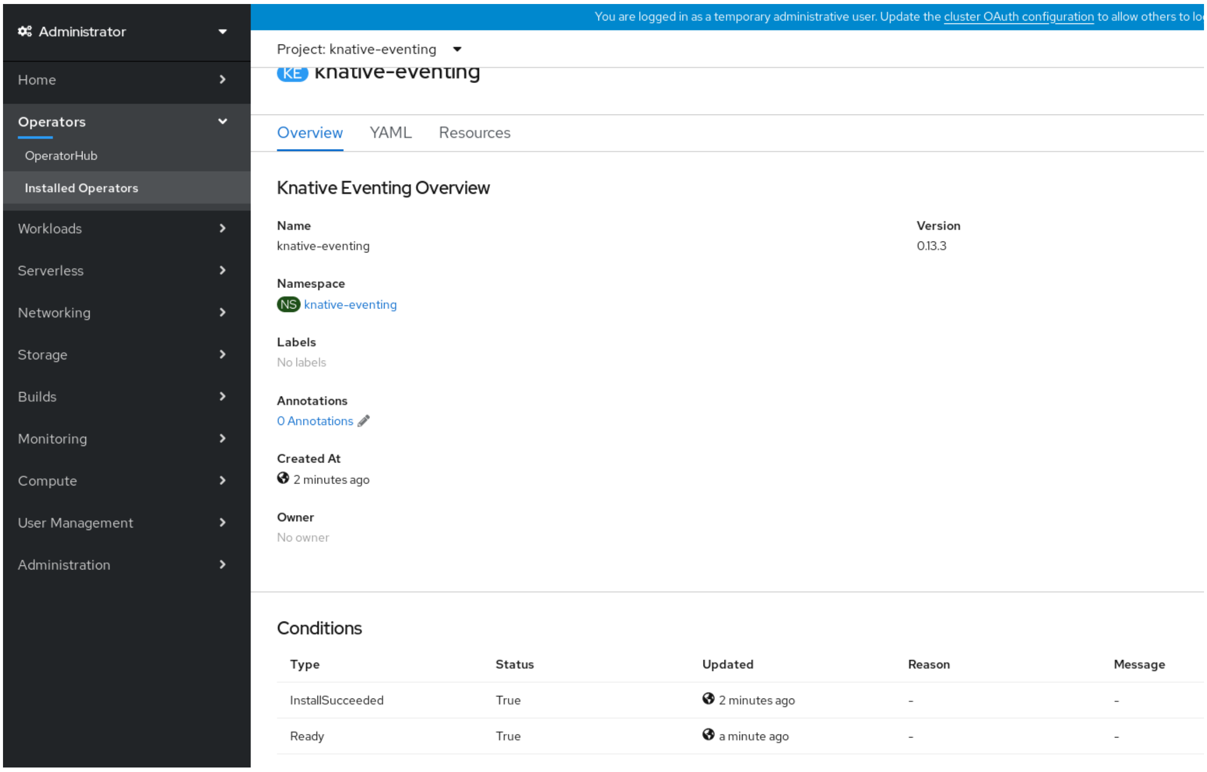
Annotations
0 Annotations

Created At
a minute ago

Owner
No owner

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.



You are logged in as a temporary administrative user. Update the cluster OAuth configuration to allow others to lo

Knative Eventing Overview

Name
knative-eventing

Version
0.13.3

Namespace
NS knative-eventing

Labels
No labels

Annotations
0 Annotations

Created At
2 minutes ago

Owner
No owner

Conditions

Type	Status	Updated	Reason	Message
InstallSucceeded	True	2 minutes ago	-	-
Ready	True	a minute ago	-	-

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.

3.5.2. Installing Knative Eventing by using YAML

After you install the OpenShift Serverless Operator, you can install Knative Eventing by using the default settings, or configure more advanced settings in the **KnativeEventing** custom resource (CR). You can use the following procedure to install Knative Eventing by using YAML files and the **oc** CLI.

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- You have installed the OpenShift Serverless Operator.
- Install the OpenShift CLI (**oc**).

Procedure

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

```
apiVersion: operator.knative.dev/v1beta1
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
```

3.5.3. Installing Knative Kafka

Knative Kafka provides integration options for you to use supported versions of the Apache Kafka message streaming platform with OpenShift Serverless. Knative Kafka functionality is available in an OpenShift Serverless installation if you have installed the **KnativeKafka** custom resource.

Prerequisites

- You have installed the OpenShift Serverless Operator and Knative Eventing on your cluster.
- You have access to a Red Hat AMQ Streams cluster.
- Install the OpenShift CLI (**oc**) if you want to use the verification steps.
- 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, source, broker, or sink on your cluster, you must toggle the **enabled** switch for the options you want to use to **true**. These switches are set to **false** by default. Additionally, to use the Kafka channel, broker, or sink you must specify the bootstrap servers.

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
  broker:
    enabled: true 4
    defaultConfig:
      bootstrapServers: <bootstrap_servers> 5
      numPartitions: <num_partitions> 6
      replicationFactor: <replication_factor> 7
  sink:
    enabled: true 8
```

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.

4 Enables developers to use the Knative Kafka broker implementation in the cluster.

5 A comma-separated list of bootstrap servers from your Red Hat AMQ Streams cluster.

6 Defines the number of partitions of the Kafka topics, backed by the **Broker** objects. The default is **10**.

7 Defines the replication factor of the Kafka topics, backed by the **Broker** objects. The default is **3**.

8 Enables developers to use a Kafka sink in the cluster.

NOTE

The **replicationFactor** value must be less than or equal to the number of nodes of your Red Hat AMQ Streams cluster.

a. Using the form is recommended for simpler configurations that do not require full control of **KnativeKafka** object creation.

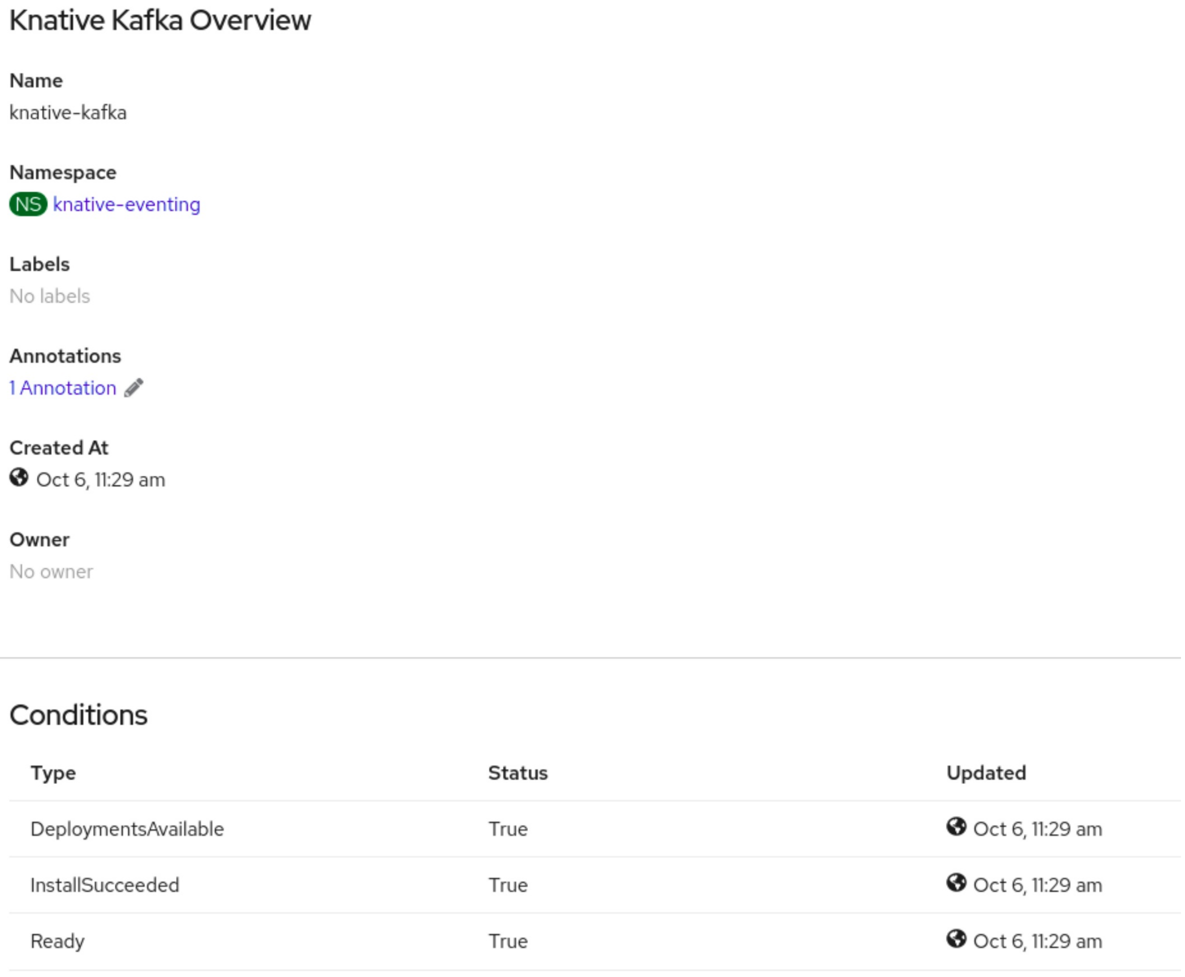
b. Editing the YAML is recommended for more complex configurations that require full control of **KnativeKafka** object creation. You can access the YAML by clicking the **Edit YAML** link in the top right of the **Create Knative Kafka** page.

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**.



Knative Kafka Overview

Name
knative-kafka

Namespace
NS knative-eventing

Labels
No labels

Annotations
1 Annotation

Created At
Oct 6, 11:29 am

Owner
No owner

Conditions

Type	Status	Updated
DeploymentsAvailable	True	Oct 6, 11:29 am
InstallSucceeded	True	Oct 6, 11:29 am
Ready	True	Oct 6, 11:29 am

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-broker-dispatcher-7769fbbcbb-xgffn     2/2     Running   0          44s
kafka-broker-receiver-5fb56f7656-fhq8d       2/2     Running   0          44s
kafka-channel-dispatcher-84fd6cb7f9-k2tjv    2/2     Running   0          44s
kafka-channel-receiver-9b7f795d5-c76xr       2/2     Running   0          44s
kafka-controller-6f95659bf6-trd6r            2/2     Running   0          44s
kafka-source-dispatcher-6bf98bdfff-8bcsn     2/2     Running   0          44s
kafka-webhook-eventing-68dc95d54b-825xs      2/2     Running   0          44s
```

3.5.4. Next steps

- If you want to use Knative services you can install Knative Serving.

3.6. CONFIGURING KNATIVE KAFKA

Knative Kafka provides integration options for you to use supported versions of the Apache Kafka message streaming platform with OpenShift Serverless. Kafka provides options for event source, channel, broker, and event sink capabilities.

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).

> NOTE
>
> Knative Kafka is not currently supported for IBM Z and IBM Power.

The **KnativeKafka** CR provides users with additional options, such as:

- Kafka source
- Kafka channel
- Kafka broker
- Kafka sink

3.7. CONFIGURING OPENSHIFT SERVERLESS FUNCTIONS

To improve the process of deployment of your application code, you can use OpenShift Serverless to deploy stateless, event-driven functions as a Knative service on OpenShift Container Platform. If you want to develop functions, you must complete the set up steps.

3.7.1. Prerequisites

To enable the use of OpenShift Serverless Functions on your cluster, you must complete the following steps:

- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.

  > NOTE
  >
  > Functions are deployed as a Knative service. If you want to use event-driven architecture with your functions, you must also install Knative Eventing.

- You have the **oc** CLI installed.
- You have the Knative (**kn**) CLI installed. Installing the Knative 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 version 3.4.7 or higher.
- You have access to an available image registry, such as the OpenShift Container 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.

3.7.2. Setting up Podman

To use advanced container management features, you might want to use Podman with OpenShift Serverless Functions. To do so, you need to start the Podman service and configure the Knative (**kn**) CLI to connect to it.

Procedure

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 inside your function project directory with the **-v** flag to see verbose output. You should see a connection to your local UNIX socket:

   ```
   $ kn func build -v
   ```

3.7.3. Setting up Podman on macOS

To use advanced container management features, you might want to use Podman with OpenShift Serverless Functions. To do so on macOS, you need to start the Podman machine and configure the Knative (**kn**) CLI to connect to it.

Procedure

1. Create the Podman machine:

   ```
   $ podman machine init --memory=8192 --cpus=2 --disk-size=20
   ```

2. Start the Podman machine, which serves the Docker API on a UNIX socket:

   ```
   $ podman machine start
   Starting machine "podman-machine-default"
   Waiting for VM ...
   Mounting volume... /Users/myuser:/Users/user

   [...truncated output...]

   You can still connect Docker API clients by setting DOCKER_HOST using the
   ```

```
following command in your terminal session:

 export
DOCKER_HOST='unix:///Users/myuser/.local/share/containers/podman/machine/podman-
machine-default/podman.sock'

Machine "podman-machine-default" started successfully
```

> **NOTE**
>
> On most macOS systems, this socket is located at **/Users/myuser/.local/share/containers/podman/machine/podman-machine-default/podman.sock**.

3. Establish the environment variable that is used to build a function:

```
$ export
DOCKER_HOST='unix:///Users/myuser/.local/share/containers/podman/machine/podman-
machine-default/podman.sock'
```

4. Run the build command inside your function project directory with the **-v** flag to see verbose output. You should see a connection to your local UNIX socket:

```
$ kn func build -v
```

3.7.4. Next steps

- For more information about Docker Container Engine or Podman, see Container build tool options.
- See Getting started with functions.

3.8. SERVERLESS UPGRADES

OpenShift Serverless should be upgraded without skipping release versions. This section shows how to resolve problems with upgrading.

3.8.1. Resolving an OpenShift Serverless Operator upgrade failure

You might encounter an error when upgrading OpenShift Serverless Operator, for example, when performing manual uninstalls and reinstalls. If you encounter an error, you must manually reinstall OpenShift Serverless Operator.

Procedure

1. Identify the version of OpenShift Serverless Operator that was installed originally by searching in the OpenShift Serverless Release Notes.
For example, the error message during attempted upgrade might contain the following string:

```
The installed KnativeServing version is v1.5.0.
```

In this example, the KnativeServing **MAJOR.MINOR** version is **1.5**, which is covered in the release notes for OpenShift Serverless 1.26: *OpenShift Serverless now uses Knative Serving 1.5* .

2. Uninstall OpenShift Serverless Operator and all of its install plans.

3. Manually install the version of OpenShift Serverless Operator that you discovered in the first step. To install, first create a **serverless-subscription.yaml** file as shown in the following example:

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: serverless-operator
  namespace: openshift-serverless
spec:
  channel: stable
  name: serverless-operator
  source: redhat-operators
  sourceNamespace: openshift-marketplace
  installPlanApproval: Manual
  startingCSV: serverless-operator.v1.26.0
```

4. Then, install the subscription by running the following command:

```
$ oc apply -f serverless-subscription.yaml
```

5. Upgrade by manually approving the upgrade install plans as they appear.

Additional resources

- OpenShift Serverless Release Notes
- Deleting Operators from a cluster using the web console
- Installing the OpenShift Serverless Operator from the web console

CHAPTER 4. SERVING

4.1. GETTING STARTED WITH KNATIVE SERVING

4.1.1. Serverless applications

Serverless applications are created and deployed as Kubernetes services, defined by a route and a configuration, and contained in a YAML file. To deploy a serverless application using OpenShift Serverless, you must create a Knative **Service** object.

Example Knative Service object YAML file

```
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.

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 Creating applications using the Developer perspective for more information.
- Create a Knative service by using the Knative (**kn**) CLI.
- Create and apply a Knative **Service** object as a YAML file, by using the **oc** CLI.

4.1.1.1. Creating serverless applications by using the Knative CLI

Using the Knative (**kn**) CLI to create serverless applications provides a more streamlined and intuitive user interface over modifying YAML files directly. You can use the **kn service create** command to create a basic serverless application.

Prerequisites

- OpenShift Serverless Operator and Knative Serving are installed on your cluster.

- You have installed the Knative (**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 Knative service:

  ```
  $ kn service create <service-name> --image <image> --tag <tag-value>
  ```

  Where:

  - **--image** is the URI of the image for the application.
  - **--tag** is an optional flag that can be used to add a tag to the initial revision that is created with the service.

    #### 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
    ```

4.1.1.2. Creating serverless applications using YAML

Creating Knative resources by using YAML files uses a declarative API, which enables you to describe applications declaratively and in a reproducible manner. To create a serverless application by using YAML, you must create a YAML file that defines a Knative **Service** object, then apply it by using **oc apply**.

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.

Prerequisites

- OpenShift Serverless Operator and Knative Serving 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.

- Install the OpenShift CLI (**oc**).

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>
```

If you do not want to switch to the **Developer** perspective in the OpenShift Container Platform web console or use the Knative (**kn**) CLI or YAML files, you can create Knative components by using the **Administator** perspective of the OpenShift Container Platform web console.

4.1.1.3. Creating serverless applications using the Administrator perspective

Serverless applications are created and deployed as Kubernetes services, defined by a route and a configuration, and contained in a YAML file. To deploy a serverless application using OpenShift Serverless, you must create a Knative **Service** object.

Example Knative Service object YAML file

```
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.

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.

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**.

4.1.1.4. Creating a service using offline mode

You can execute **kn service** commands in offline mode, so that no changes happen on the cluster, and instead the service descriptor file is created on your local machine. After the descriptor file is created, you can modify the file before propagating changes to the cluster.

> **IMPORTANT**
>
> The offline mode of the Knative 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 Technology Preview Features Support Scope .

Prerequisites

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

4.1.1.5. Additional resources

- Knative Serving CLI commands
- Configuring JSON Web Token authentication for Knative services

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

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

Prerequisites

- OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have installed the **oc** CLI.
- You have created a Knative service.

Prerequisites

- Install the OpenShift CLI (**oc**).

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!
   ```

4.2. AUTOSCALING

4.2.1. 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 configured for applications on the cluster. Replicas can also be scaled up to meet demand if traffic to the application increases.

Autoscaling settings for Knative services can be global settings that are configured by cluster administrators, or per-revision settings that are configured for individual services.

You can modify per-revision settings for your services by using the OpenShift Container Platform web console, by modifying the YAML file for your service, or by using the Knative (**kn**) CLI.

NOTE

Any limits or targets that you set for a service 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.

4.2.2. 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.

4.2.2.1. Minimum scale bounds

The minimum number of replicas that can serve an application is determined by the **min-scale** annotation. If scale to zero is not enabled, the **min-scale** value defaults to **1**.

The **min-scale** value defaults to **0** replicas if the following conditions are met:

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

Example service spec with min-scale annotation

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

4.2.2.1.1. Setting the min-scale annotation by using the Knative CLI

Using the Knative (**kn**) CLI to set the **min-scale** annotation provides a more streamlined and intuitive user interface over modifying YAML files directly. You can use the **kn service** command with the **--scale-min** flag to create or modify the **min-scale** value for a service.

Prerequisites

- Knative Serving is installed on the cluster.

- You have installed the Knative (**kn**) CLI.

Procedure

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

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

  Example command

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

4.2.2.2. Maximum scale bounds

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

Example service spec with max-scale annotation

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

4.2.2.2.1. Setting the max-scale annotation by using the Knative CLI

Using the Knative (**kn**) CLI to set the **max-scale** annotation provides a more streamlined and intuitive user interface over modifying YAML files directly. You can use the **kn service** command with the **--scale-max** flag to create or modify the **max-scale** value for a service.

Prerequisites

- Knative Serving is installed on the cluster.
- You have installed the Knative (**kn**) CLI.

Procedure

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

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

  Example command

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

4.2.3. Concurrency

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

4.2.3.1. Configuring a soft concurrency target

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. 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
  ```

4.2.3.2. Configuring a hard concurrency limit

A hard concurrency 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. 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
  ```

4.2.3.3. 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** value is set to 10, and the **target-utilization-percentage** 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** value is reached.

Example service configured using the target-utilization-percentage annotation

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: example-service
  namespace: default
spec:
  template:
    metadata:
      annotations:
        autoscaling.knative.dev/target-utilization-percentage: "70"
...
```

4.2.4. Scale-to-zero

Knative Serving provides automatic scaling, or *autoscaling*, for applications to match incoming demand.

4.2.4.1. Enabling scale-to-zero

You can use the **enable-scale-to-zero** spec to enable or disable scale-to-zero globally for applications on 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** custom resource (CR):

  #### Example KnativeServing CR

  ```
  apiVersion: operator.knative.dev/v1beta1
  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"**.

4.2.4.2. Configuring the scale-to-zero grace period

Knative Serving provides automatic scaling down to zero pods for applications. You can use the **scale-to-zero-grace-period** spec to define an upper bound time limit that Knative waits for scale-to-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** custom resource (CR):

  Example KnativeServing CR

  ```
  apiVersion: operator.knative.dev/v1beta1
  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.

4.3. CONFIGURING SERVERLESS APPLICATIONS

4.3.1. Overriding Knative Serving system deployment configurations

You can override the default configurations for some specific deployments by modifying the **deployments** spec in the **KnativeServing** custom resources (CRs).

NOTE

You can only override probes that are defined in the deployment by default.

All Knative Serving deployments define a readiness and a liveness probe by default, with these exceptions:

- **net-kourier-controller** and **3scale-kourier-gateway** only define a readiness probe.
- **net-istio-controller** and **net-istio-webhook** define no probes.

4.3.1.1. Overriding system deployment configurations

Currently, overriding default configuration settings is supported for the **resources**, **replicas**, **labels**, **annotations**, and **nodeSelector** fields, as well as for the **readiness** and **liveness** fields for probes.

In the following example, a **KnativeServing** CR overrides the **webhook** deployment so that:

- The **readiness** probe timeout for **net-kourier-controller** is set to be 10 seconds.
- The deployment has specified CPU and memory resource limits.
- The deployment has 3 replicas.
- The **example-label: label** label is added.
- The **example-annotation: annotation** annotation 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/v1beta1
kind: KnativeServing
metadata:
  name: ks
  namespace: knative-serving
spec:
  high-availability:
    replicas: 2
  deployments:
  - name: net-kourier-controller
    readinessProbes: 1
      - container: controller
        timeoutSeconds: 10
  - name: webhook
    resources:
    - container: webhook
      requests:
```

```
    cpu: 300m
    memory: 60Mi
  limits:
    cpu: 1000m
    memory: 1000Mi
replicas: 3
labels:
  example-label: label
annotations:
  example-annotation: annotation
nodeSelector:
  disktype: hdd
```

1 You can use the **readiness** and **liveness** probe overrides to override all fields of a probe in a container of a deployment as specified in the Kubernetes API except for the fields related to the probe handler: **exec**, **grpc**, **httpGet**, and **tcpSocket**.

Additional resources

- Probe configuration section of the Kubernetes API documentation

4.3.2. Multi-container support for Serving

You can deploy a multi-container pod by using a single Knative service. This method is useful for separating application responsibilities into smaller, specialized parts.

IMPORTANT

Multi-container support for Serving 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 Technology Preview Features Support Scope .

4.3.2.1. Configuring a multi-container service

Multi-container support is enabled by default. You can create a multi-container pod by specifiying multiple containers in the service.

Procedure

1. Modify your service to include additional containers. Only one container can handle requests, so specify **ports** for exactly one container. Here is an example configuration with two containers:

   Multiple containers configuration

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

```
spec:
  template:
    spec:
      containers:
        - name: first-container ①
          image: gcr.io/knative-samples/helloworld-go
          ports:
            - containerPort: 8080 ②
        - name: second-container ③
          image: gcr.io/knative-samples/helloworld-java
```

① First container configuration.

② Port specification for the first container.

③ Second container configuration.

4.3.3. EmptyDir volumes

emptyDir volumes are empty volumes that are created when a pod is created, and are used to provide temporary working disk space. **emptyDir** volumes are deleted when the pod they were created for is deleted.

4.3.3.1. Configuring the EmptyDir extension

The **kubernetes.podspec-volumes-emptydir** extension controls whether **emptyDir** volumes can be used with Knative Serving. To enable using **emptyDir** volumes, you must modify the **KnativeServing** custom resource (CR) to include the following YAML:

Example KnativeServing CR

```
apiVersion: operator.knative.dev/v1beta1
kind: KnativeServing
metadata:
  name: knative-serving
spec:
  config:
    features:
      kubernetes.podspec-volumes-emptydir: enabled
...
```

4.3.4. Persistent Volume Claims for Serving

Some serverless applications need permanent data storage. To achieve this, you can configure persistent volume claims (PVCs) for your Knative services.

4.3.4.1. Enabling PVC support

Procedure

1. To enable Knative Serving to use PVCs and write to them, modify the **KnativeServing** custom resource (CR) to include the following YAML:

Enabling PVCs with write access

```
...
spec:
  config:
    features:
      "kubernetes.podspec-persistent-volume-claim": enabled
      "kubernetes.podspec-persistent-volume-write": enabled
...
```

- The **kubernetes.podspec-persistent-volume-claim** extension controls whether persistent volumes (PVs) can be used with Knative Serving.
- The **kubernetes.podspec-persistent-volume-write** extension controls whether PVs are available to Knative Serving with the write access.

2. To claim a PV, modify your service to include the PV configuration. For example, you might have a persistent volume claim with the following configuration:

NOTE

Use the storage class that supports the access mode that you are requesting. For example, you can use the **ocs-storagecluster-cephfs** class for the **ReadWriteMany** access mode.

PersistentVolumeClaim configuration

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: example-pv-claim
  namespace: my-ns
spec:
  accessModes:
    - ReadWriteMany
  storageClassName: ocs-storagecluster-cephfs
  resources:
    requests:
      storage: 1Gi
```

In this case, to claim a PV with write access, modify your service as follows:

Knative service PVC configuration

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  namespace: my-ns
...
spec:
 template:
   spec:
     containers:
         ...
```

```
      volumeMounts: 1
       - mountPath: /data
         name: mydata
         readOnly: false
    volumes:
     - name: mydata
      persistentVolumeClaim: 2
       claimName: example-pv-claim
       readOnly: false 3
```

1 Volume mount specification.

2 Persistent volume claim specification.

3 Flag that enables read-only access.

NOTE

To successfully use persistent storage in Knative services, you need additional configuration, such as the user permissions for the Knative container user.

4.3.4.2. Additional resources

- Understanding persistent storage

4.3.5. Init containers

Init containers are specialized containers that are run before application containers in a pod. They are generally used to implement initialization logic for an application, which may include running setup scripts or downloading required configurations. You can enable the use of init containers for Knative services by modifying the **KnativeServing** custom resource (CR).

NOTE

Init containers may cause longer application start-up times and should be used with caution for serverless applications, which are expected to scale up and down frequently.

4.3.5.1. Enabling init containers

Prerequisites

- You have installed OpenShift Serverless Operator and Knative Serving on your cluster.
- You have cluster administrator permissions.

Procedure

- Enable the use of init containers by adding the **kubernetes.podspec-init-containers** flag to the **KnativeServing** CR:

  Example KnativeServing CR

```
apiVersion: operator.knative.dev/v1beta1
kind: KnativeServing
metadata:
  name: knative-serving
spec:
  config:
    features:
      kubernetes.podspec-init-containers: enabled
...
```

4.3.6. Resolving image tags to digests

If the Knative Serving controller has access to the container registry, Knative Serving resolves image tags to a digest when you create a revision of a service. This is known as *tag-to-digest resolution*, and helps to provide consistency for deployments.

4.3.6.1. Tag-to-digest resolution

To give the controller access to the container registry on OpenShift Container Platform, you must create a secret and then configure controller custom certificates. You can configure controller custom certificates by modifying the **controller-custom-certs** spec in the **KnativeServing** custom resource (CR). The secret must reside in the same namespace as the **KnativeServing** CR.

If a secret is not included in the **KnativeServing** CR, this setting defaults to using public key infrastructure (PKI). When using PKI, the cluster-wide certificates are automatically injected into the Knative Serving controller by using the **config-service-sa** config map. The OpenShift Serverless Operator populates the **config-service-sa** config map with cluster-wide certificates and mounts the config map as a volume to the controller.

4.3.6.1.1. Configuring tag-to-digest resolution by using a secret

If the **controller-custom-certs** spec uses the **Secret** type, the secret is mounted as a secret volume. Knative components consume the secret directly, assuming that the secret has the required certificates.

Prerequisites

- You have cluster administrator permissions on OpenShift Container Platform.
- You have installed the OpenShift Serverless Operator and Knative Serving on your cluster.

Procedure

1. Create a secret:

   Example command

   ```
   $ oc -n knative-serving create secret generic custom-secret --from-file=<secret_name>.crt=
   <path_to_certificate>
   ```

2. Configure the **controller-custom-certs** spec in the **KnativeServing** custom resource (CR) to use the **Secret** type:

   Example KnativeServing CR

```
apiVersion: operator.knative.dev/v1beta1
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
spec:
  controller-custom-certs:
    name: custom-secret
    type: Secret
```

4.3.7. Configuring TLS authentication

You can use *Transport Layer Security* (TLS) to encrypt Knative traffic and for authentication.

TLS is the only supported method of traffic encryption for Knative Kafka. Red Hat recommends using both SASL and TLS together for Knative Kafka resources.

NOTE

If you want to enable internal TLS with a Red Hat OpenShift Service Mesh integration, you must enable Service Mesh with mTLS instead of the internal encryption explained in the following procedure. See the documentation for Enabling Knative Serving metrics when using Service Mesh with mTLS.

4.3.7.1. Enabling TLS authentication for internal traffic

OpenShift Serverless supports TLS edge termination by default, so that HTTPS traffic from end users is encrypted. However, internal traffic behind the OpenShift route is forwarded to applications by using plain data. By enabling TLS for internal traffic, the traffic sent between components is encrypted, which makes this traffic more secure.

NOTE

If you want to enable internal TLS with a Red Hat OpenShift Service Mesh integration, you must enable Service Mesh with mTLS instead of the internal encryption explained in the following procedure.

IMPORTANT

Internal TLS encryption support 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 Technology Preview Features Support Scope .

Prerequisites

- You have installed the OpenShift Serverless Operator and Knative Serving.

- You have installed the OpenShift (**oc**) CLI.

Procedure

1. Create a Knative service that includes the **internal-encryption: "true"** field in the spec:

```
...
spec:
  config:
    network:
      internal-encryption: "true"
...
```

2. Restart the activator pods in the **knative-serving** namespace to load the certificates:

```
$ oc delete pod -n knative-serving --selector app=activator
```

Additional resources

- Configuring TLS authentication for Kafka brokers
- Configuring TLS authentication for Kafka channels
- Enabling Knative Serving metrics when using Service Mesh with mTLS

4.3.8. Restrictive network policies

4.3.8.1. Clusters 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: []
```

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

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. JSON Web Token authentication for Knative services requires Service Mesh.

Prerequisites

- Install the OpenShift CLI (**oc**).
- OpenShift Serverless Operator and Knative Serving are installed on your cluster.

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:
   ```

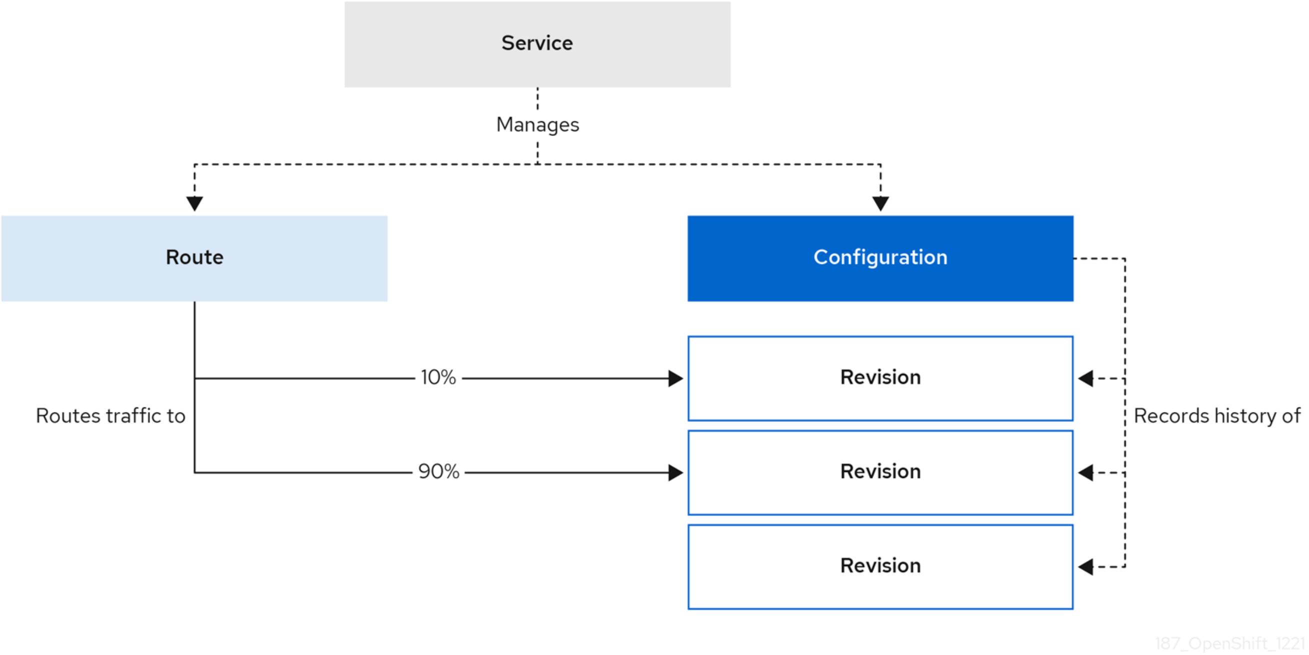
```
        knative.openshift.io/system-namespace: "true"
  podSelector: {}
  policyTypes:
  - Ingress
```

1. Provide a name for your network policy.
2. The namespace where your application exists.

4.4. TRAFFIC SPLITTING

4.4.1. Traffic splitting overview

In a Knative application, traffic can be managed by creating a traffic split. A traffic split is configured as part of a route, which is managed by a Knative service.



Configuring a route allows requests to be sent to different revisions of a service. This routing is determined by the **traffic** spec of the **Service** object.

A **traffic** spec declaration consists of one or more revisions, each responsible for handling a portion of the overall traffic. The percentages of traffic routed to each revision must add up to 100%, which is ensured by a Knative validation.

The revisions specified in a **traffic** spec can either be a fixed, named revision, or can point to the “latest” revision, which tracks the head of the list of all revisions for the service. The "latest" revision is a type of floating reference that updates if a new revision is created. Each revision can have a tag attached that creates an additional access URL for that revision.

The **traffic** spec can be modified by:

- Editing the YAML of a **Service** object directly.
- Using the Knative (**kn**) CLI **--traffic** flag.

- Using the OpenShift Container Platform web console.

When you create a Knative service, it does not have any default **traffic** spec settings.

4.4.2. Traffic spec examples

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
```

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
```

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**. 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-1
    percent: 50
  - tag: candidate
    revisionName: example-service-2
    percent: 50
  - tag: latest
    latestRevision: true
    percent: 0
```

4.4.3. Traffic splitting using the Knative CLI

Using the Knative (**kn**) CLI to create traffic splits provides a more streamlined and intuitive user interface over modifying YAML files directly. You can use the **kn service update** command to split traffic between revisions of a service.

4.4.3.1. Creating a traffic split by using the Knative CLI

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have installed the Knative (**kn**) CLI.
- You have created a Knative service.

Procedure

- Specify the revision of your service and what percentage of traffic you want to route to it by using the **--traffic** tag with a standard **kn service update** command:

  Example command

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

  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.
  - **<percentage>** is the percentage of traffic that you want to send to the specified revision.

- Optional: The **--traffic** flag can be specified multiple times in one command. For example, if you have a revision tagged as **@latest** and a revision named **stable**, you can specify the percentage of traffic that you want to split to each revision as follows:

  Example command

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

If you have multiple revisions and do not specify the percentage of traffic that should be split to the last revision, the **--traffic** flag can calculate this automatically. For example, if you have a third revision named **example**, and you use the following command:

Example command

```
$ kn service update example-service --traffic @latest=10,stable=60
```

The remaining 30% of traffic is split to the **example** revision, even though it was not specified.

4.4.4. CLI flags for traffic splitting

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

4.4.4.1. Knative CLI traffic splitting flags

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
--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

4.4.4.1.1. 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.

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

4.4.4.1.2. 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.

4.4.4.1.2.1. 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
```

4.4.4.1.2.2. 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
```

4.4.5. Splitting traffic between revisions

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.

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

Prerequisites

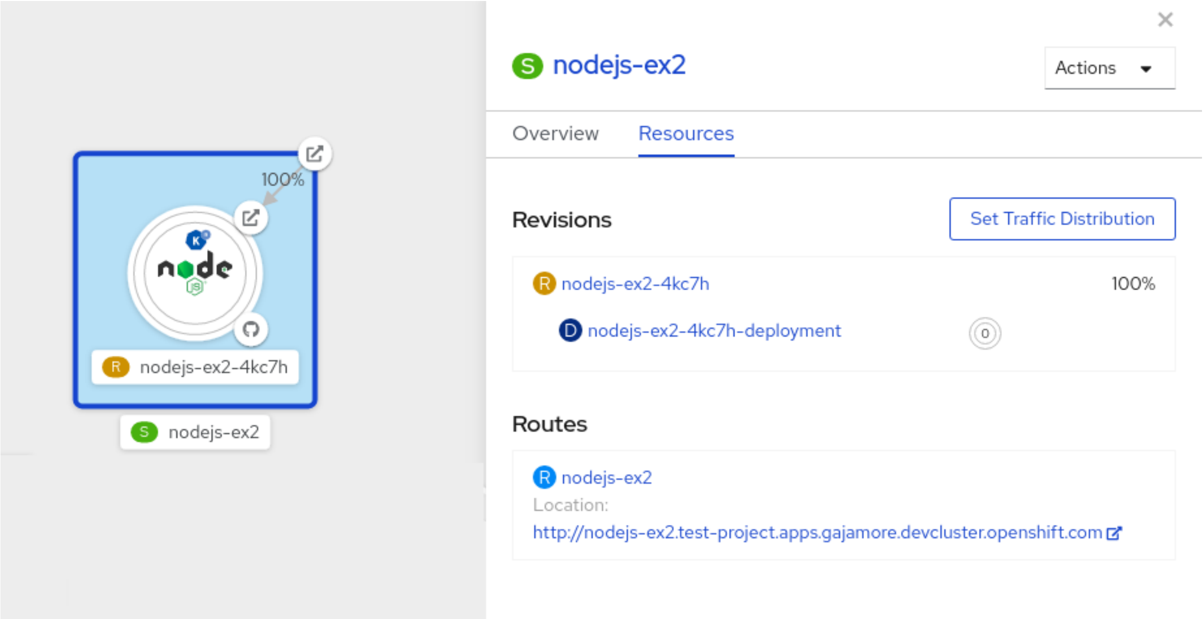
- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have logged in to the OpenShift Container Platform web console.

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.

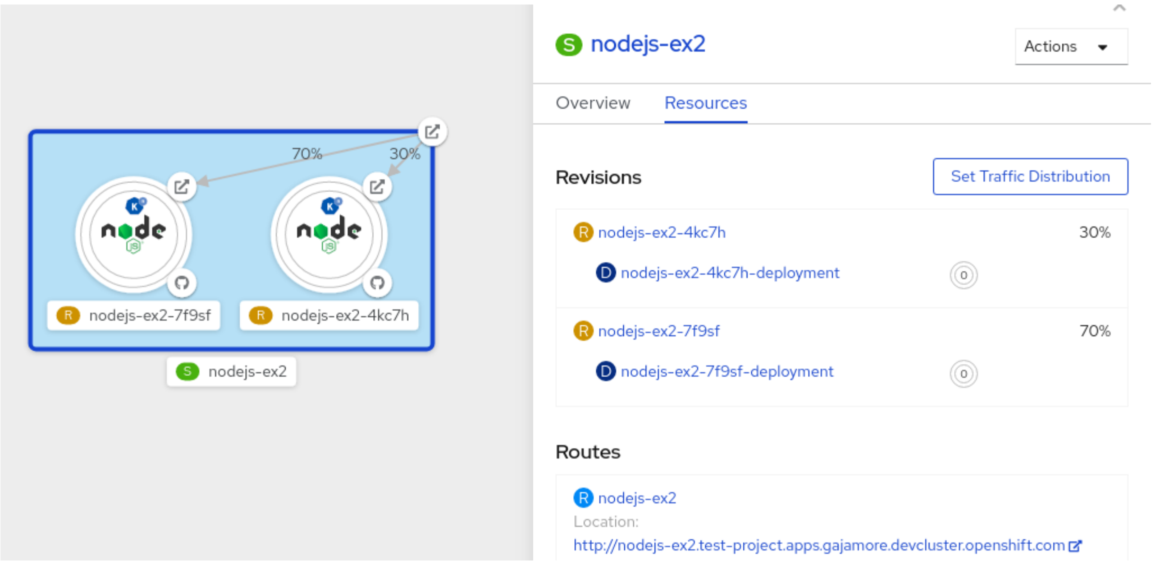
   Figure 4.1. Serverless application

   Location:
   http://nodejs-ex2.test-project.apps.gajamore.devcluster.openshift.com

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 4.2. Serverless application revisions



4.4.6. Rerouting traffic using blue-green strategy

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

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

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- Install the OpenShift CLI (**oc**).

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 Knative (**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.

4.5. EXTERNAL AND INGRESS ROUTING

4.5.1. Routing overview

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.

4.5.1.1. Additional resources

- Route-specific annotations

4.5.2. Customizing labels and annotations

OpenShift Container Platform routes support the use of custom labels and annotations, which you can configure by modifying the **metadata** spec of a Knative service. Custom labels and annotations are propagated from the service to the Knative route, then to the Knative ingress, and finally to the OpenShift Container Platform route.

4.5.2.1. Customizing labels and annotations for OpenShift Container Platform routes

Prerequisites

- You must have the OpenShift Serverless Operator and Knative Serving installed on your OpenShift Container Platform cluster.
- Install the OpenShift CLI (**oc**).

Procedure

1. Create a Knative service that contains the label or annotation that you want to propagate to the OpenShift Container Platform route:

   - To create a service by using YAML:

     Example service created by using YAML

     ```
     apiVersion: serving.knative.dev/v1
     kind: Service
     metadata:
       name: <service_name>
       labels:
         <label_name>: <label_value>
       annotations:
         <annotation_name>: <annotation_value>
     ...
     ```

   - To create a service by using the Knative (**kn**) CLI, enter:

     Example service created by using a kn command

     ```
     $ kn service create <service_name> \
       --image=<image> \
       --annotation <annotation_name>=<annotation_value> \
       --label <label_value>=<label_value>
     ```

2. Verify that the OpenShift Container Platform route has been created with the annotation or label that you added by inspecting the output from the following command:

   Example command for verification

   ```
   $ oc get routes.route.openshift.io \
        -l serving.knative.openshift.io/ingressName=<service_name> \ ❶
        -l serving.knative.openshift.io/ingressNamespace=<service_namespace> \ ❷
        -n knative-serving-ingress -o yaml \
            | grep -e "<label_name>: \"<label_value>\""  -e "<annotation_name>:
   <annotation_value>" ❸
   ```

1. Use the name of your service.
2. Use the namespace where your service was created.
3. Use your values for the label and annotation names and values.

4.5.3. Configuring 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.

4.5.3.1. Configuring OpenShift Container Platform routes for Knative services

Prerequisites

- The OpenShift Serverless Operator and Knative Serving component must be installed on your OpenShift Container Platform cluster.
- Install the OpenShift CLI (**oc**).

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>
```

4.5.4. Global HTTPS redirection

HTTPS redirection provides redirection for incoming HTTP requests. These redirected HTTP requests are encrypted. You can enable HTTPS redirection for all services on the cluster by configuring the **httpProtocol** spec for the **KnativeServing** custom resource (CR).

4.5.4.1. HTTPS redirection global settings

Example KnativeServing CR that enables HTTPS redirection

```
apiVersion: operator.knative.dev/v1beta1
kind: KnativeServing
metadata:
  name: knative-serving
spec:
  config:
    network:
      httpProtocol: "redirected"
...
```

4.5.5. URL scheme for external routes

The URL scheme of external routes defaults to HTTPS for enhanced security. This scheme is determined by the **default-external-scheme** key in the **KnativeServing** custom resource (CR) spec.

4.5.5.1. Setting the URL scheme for external routes

Default spec

```
...
spec:
  config:
    network:
      default-external-scheme: "https"
...
```

You can override the default spec to use HTTP by modifying the **default-external-scheme** key:

HTTP override spec

```
...
spec:
  config:
    network:
      default-external-scheme: "http"
...
```

4.5.6. HTTPS redirection per service

You can enable or disable HTTPS redirection for a service by configuring the **networking.knative.dev/http-option** annotation.

4.5.6.1. Redirecting HTTPS for a service

The following example shows how you can use this annotation in a Knative **Service** YAML object:

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

4.5.7. Cluster local availability

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.

4.5.7.1. Setting cluster availability to cluster local

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have created a Knative service.

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
  ```

4.5.7.2. Enabling TLS authentication for cluster local services

For cluster local services, the Kourier local gateway **kourier-internal** is used. If you want to use TLS traffic against the Kourier local gateway, you must configure your own server certificates in the local gateway.

Prerequisites

- You have installed the OpenShift Serverless Operator and Knative Serving.
- You have administrator permissions.
- You have installed the OpenShift (**oc**) CLI.

Procedure

1. Deploy server certificates in the **knative-serving-ingress** namespace:

```
$ export san="knative"
```

NOTE

Subject Alternative Name (SAN) validation is required so that these certificates can serve the request to **<app_name>.<namespace>.svc.cluster.local**.

2. Generate a root key and certificate:

```
$ openssl req -x509 -sha256 -nodes -days 365 -newkey rsa:2048 \
    -subj '/O=Example/CN=Example' \
    -keyout ca.key \
    -out ca.crt
```

3. Generate a server key that uses SAN validation:

```
$ openssl req -out tls.csr -newkey rsa:2048 -nodes -keyout tls.key \
  -subj "/CN=Example/O=Example" \
  -addext "subjectAltName = DNS:$san"
```

4. Create server certificates:

```
$ openssl x509 -req -extfile <(printf "subjectAltName=DNS:$san") \
  -days 365 -in tls.csr \
  -CA ca.crt -CAkey ca.key -CAcreateserial -out tls.crt
```

5. Configure a secret for the Kourier local gateway:

   a. Deploy a secret in **knative-serving-ingress** namespace from the certificates created by the previous steps:

```
$ oc create -n knative-serving-ingress secret tls server-certs \
    --key=tls.key \
    --cert=tls.crt --dry-run=client -o yaml | oc apply -f -
```

   b. Update the **KnativeServing** custom resource (CR) spec to use the secret that was created by the Kourier gateway:

Example KnativeServing CR

```
...
spec:
  config:
    kourier:
      cluster-cert-secret: server-certs
...
```

The Kourier controller sets the certificate without restarting the service, so that you do not need to restart the pod.

You can access the Kourier internal service with TLS through port **443** by mounting and using the **ca.crt** from the client.

4.5.8. Kourier Gateway service type

The Kourier Gateway is exposed by default as the **ClusterIP** service type. This service type is determined by the **service-type** ingress spec in the **KnativeServing** custom resource (CR).

Default spec

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

4.5.8.1. Setting the Kourier Gateway service type

You can override the default service type to use a load balancer service type instead by modifying the **service-type** spec:

LoadBalancer override spec

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

4.5.9. 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.

4.5.9.1. Interacting with a serverless application using HTTP2 and gRPC

IMPORTANT

This method applies to OpenShift Container Platform 4.10 and later. For older versions, see the following section.

Prerequisites

- Install OpenShift Serverless Operator and Knative Serving on your cluster.
- Install the OpenShift CLI (**oc**).
- Create a Knative service.
- Upgrade OpenShift Container Platform 4.10 or later.

- Enable HTTP/2 on OpenShift Ingress controller.

Procedure

1. Add the **serverless.openshift.io/default-enable-http2=true** annotation to the **KnativeServing** Custom Resource:

   ```
   $ oc annotate knativeserving <your_knative_CR> -n knative-serving
   serverless.openshift.io/default-enable-http2=true
   ```

2. After the annotation is added, you can verify that the **appProtocol** value of the Kourier service is **h2c**:

   ```
   $ oc get svc -n knative-serving-ingress kourier -o jsonpath="{.spec.ports[0].appProtocol}"
   ```

   #### Example output

   ```
   h2c
   ```

3. Now you can use the gRPC framework over the HTTP/2 protocol for external traffic, for example:

   ```
   import "google.golang.org/grpc"

   grpc.Dial(
     YOUR_URL, ①
     grpc.WithTransportCredentials(insecure.NewCredentials())), ②
   )
   ```

   ① Your **ksvc** URL.

   ② Your certificate.

Additional resources

- Enabling HTTP/2 Ingress connectivity

4.5.9.2. Interacting with a serverless application using HTTP2 and gRPC in OpenShift Container Platform 4.9 and older

IMPORTANT

This method needs to expose Kourier Gateway using the **LoadBalancer** service type. You can configure this by adding the following YAML to your **KnativeServing** custom resource definition (CRD):

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

Prerequisites

- Install OpenShift Serverless Operator and Knative Serving on your cluster.
- Install the OpenShift CLI (**oc**).
- Create a Knative service.

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 direct gRPC request against the ingress gateway:

```
import "google.golang.org/grpc"

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.

4.6. CONFIGURING ACCESS TO KNATIVE SERVICES

4.6.1. Configuring JSON Web Token authentication for Knative services

OpenShift Serverless does not currently have user-defined authorization features. To add user-defined authorization to your deployment, you must integrate OpenShift Serverless with Red Hat OpenShift Service Mesh, and then configure JSON Web Token (JWT) authentication and sidecar injection for Knative services.

4.6.2. Using JSON Web Token authentication with Service Mesh 2.x

You can use JSON Web Token (JWT) authentication with Knative services by using Service Mesh 2.x and OpenShift Serverless. To do this, you must create authentication requests and policies in the application namespace that is a member of the **ServiceMeshMemberRoll** object. You must also enable sidecar injection for the service.

4.6.2.1. Configuring JSON Web Token authentication for Service Mesh 2.x and OpenShift Serverless

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* .

Prerequisites

- You have installed the OpenShift Serverless Operator, Knative Serving, and Red Hat OpenShift Service Mesh on your cluster.

- Install the OpenShift CLI (**oc**).

- 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. Add the **sidecar.istio.io/inject="true"** annotation to your service:

   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, because OpenShift Serverless versions 1.14.0 and higher use an HTTP probe as the readiness probe for Knative services by default.

2. Apply the **Service** resource:

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

3. 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
   ```

4. Apply the **RequestAuthentication** resource:

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

5. 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.

6. Apply the **AuthorizationPolicy** resource:

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

7. 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"]
```

8. 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!
```

4.6.3. Using JSON Web Token authentication with Service Mesh 1.x

You can use JSON Web Token (JWT) authentication with Knative services by using Service Mesh 1.x and OpenShift Serverless. To do this, you must create a policy in the application namespace that is a member of the **ServiceMeshMemberRoll** object. You must also enable sidecar injection for the service.

4.6.3.1. Configuring JSON Web Token authentication for Service Mesh 1.x and OpenShift Serverless

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* .

Prerequisites

- You have installed the OpenShift Serverless Operator, Knative Serving, and Red Hat OpenShift Service Mesh on your cluster.
- Install the OpenShift CLI (**oc**).
- 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. Add the **sidecar.istio.io/inject="true"** annotation to your service:

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, because OpenShift Serverless versions 1.14.0 and higher use an HTTP probe as the readiness probe for Knative services by default.

2. Apply the **Service** resource:

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

3. 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.

4. 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!
   ```

4.7. CONFIGURING CUSTOM DOMAINS FOR KNATIVE SERVICES

4.7.1. 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.

You can do this 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.

4.7.2. Custom domain mapping

You can customize the domain for your Knative service by mapping a custom domain name that you own to a Knative service. 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.

4.7.2.1. Creating a custom domain mapping

You can customize the domain for your Knative service by mapping a custom domain name that you own to a Knative service. 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.
- Install the OpenShift CLI (**oc**).
- 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. 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>
```

4.7.3. Custom domains for Knative services using the Knative CLI

You can customize the domain for your Knative service by mapping a custom domain name that you own to a Knative service. You can use the Knative (**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.

4.7.3.1. Creating a custom domain mapping by using the Knative CLI

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 Knative (**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

- 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
```

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.

- 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
```

4.7.4. Domain mapping using the Developer perspective

You can customize the domain for your Knative service by mapping a custom domain name that you own to a Knative service. You can use the **Developer** perspective of the OpenShift Container Platform web console to map a **DomainMapping** custom resource (CR) to a Knative service.

4.7.4.1. Mapping a custom domain to a service by using the Developer perspective

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 in the **Domain mapping** list.
    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**.

4.7.5. Domain mapping using the Administrator perspective

If you do not want to switch to the **Developer** perspective in the OpenShift Container Platform web console or use the Knative (**kn**) CLI or YAML files, you can use the **Administator** perspective of the OpenShift Container Platform web console.

4.7.5.1. Mapping a custom domain to a service by using the Administrator perspective

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.

You can do this 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.

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!
  ```

4.7.6. Securing a mapped service using a TLS certificate

4.7.6.1. Securing a service with a custom domain by using a TLS certificate

After you have configured a custom domain for a Knative service, you can use a TLS certificate to secure the mapped service. To do this, you must create a Kubernetes TLS secret, and then update the **DomainMapping** CR to use the TLS secret that you have created.

> NOTE
>
> If you use **net-istio** for Ingress and enable mTLS via SMCP using **security.dataPlane.mtls: true**, Service Mesh deploys **DestinationRules** for the ***.local** host, which does not allow **DomainMapping** for OpenShift Serverless.
>
> To work around this issue, enable mTLS by deploying **PeerAuthentication** instead of using **security.dataPlane.mtls: true**.

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.
- Install the OpenShift CLI (**oc**).

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. Add the **networking.internal.knative.dev/certificate-uid: <id>`** label to the Kubernetes TLS secret:

```
$ oc label secret <tls_secret_name> networking.internal.knative.dev/certificate-uid="<id>"
```

If you are using a third-party secret provider such as cert-manager, you can configure your secret manager to label the Kubernetes TLS secret automatically. Cert-manager users can use the secret template offered to automatically generate secrets with the correct label. In this case, secret filtering is done based on the key only, but this value can carry useful information such as the certificate ID that the secret contains.

> NOTE
>
> The {cert-manager-operator} is a Technology Preview feature. For more information, see the **Installing the {cert-manager-operator}** documentation.

3. Update the **DomainMapping** CR to use the TLS secret that 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.

4.7.6.2. Improving net-kourier memory usage by using secret filtering

By default, the informers implementation for the Kubernetes **client-go** library fetches all resources of a particular type. This can lead to a substantial overhead when many resources are available, which can cause the Knative **net-kourier** ingress controller to fail on large clusters due to memory leaking. However, a filtering mechanism is available for the Knative **net-kourier** ingress controller, which enables the controller to only fetch Knative related secrets. You can enable this mechanism by setting an environment variable to the **KnativeServing** custom resource (CR).

IMPORTANT

If you enable secret filtering, all of your secrets need to be labeled with **networking.internal.knative.dev/certificate-uid: "<id>"**. Otherwise, Knative Serving does not detect them, which leads to failures. You must label both new and existing secrets.

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- A project that you created or that you have roles and permissions for to create applications and other workloads in OpenShift Container Platform.
- Install the OpenShift Serverless Operator and Knative Serving.
- Install the OpenShift CLI (**oc**).

Procedure

- Set the **ENABLE_SECRET_INFORMER_FILTERING_BY_CERT_UID** variable to **true** for **net-kourier-controller** in the **KnativeServing** CR:

  Example KnativeServing CR

  ```
  apiVersion: operator.knative.dev/v1beta1
  kind: KnativeServing
  metadata:
    name: knative-serving
    namespace: knative-serving
  spec:
    deployments:
    - env:
      - container: controller
        envVars:
        - name: ENABLE_SECRET_INFORMER_FILTERING_BY_CERT_UID
          value: 'true'
      name: net-kourier-controller
  ```

4.8. CONFIGURING HIGH AVAILABILITY FOR KNATIVE SERVICES

4.8.1. High availability for Knative services

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 readily available. This controller takes 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 called the leader.

4.8.2. High availability for Knative services

High availability (HA) is available by default for the Knative Serving **activator**, **autoscaler**, **autoscaler-hpa**, **controller**, **webhook**, **kourier-control**, and **kourier-gateway** components, which are configured to have two replicas each by default. You can change the number of replicas for these components by modifying the **spec.high-availability.replicas** value in the **KnativeServing** custom resource (CR).

4.8.2.1. Configuring high availability replicas for Knative Serving

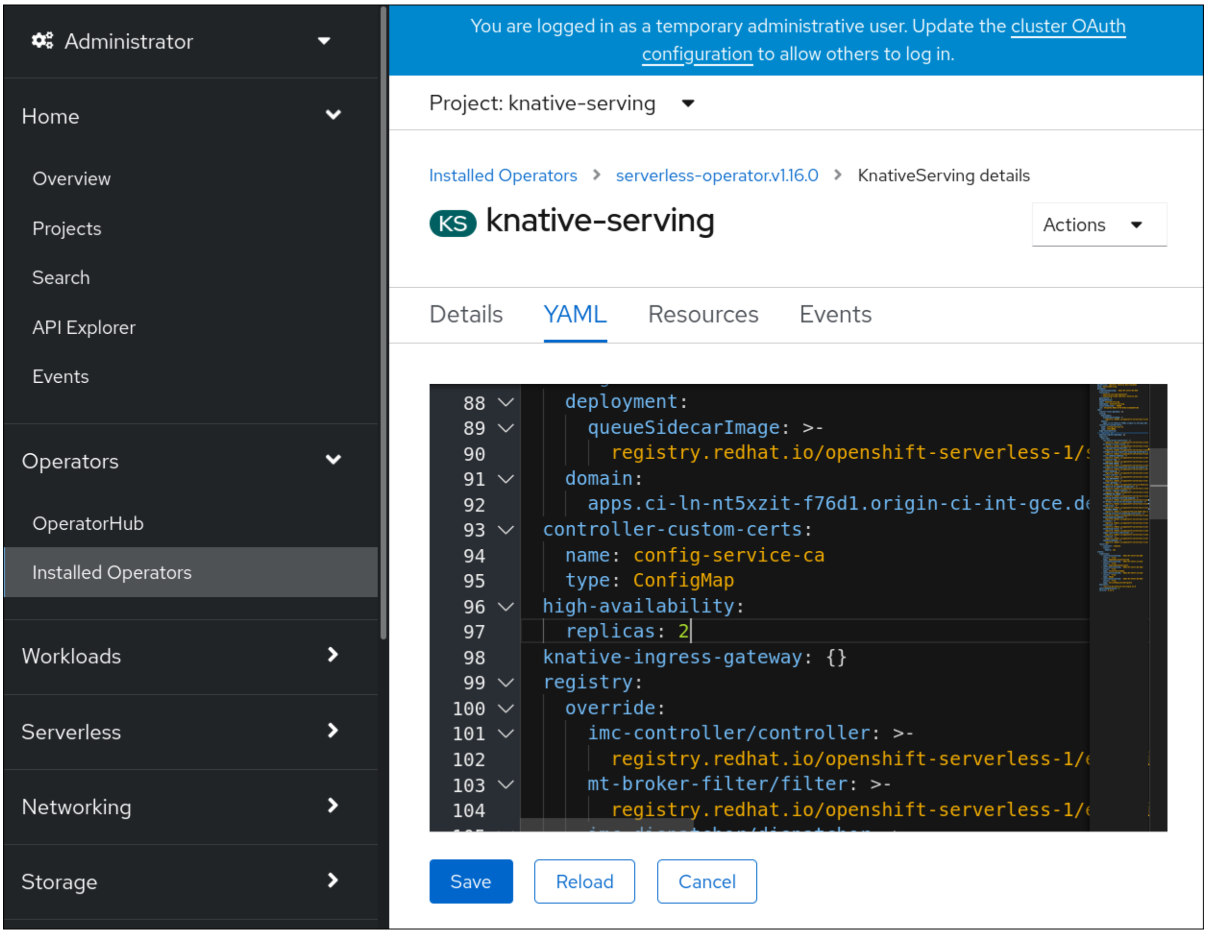
To specify three minimum replicas for the eligible deployment resources, set the value of the field **spec.high-availability.replicas** in the custom resource to **3**.

Prerequisites

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



```
    deployment:
      queueSidecarImage: >-
        registry.redhat.io/openshift-serverless-1/s
    domain:
      apps.ci-ln-nt5xzit-f76d1.origin-ci-int-gce.de
  controller-custom-certs:
    name: config-service-ca
    type: ConfigMap
  high-availability:
    replicas: 2
  knative-ingress-gateway: {}
  registry:
    override:
      imc-controller/controller: >-
        registry.redhat.io/openshift-serverless-1/e
      mt-broker-filter/filter: >-
        registry.redhat.io/openshift-serverless-1/e
```

5. Modify the number of replicas in the **KnativeServing** CR:

Example YAML

```
apiVersion: operator.knative.dev/v1beta1
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
spec:
  high-availability:
    replicas: 3
```

CHAPTER 5. EVENTING

5.1. 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.

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.

5.2. EVENT SOURCES

5.2.1. 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 Knative (**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.

5.2.2. Event source in the Administrator perspective

Sourcing events is critical to developing a distributed system that reacts to events.

5.2.2.1. Creating an event source by using the Administrator perspective

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*.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have logged in to the web console and are in the **Administrator** perspective.
- 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.

5.2.3. Creating an 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.

5.2.3.1. Creating an API server source by using the web console

After Knative Eventing is installed on your cluster, you can create an API server source by using the web console. Using the OpenShift Container Platform web console provides a streamlined and intuitive user interface to create an event source.

Prerequisites

- You have logged in to the OpenShift Container Platform web console.
- The OpenShift Serverless Operator and Knative Eventing are installed on the 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 installed the OpenShift CLI (**oc**).

PROCEDURE

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.

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

```
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>
```

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

4. 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.

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

6. 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**.

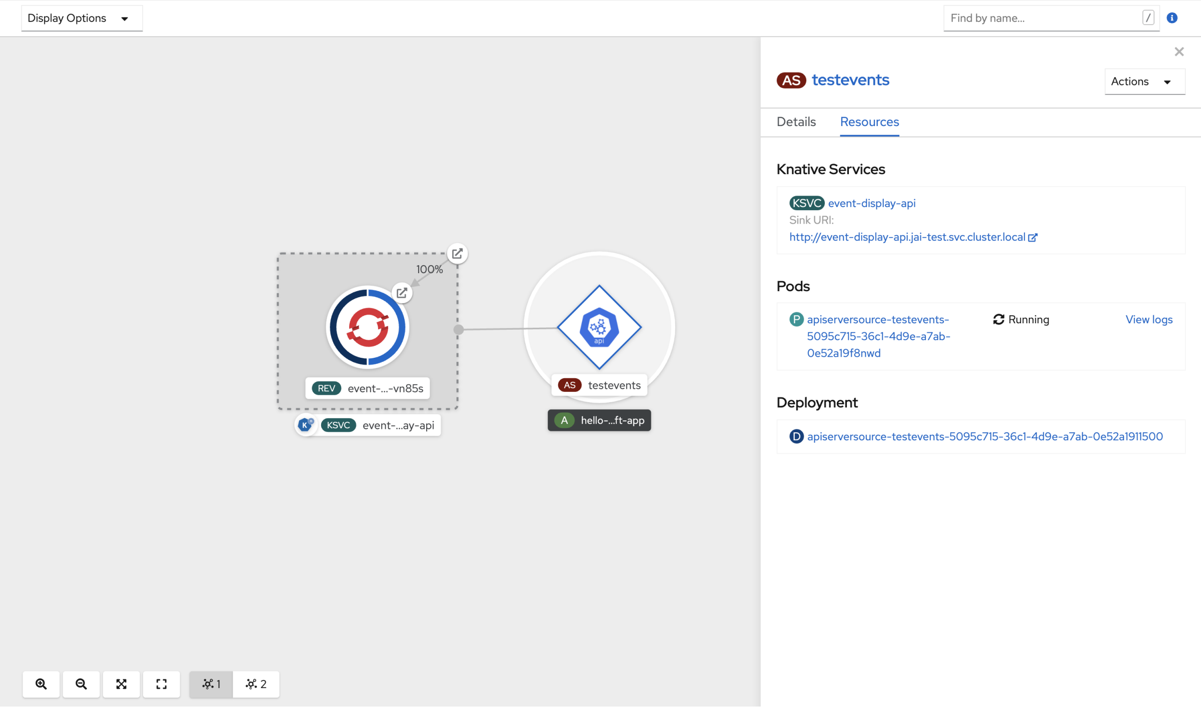
   b. Select the **Service Account Name** for the service account that you created.

   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**.

7. 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.



Knative Services

KSVC event-display-api
Sink URI:
http://event-display-api.jai-test.svc.cluster.local

Pods

P apiserversource-testevents-5095c715-36c1-4d9e-a7ab-0e52a19f8nwd Running View logs

Deployment

D apiserversource-testevents-5095c715-36c1-4d9e-a7ab-0e52a1911500

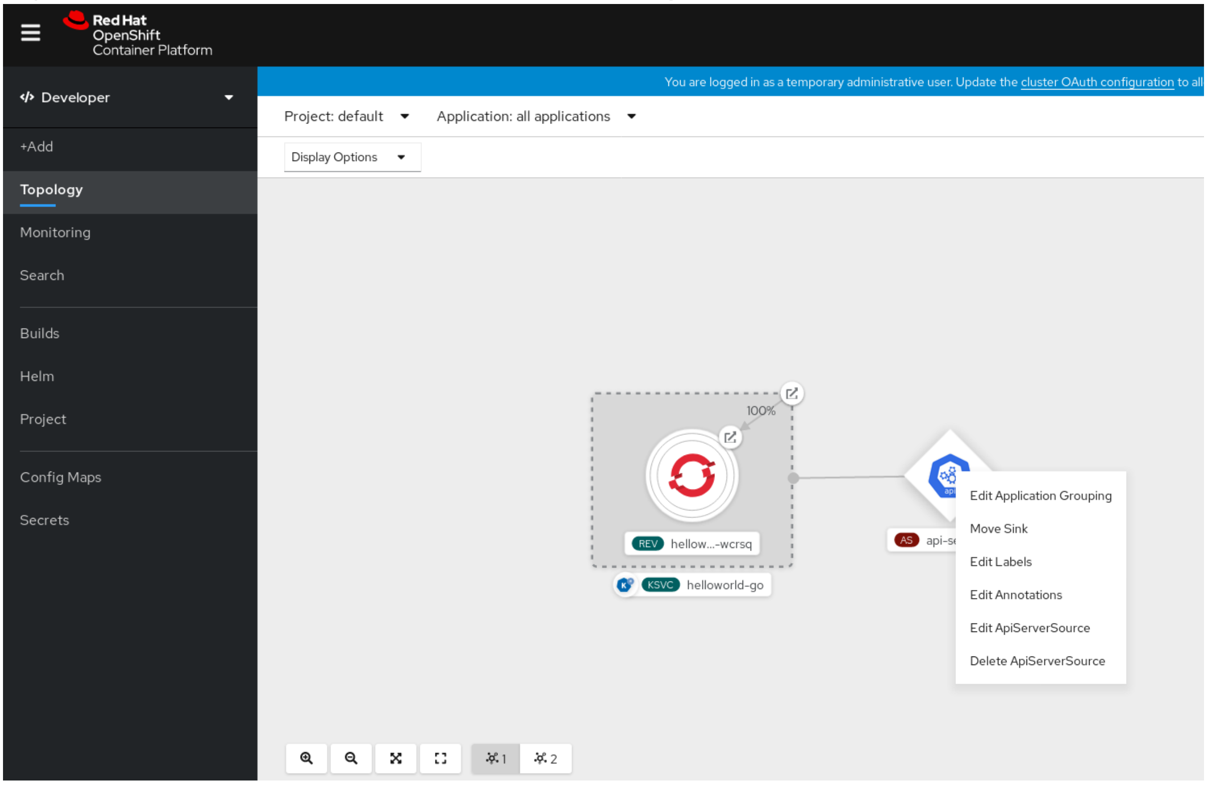
NOTE

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

Deleting the API server source

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

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



You are logged in as a temporary administrative user. Update the cluster OAuth configuration to all

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

You can use the **kn source apiserver create** command to create an API server source by using the **kn** CLI. Using the **kn** CLI to create an API server source provides a more streamlined and intuitive user interface than modifying YAML files directly.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on the 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 installed the OpenShift CLI (**oc**).
- You have installed the Knative (**kn**) CLI.

PROCEDURE

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.

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

```
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
```

①②③④ Change this namespace to the namespace that you have selected for installing the event source.

2. Apply the YAML file:

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

3. Create an API server source that has an event sink. In the following example, the sink is a broker:

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

4. 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
```

5. If you used a broker as an event sink, create a trigger to filter events from the **default** broker to the service:

–

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

6. 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
```

7. 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",
    ...
  }
```

Deleting the API server source

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
```

5.2.3.2.1. Knative CLI sink flag

When you create an event source 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 sink can be any addressable or callable resource that can receive incoming events from other resources.

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**.

5.2.3.3. Creating an API server source by using YAML files

Creating Knative resources by using YAML files uses a declarative API, which enables you to describe event sources declaratively and in a reproducible manner. To create an API server source by using YAML, you must create a YAML file that defines an **ApiServerSource** object, then apply it by using the **oc apply** command.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on the 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 created the **default** broker in the same namespace as the one defined in the API server source YAML file.
- Install the OpenShift CLI (**oc**).

PROCEDURE

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.

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

```
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>
```

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",
  ...
}
```

Deleting the API server source

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
```

5.2.4. Creating a ping source

A ping source is an event source that can be 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.

5.2.4.1. Creating a ping source by using the web console

After Knative Eventing is installed on your cluster, you can create a ping source by using the web console. Using the OpenShift Container Platform web console provides a streamlined and intuitive user interface to create an event source.

Prerequisites

- You have logged in to the OpenShift Container Platform web console.
- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on the 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. 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.

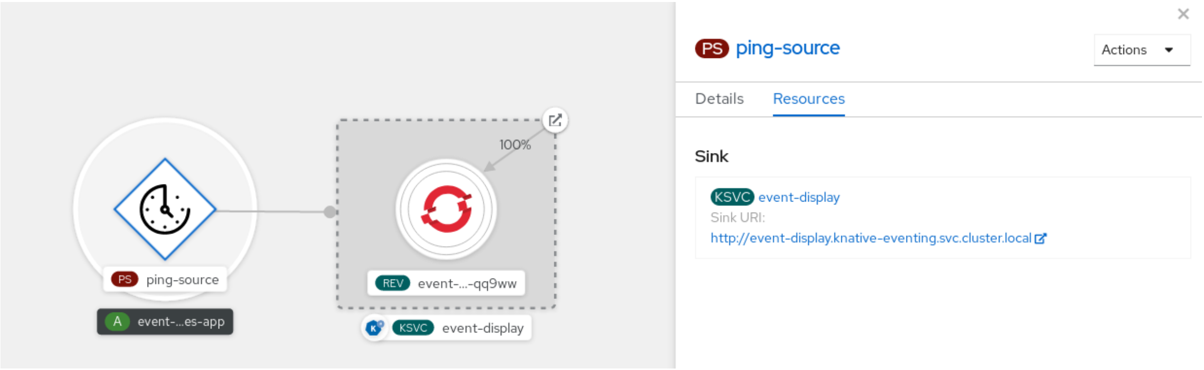
    g. Click **Create**.

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.



Deleting the ping source

1. Navigate to the **Topology** view.
2. Right-click the API server source and select **Delete Ping Source**.

5.2.4.2. Creating a ping source by using the Knative CLI

You can use the **kn source ping create** command to create a ping source by using the Knative (**kn**) CLI. Using the Knative CLI to create event sources provides a more streamlined and intuitive user interface than modifying YAML files directly.

Prerequisites

- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on the cluster.
- You have installed the Knative (**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.
- Optional: If you want to use the verification steps for this procedure, install the OpenShift CLI (**oc**).

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!"
  }
```

Deleting the ping source

- Delete the ping source:

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

5.2.4.2.1. Knative CLI sink flag

When you create an event source 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 sink can be any addressable or callable resource that can receive incoming events from other resources.

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**.

5.2.4.3. Creating a ping source by using YAML

Creating Knative resources by using YAML files uses a declarative API, which enables you to describe event sources declaratively and in a reproducible manner. To create a serverless ping source by using YAML, you must create a YAML file that defines a **PingSource** object, then apply it by using **oc apply**.

Example PingSource object

```
apiVersion: sources.knative.dev/v1
kind: PingSource
metadata:
  name: test-ping-source
spec:
  schedule: "*/2 * * * *" ①
  data: '{"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**.

Prerequisites

- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on the cluster.
- Install the OpenShift CLI (**oc**).
- 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 service's logs.

   a. Create a service YAML file:

```
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 -f <filename>
```

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. Create a YAML file for the ping source:

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

b. Create the ping source:

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

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

```
$ oc get pingsource.sources.knative.dev <ping_source_name> -oyaml
```

Example output

```
apiVersion: sources.knative.dev/v1
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/v1/namespaces/default/pingsources/test-ping-source
  uid: 3d80d50b-f8c7-4c1b-99f7-3ec00e0a8164
spec:
  data: '{ 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!"
  }
```

Deleting the ping source

- Delete the ping source:

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

  #### Example command

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

5.2.5. Kafka source

You can create a Kafka source that reads events from an Apache Kafka cluster and passes these events to a sink. You can create a Kafka source by using the OpenShift Container Platform web console, the Knative (**kn**) CLI, or by creating a **KafkaSource** object directly as a YAML file and using the OpenShift CLI (**oc**) to apply it.

5.2.5.1. Creating a Kafka event source by using the web console

After Knative Kafka is installed on your cluster, you can create a Kafka source by using the web console. Using the OpenShift Container Platform web console provides a streamlined and intuitive user interface to create a Kafka source.

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 have access to a Red Hat AMQ Streams (Kafka) cluster that produces the Kafka messages you want to import.
- 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.

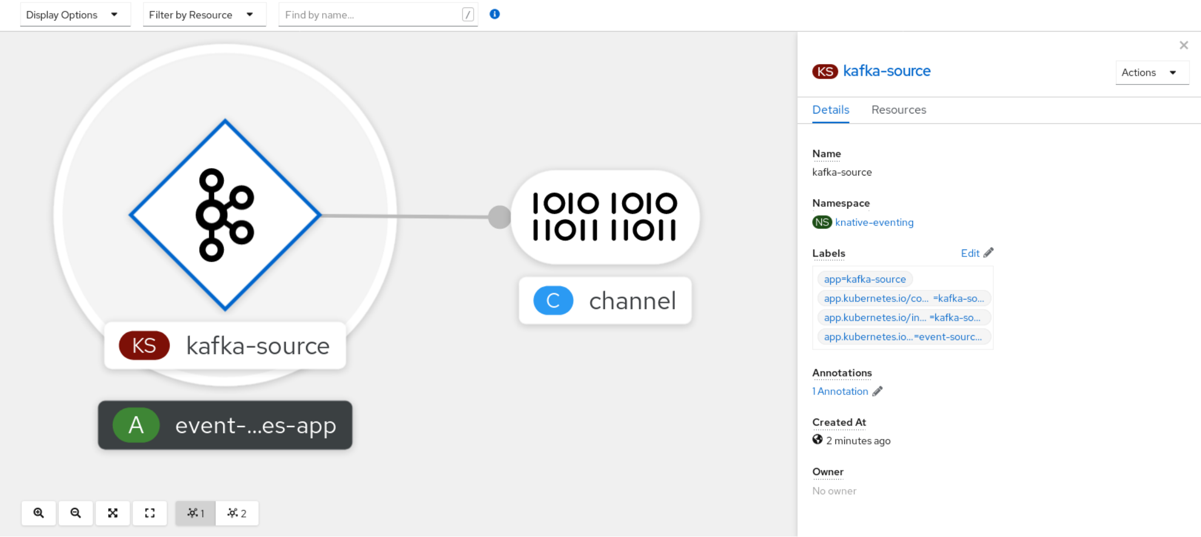
Procedure

1. In the **Developer** perspective, navigate to 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.



KS kafka-source

Name
kafka-source

Namespace
NS knative-eventing

Labels
app=kafka-source
app.kubernetes.io/co... =kafka-so...
app.kubernetes.io/in... =kafka-so...
app.kubernetes.io...=event-sourc...

Annotations
1 Annotation

Created At
2 minutes ago

Owner
No owner

5.2.5.2. Creating a Kafka event source by using the Knative CLI

You can use the **kn source kafka create** command to create a Kafka source by using the Knative (**kn**) CLI. Using the Knative CLI to create event sources provides a more streamlined and intuitive user interface than modifying YAML files directly.

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.
- You have installed the Knative (**kn**) CLI.
- Optional: You have installed the OpenShift CLI (**oc**) if you want to use the verification steps in this procedure.

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!
   ```

5.2.5.2.1. Knative CLI sink flag

When you create an event source 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 sink can be any addressable or callable resource that can receive incoming events from other resources.

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**.

5.2.5.3. Creating a Kafka event source by using YAML

Creating Knative resources by using YAML files uses a declarative API, which enables you to describe applications declaratively and in a reproducible manner. To create a Kafka source by using YAML, you must create a YAML file that defines a **KafkaSource** object, then apply it by using the **oc apply** command.

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.
- You have access to a Red Hat AMQ Streams (Kafka) cluster that produces the Kafka messages you want to import.
- Install the OpenShift CLI (**oc**).

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
```

5.2.5.4. Configuring SASL authentication for Kafka sources

Simple Authentication and Security Layer (SASL) is used by Apache Kafka for authentication. If you use SASL authentication on your cluster, users must provide credentials to Knative for communicating with the Kafka cluster; otherwise events cannot be produced or consumed.

Prerequisites

- You have cluster or dedicated administrator permissions on OpenShift Container Platform.
- The OpenShift Serverless Operator, Knative Eventing, and the **KnativeKafka** CR 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.
- You have a username and password for a Kafka cluster.
- You have chosen 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.
- You have installed the OpenShift (**oc**) CLI.

Procedure

1. Create the certificate files as secrets in your chosen namespace:

```
$ oc create secret -n <namespace> generic <kafka_auth_secret> \
  --from-file=ca.crt=caroot.pem \
  --from-literal=password="SecretPassword" \
  --from-literal=saslType="SCRAM-SHA-512" \ 1
  --from-literal=user="my-sasl-user"
```

1 The SASL type can be **PLAIN**, **SCRAM-SHA-256**, or **SCRAM-SHA-512**.

2. Create or modify your Kafka source so that it contains the following **spec** configuration:

```
apiVersion: sources.knative.dev/v1beta1
kind: KafkaSource
metadata:
  name: example-source
spec:
...
  net:
    sasl:
      enable: true
      user:
        secretKeyRef:
          name: <kafka_auth_secret>
          key: user
      password:
        secretKeyRef:
          name: <kafka_auth_secret>
          key: password
      type:
        secretKeyRef:
          name: <kafka_auth_secret>
          key: saslType
    tls:
      enable: true
      caCert: 1
        secretKeyRef:
          name: <kafka_auth_secret>
          key: ca.crt
...
```

1 The **caCert** spec is not required if you are using a public cloud Kafka service, such as Red Hat OpenShift Streams for Apache Kafka.

5.2.6. 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 creating a custom event source. You can create a custom event source 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.

5.2.6.1. 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.

NOTE

The **SinkBinding** object currently does not support custom revision names for services.

5.2.6.1.1. Creating a sink binding by using YAML

Creating Knative resources by using YAML files uses a declarative API, which enables you to describe event sources declaratively and in a reproducible manner. To create a sink binding by using YAML, you must create a YAML file that defines an **SinkBinding** object, then apply it by using the **oc apply** command.

Prerequisites

- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on the cluster.
- Install the OpenShift CLI (**oc**).
- 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 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. Create a service YAML file:

   Example service YAML file

```
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 -f <filename>
```

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

   a. Create a sink binding YAML file:

   Example service YAML file

```
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. Create the sink binding:

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

3. Create a **CronJob** object.

a. Create a cron job YAML file:

Example cron job YAML file

```
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. Create the cron job:

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

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": ""
}
```

5.2.6.1.2. Creating a sink binding by using the Knative CLI

You can use the **kn source binding create** command to create a sink binding by using the Knative (**kn**) CLI. Using the Knative CLI to create event sources provides a more streamlined and intuitive user interface than modifying YAML files directly.

Prerequisites

- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on the 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.
- Install the Knative (**kn**) CLI.
- Install the OpenShift CLI (**oc**).

> 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** object.

   a. Create a cron job YAML file:

Example cron job YAML file

```
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. Create the cron job:

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

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": ""
  }
```

5.2.6.1.2.1. Knative CLI sink flag

When you create an event source 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 sink can be any addressable or callable resource that can receive incoming events from other resources.

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**.

5.2.6.1.3. Creating a sink binding by using the web console

After Knative Eventing is installed on your cluster, you can create a sink binding by using the web console. Using the OpenShift Container Platform web console provides a streamlined and intuitive user interface to create an event source.

Prerequisites

- You have logged in to the OpenShift Container Platform web console.
- The OpenShift Serverless Operator, Knative Serving, 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

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**.

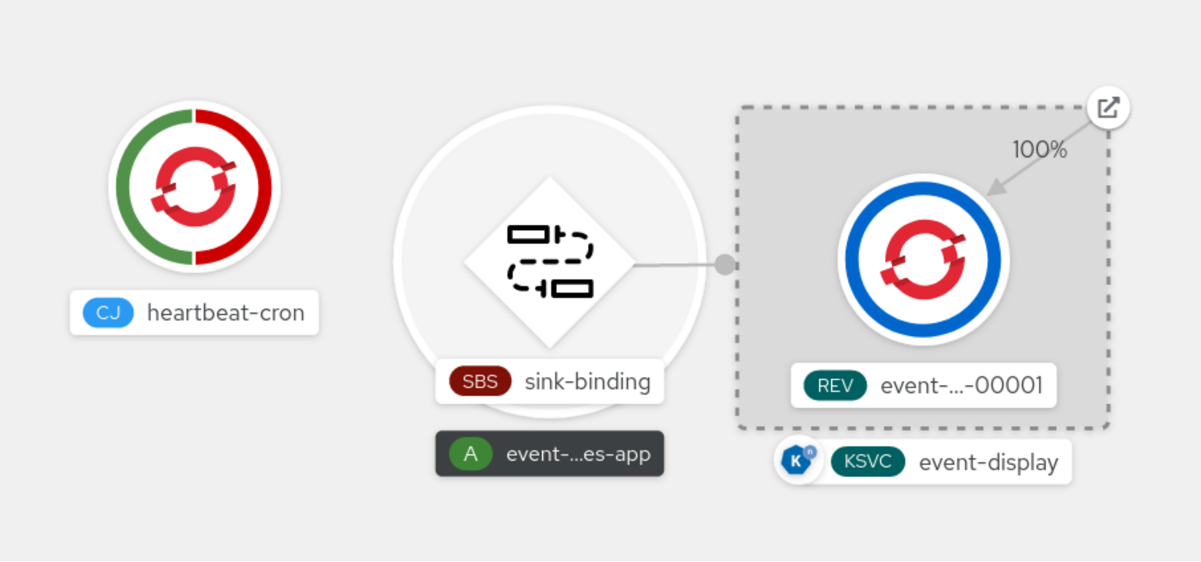
h. Click **Create**.

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.

5.2.6.1.4. Sink binding reference

You can use a **PodSpecable** object as an event source by creating a sink binding. You can configure multiple parameters when creating a **SinkBinding** object.

SinkBinding objects support the following parameters:

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

Field	Description	Required or optional
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

5.2.6.1.4.1. Subject parameter

The **Subject** parameter references the resources for which the runtime contract is augmented by binding implementations. You can configure multiple fields for a **Subject** definition.

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**.
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**.

Field	Description	Required or optional
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**.

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
 ...
```

5.2.6.1.4.2. CloudEvent overrides

A **ceOverrides** definition provides overrides that control the CloudEvent's output format and modifications sent to the sink. You can configure multiple fields for the **ceOverrides** definition.

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: 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" } }
```

5.2.6.1.4.3. The include label

To use a sink binding, you need to do assign the **bindings.knative.dev/include: "true"** label to either the resource or the namespace that the resource is included in. 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
```

5.2.6.2. 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.

5.2.6.2.1. 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. Events are sent to the sink URI specified in the **K_SINK** environment variable. The message must be sent as a **POST** using the **CloudEvent** HTTP format.

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
...
```

5.2.6.2.2. Creating and managing container sources by using the Knative CLI

You can use the **kn source container** commands to create and manage container sources by using the Knative (**kn**) CLI. Using the Knative CLI to create event sources provides a more streamlined and intuitive user interface than modifying YAML files directly.

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>
```

5.2.6.2.3. Creating a container source by using the web console

After Knative Eventing is installed on your cluster, you can create a container source by using the web console. Using the OpenShift Container Platform web console provides a streamlined and intuitive user interface to create an event source.

Prerequisites

- You have logged in to the OpenShift Container Platform web console.
- The OpenShift Serverless Operator, Knative Serving, 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

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**.

5.2.6.2.4. Container source reference

You can use a container as an event source, by creating a **ContainerSource** object. You can configure multiple parameters when creating a **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

Field	Description	Required or optional
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

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"
  ...
```

5.2.6.2.4.1. CloudEvent overrides

A **ceOverrides** definition provides overrides that control the CloudEvent's output format and modifications sent to the sink. You can configure multiple fields for the **ceOverrides** definition.

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" } }
```

5.2.7. Connecting an event source to a sink using the Developer perspective

When you create an event source by using the OpenShift Container Platform web console, you can specify a sink that events are sent to from that source. The sink can be any addressable or callable resource that can receive incoming events from other resources.

5.2.7.1. Connect an event source to a sink using the 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 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.
- You have created a sink, such as a Knative service, channel or broker.

Procedure

1. Create an event source of any type, by navigating to **+Add → Event Source** and selecting the event source type that you want to create.
2. In the **Sink** section of the **Create Event Source** form view, select your sink in the **Resource** list.
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 the connected sink to see the sink details in the right panel.

5.3. EVENT SINKS

5.3.1. Event sinks

When you create an event source, you can specify a sink where events are sent to from the source. A sink is an addressable or a callable resource that can receive incoming events from other resources. Knative services, channels and brokers are all examples of sinks.

Addressable objects receive and acknowledge an event delivered over HTTP to an address defined in their **status.address.url** field. As a special case, the core Kubernetes **Service** object also fulfills the addressable interface.

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

5.3.1.1. Knative CLI sink flag

When you create an event source 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 sink can be any addressable or callable resource that can receive incoming events from other resources.

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**.

TIP

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

5.3.2. Kafka sink

Kafka sinks are a type of event sink that are available if a cluster administrator has enabled Kafka on your cluster. You can send events directly from an event source to a Kafka topic by using a Kafka sink.

5.3.2.1. Using a Kafka sink

You can create an event sink called a Kafka sink that sends events to a Kafka topic. Creating Knative resources by using YAML files uses a declarative API, which enables you to describe applications declaratively and in a reproducible manner. By default, a Kafka sink uses the binary content mode, which is more efficient than the structured mode. To create a Kafka sink by using YAML, you must create a YAML file that defines a **KafkaSink** object, then apply it by using the **oc apply** command.

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, 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.
- Install the OpenShift CLI (**oc**).

Procedure

1. Create a **KafkaSink** object definition as a YAML file:

   Kafka sink YAML

   ```
   apiVersion: eventing.knative.dev/v1alpha1
   kind: KafkaSink
   metadata:
     name: <sink-name>
     namespace: <namespace>
   spec:
     topic: <topic-name>
     bootstrapServers:
      - <bootstrap-server>
   ```

2. To create the Kafka sink, apply the **KafkaSink** YAML file:

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

3. Configure an event source so that the sink is specified in its spec:

   Example of a Kafka sink connected to an API server source

   ```
   apiVersion: sources.knative.dev/v1alpha2
   kind: ApiServerSource
   metadata:
     name: <source-name> ①
     namespace: <namespace> ②
   spec:
   ```

```
serviceAccountName: <service-account-name> 3
mode: Resource
resources:
- apiVersion: v1
  kind: Event
sink:
  ref:
    apiVersion: eventing.knative.dev/v1alpha1
    kind: KafkaSink
    name: <sink-name> 4
```

1. The name of the event source.
2. The namespace of the event source.
3. The service account for the event source.
4. The Kafka sink name.

5.3.2.2. Configuring security for Kafka sinks

Transport Layer Security (TLS) is used by Apache Kafka clients and servers to encrypt traffic between Knative and Kafka, as well as for authentication. TLS is the only supported method of traffic encryption for Knative Kafka.

Simple Authentication and Security Layer (SASL) is used by Apache Kafka for authentication. If you use SASL authentication on your cluster, users must provide credentials to Knative for communicating with the Kafka cluster; otherwise events cannot be produced or consumed.

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, and the **KnativeKafka** custom resources (CRs) are installed on your OpenShift Container Platform cluster.
- Kafka sink is enabled in the **KnativeKafka** CR.
- 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 a Kafka cluster CA certificate stored as a **.pem** file.
- You have a Kafka cluster client certificate and a key stored as **.pem** files.
- You have installed the OpenShift (**oc**) CLI.
- You have chosen the SASL mechanism to use, for example, **PLAIN**, **SCRAM-SHA-256**, or **SCRAM-SHA-512**.

Procedure

1. Create the certificate files as a secret in the same namespace as your **KafkaSink** object:

IMPORTANT

Certificates and keys must be in PEM format.

- For authentication using SASL without encryption:

```
$ oc create secret -n <namespace> generic <secret_name> \
  --from-literal=protocol=SASL_PLAINTEXT \
  --from-literal=sasl.mechanism=<sasl_mechanism> \
  --from-literal=user=<username> \
  --from-literal=password=<password>
```

- For authentication using SASL and encryption using TLS:

```
$ oc create secret -n <namespace> generic <secret_name> \
  --from-literal=protocol=SASL_SSL \
  --from-literal=sasl.mechanism=<sasl_mechanism> \
  --from-file=ca.crt=<my_caroot.pem_file_path> \ 1
  --from-literal=user=<username> \
  --from-literal=password=<password>
```

1 The **ca.crt** can be omitted to use the system's root CA set if you are using a public cloud managed Kafka service, such as Red Hat OpenShift Streams for Apache Kafka.

- For authentication and encryption using TLS:

```
$ oc create secret -n <namespace> generic <secret_name> \
  --from-literal=protocol=SSL \
  --from-file=ca.crt=<my_caroot.pem_file_path> \ 1
  --from-file=user.crt=<my_cert.pem_file_path> \
  --from-file=user.key=<my_key.pem_file_path>
```

1 The **ca.crt** can be omitted to use the system's root CA set if you are using a public cloud managed Kafka service, such as Red Hat OpenShift Streams for Apache Kafka.

2. Create or modify a **KafkaSink** object and add a reference to your secret in the **auth** spec:

```
apiVersion: eventing.knative.dev/v1alpha1
kind: KafkaSink
metadata:
  name: <sink_name>
  namespace: <namespace>
spec:
...
  auth:
    secret:
      ref:
        name: <secret_name>
...
```

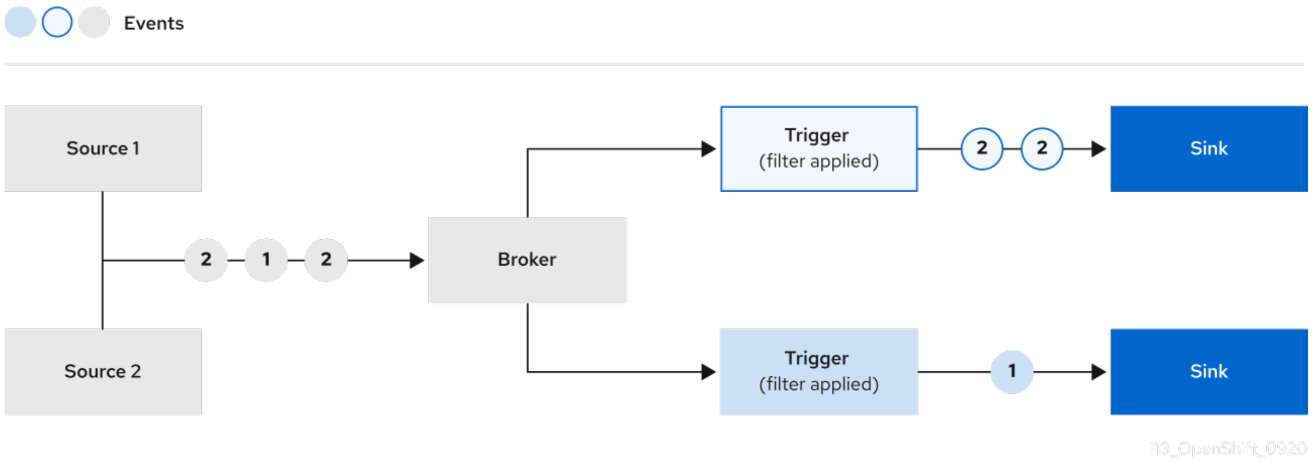
3. Apply the **KafkaSink** object:

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

5.4. BROKERS

5.4.1. Brokers

Brokers can be used in combination with triggers to deliver events from an event source to an event sink. Events are 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.



5.4.2. Broker types

Cluster administrators can set the default broker implementation for a cluster. When you create a broker, the default broker implementation is used, unless you provide set configurations in the **Broker** object.

5.4.2.1. Default broker implementation for development purposes

Knative provides a default, channel-based broker implementation. This channel-based broker can be used for development and testing purposes, but does not provide adequate event delivery guarantees for production environments. The default broker is backed by the **InMemoryChannel** channel implementation by default.

If you want to use Kafka to reduce network hops, use the Kafka broker implementation. Do not configure the channel-based broker to be backed by the **KafkaChannel** channel implementation.

5.4.2.2. Production-ready Kafka broker implementation

For production-ready Knative Eventing deployments, Red Hat recommends using the Knative Kafka broker implementation. The Kafka broker is an Apache Kafka native implementation of the Knative broker, which sends CloudEvents directly to the Kafka instance.

The Kafka broker has a native integration with Kafka for storing and routing events. This allows better integration with Kafka for the broker and trigger model over other broker types, and reduces network hops. Other benefits of the Kafka broker implementation include:

- At-least-once delivery guarantees

- Ordered delivery of events, based on the CloudEvents partitioning extension
- Control plane high availability
- A horizontally scalable data plane

The Knative Kafka broker stores incoming CloudEvents as Kafka records, using the binary content mode. This means that all CloudEvent attributes and extensions are mapped as headers on the Kafka record, while the **data** spec of the CloudEvent corresponds to the value of the Kafka record.

5.4.3. Creating brokers

Knative provides a default, channel-based broker implementation. This channel-based broker can be used for development and testing purposes, but does not provide adequate event delivery guarantees for production environments.

If a cluster administrator has configured your OpenShift Serverless deployment to use Kafka as the default broker type, creating a broker by using the default settings creates a Kafka-based broker.

If your OpenShift Serverless deployment is not configured to use Kafka broker as the default broker type, the channel-based broker is created when you use the default settings in the following procedures.

5.4.3.1. Creating a broker by using the Knative CLI

Brokers can be used in combination with triggers to deliver events from an event source to an event sink. Using the Knative (**kn**) CLI to create brokers provides a more streamlined and intuitive user interface over modifying YAML files directly. You can use the **kn broker create** command to create a broker.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the Knative (**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 broker:

```
$ kn broker create <broker_name>
```

Verification

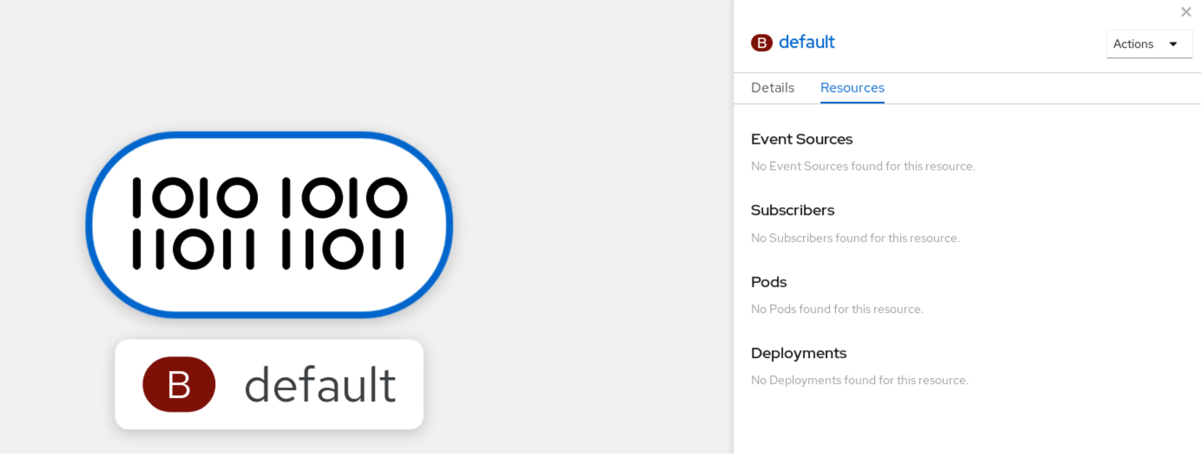
1. Use the **kn** command to list all existing brokers:

```
$ 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:



Event Sources

No Event Sources found for this resource.

Subscribers

No Subscribers found for this resource.

Pods

No Pods found for this resource.

Deployments

No Deployments found for this resource.

5.4.3.2. Creating a broker by annotating a trigger

Brokers can be used in combination with triggers to deliver events from an event source to an event sink. 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.
- Install the OpenShift CLI (**oc**).
- 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 **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.

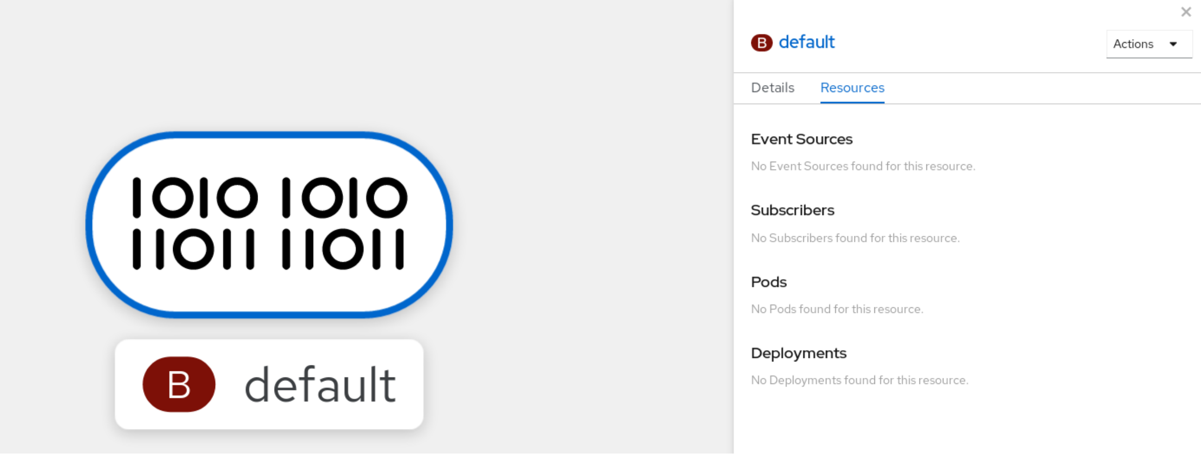
1. Enter the following **oc** command to get the broker:

```
$ 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. 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:



Event Sources

No Event Sources found for this resource.

Subscribers

No Subscribers found for this resource.

Pods

No Pods found for this resource.

Deployments

No Deployments found for this resource.

5.4.3.3. Creating a broker by labeling a namespace

Brokers can be used in combination with triggers to deliver events from an event source to an event sink. You can create the **default** broker automatically by labelling a namespace that you own or have write permissions for.

NOTE

Brokers created using this method are not 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.
- Install the OpenShift CLI (**oc**).
- 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

- 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>
```

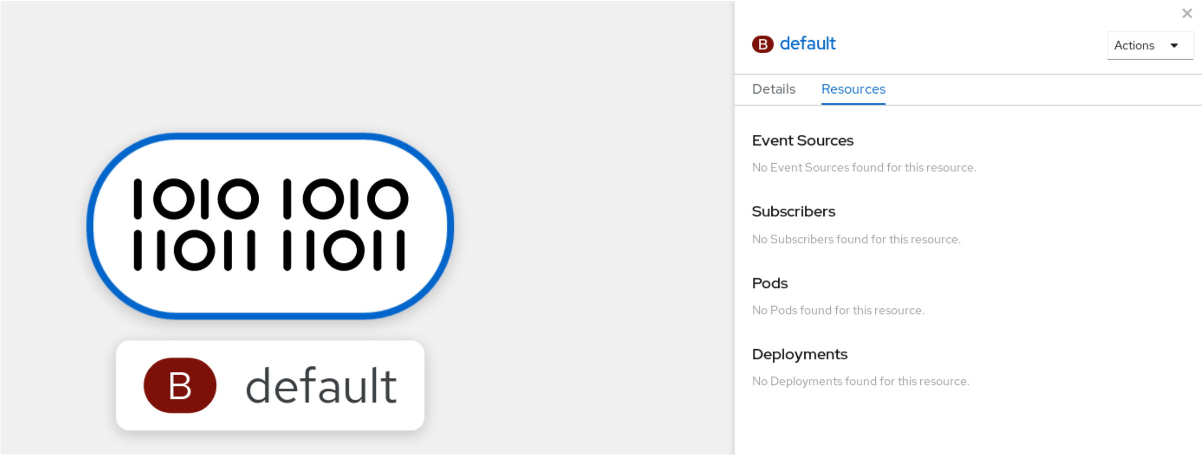
Example command

```
$ 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. 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:



Event Sources

No Event Sources found for this resource.

Subscribers

No Subscribers found for this resource.

Pods

No Pods found for this resource.

Deployments

No Deployments found for this resource.

5.4.3.4. Deleting a broker that was created by injection

If you create a broker by injection and later want to delete it, you must delete it manually. Brokers created by using a namespace label or trigger annotation are not deleted permanently if you remove the label or annotation.

Prerequisites

- Install the OpenShift CLI (**oc**).

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
```

5.4.3.5. Creating a broker by using the web console

After Knative Eventing is installed on your cluster, you can create a broker by using the web console. Using the OpenShift Container Platform web console provides a streamlined and intuitive user interface to create a broker.

Prerequisites

- You have logged in to the OpenShift Container Platform web console.
- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on the 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.

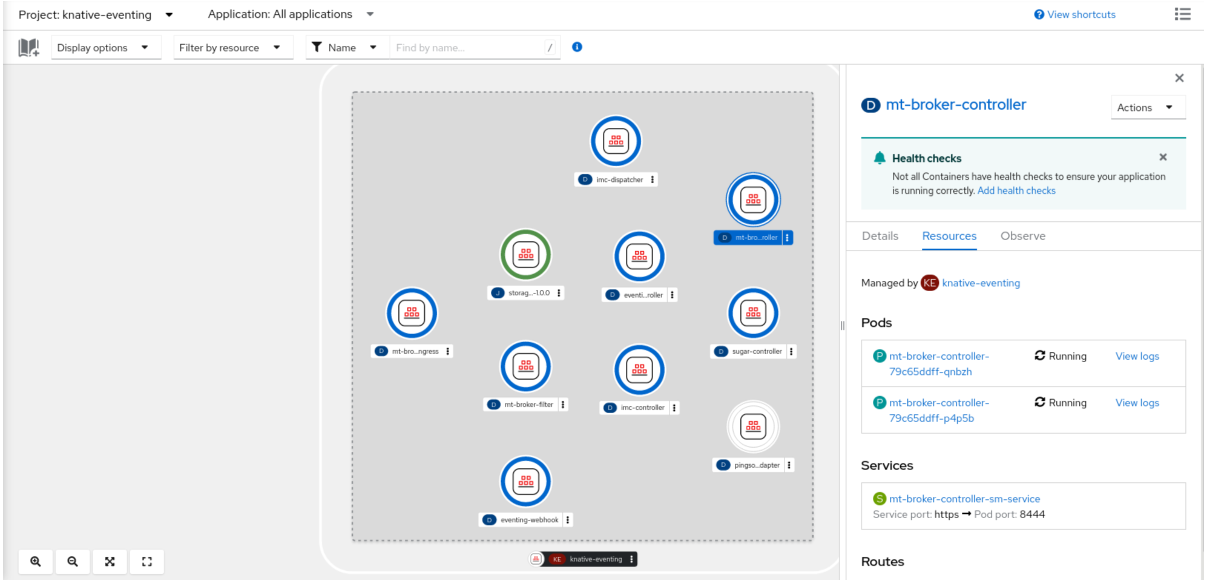
Procedure

1. In the **Developer** perspective, navigate to **+Add → Broker**. The **Broker** page is displayed.
2. Optional. Update the **Name** of the broker. If you do not update the name, the generated broker is named **default**.
3. Click **Create**.

Verification

You can verify that the broker was created by viewing broker components in the **Topology** page.

1. In the **Developer** perspective, navigate to **Topology**.
2. View the **mt-broker-ingress**, **mt-broker-filter**, and **mt-broker-controller** components.



mt-broker-controller

Health checks

Not all Containers have health checks to ensure your application is running correctly. Add health checks

Managed by KE knative-eventing

Pods

P mt-broker-controller-79c65ddff-qnbzh Running View logs

P mt-broker-controller-79c65ddff-p4p5b Running View logs

Services

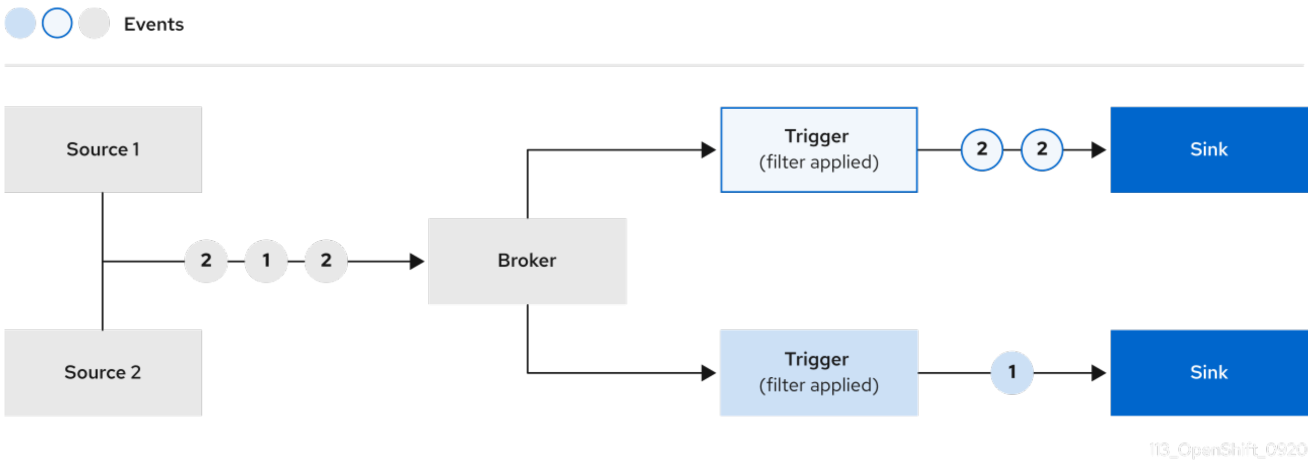
S mt-broker-controller-sm-service

Service port: https → Pod port: 8444

Routes

5.4.3.6. Creating a broker by using the Administrator perspective

Brokers can be used in combination with triggers to deliver events from an event source to an event sink. Events are 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.



Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.

- You have logged in to the web console and are in the **Administrator** perspective.

- 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**.

5.4.3.7. Next steps

- Configure event delivery parameters that are applied in cases where an event fails to be delivered to an event sink. See Examples of configuring event delivery parameters.

5.4.3.8. Additional resources

- Configuring the default broker class

- TriggersEvent sources

- Event delivery

5.4.4. Configuring the default broker backing channel

If you are using a channel-based broker, you can set the default backing channel type for the broker to either **InMemoryChannel** or **KafkaChannel**.

Prerequisites

- You have administrator permissions on OpenShift Container Platform.

- You have installed the OpenShift Serverless Operator and Knative Eventing on your cluster.
- You have installed the OpenShift (**oc**) CLI.
- If you want to use Kafka channels as the default backing channel type, you must also install the **KnativeKafka** CR on your cluster.

Procedure

1. Modify the **KnativeEventing** custom resource (CR) to add configuration details for the **config-br-default-channel** config map:

```
apiVersion: operator.knative.dev/v1beta1
kind: KnativeEventing
metadata:
  name: knative-eventing
  namespace: knative-eventing
spec:
  config: ①
    config-br-default-channel:
      channel-template-spec: |
        apiVersion: messaging.knative.dev/v1beta1
        kind: KafkaChannel ②
        spec:
          numPartitions: 6 ③
          replicationFactor: 3 ④
```

① In **spec.config**, you can specify the config maps that you want to add modified configurations for.

② The default backing channel type configuration. In this example, the default channel implementation for the cluster is **KafkaChannel**.

③ The number of partitions for the Kafka channel that backs the broker.

④ The replication factor for the Kafka channel that backs the broker.

2. Apply the updated **KnativeEventing** CR:

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

5.4.5. Configuring the default broker class

You can use the **config-br-defaults** config map to specify default broker class settings for Knative Eventing. You can specify the default broker class for the entire cluster or for one or more namespaces. Currently the **MTChannelBasedBroker** and **Kafka** broker types are supported.

Prerequisites

- You have administrator permissions on OpenShift Container Platform.
- You have installed the OpenShift Serverless Operator and Knative Eventing on your cluster.

- If you want to use Kafka broker as the default broker implementation, you must also install the **KnativeKafka** CR on your cluster.

Procedure

- Modify the **KnativeEventing** custom resource to add configuration details for the **config-br-defaults** config map:

```
apiVersion: operator.knative.dev/v1beta1
kind: KnativeEventing
metadata:
  name: knative-eventing
  namespace: knative-eventing
spec:
  defaultBrokerClass: Kafka ①
  config: ②
    config-br-defaults: ③
      default-br-config: |
        clusterDefault: ④
          brokerClass: Kafka
          apiVersion: v1
          kind: ConfigMap
          name: kafka-broker-config ⑤
          namespace: knative-eventing ⑥
        namespaceDefaults: ⑦
          my-namespace:
            brokerClass: MTChannelBasedBroker
            apiVersion: v1
            kind: ConfigMap
            name: config-br-default-channel ⑧
            namespace: knative-eventing ⑨
...
```

① The default broker class for Knative Eventing.

② In **spec.config**, you can specify the config maps that you want to add modified configurations for.

③ The **config-br-defaults** config map specifies the default settings for any broker that does not specify **spec.config** settings or a broker class.

④ The cluster-wide default broker class configuration. In this example, the default broker class implementation for the cluster is **Kafka**.

⑤ The **kafka-broker-config** config map specifies default settings for the Kafka broker. See "Configuring Kafka broker settings" in the "Additional resources" section.

⑥ The namespace where the **kafka-broker-config** config map exists.

⑦ The namespace-scoped default broker class configuration. In this example, the default broker class implementation for the **my-namespace** namespace is **MTChannelBasedBroker**. You can specify default broker class implementations for multiple namespaces.

⑧

The **config-br-default-channel** config map specifies the default backing channel for the broker. See "Configuring the default broker backing channel" in the "Additional resources"

9 The namespace where the **config-br-default-channel** config map exists.

IMPORTANT

Configuring a namespace-specific default overrides any cluster-wide settings.

5.4.6. Kafka broker

For production-ready Knative Eventing deployments, Red Hat recommends using the Knative Kafka broker implementation. The Kafka broker is an Apache Kafka native implementation of the Knative broker, which sends CloudEvents directly to the Kafka instance.

The Kafka broker has a native integration with Kafka for storing and routing events. This allows better integration with Kafka for the broker and trigger model over other broker types, and reduces network hops. Other benefits of the Kafka broker implementation include:

- At-least-once delivery guarantees
- Ordered delivery of events, based on the CloudEvents partitioning extension
- Control plane high availability
- A horizontally scalable data plane

The Knative Kafka broker stores incoming CloudEvents as Kafka records, using the binary content mode. This means that all CloudEvent attributes and extensions are mapped as headers on the Kafka record, while the **data** spec of the CloudEvent corresponds to the value of the Kafka record.

5.4.6.1. Creating a Kafka broker when it is not configured as the default broker type

If your OpenShift Serverless deployment is not configured to use Kafka broker as the default broker type, you can use one of the following procedures to create a Kafka-based broker.

5.4.6.1.1. Creating a Kafka broker by using YAML

Creating Knative resources by using YAML files uses a declarative API, which enables you to describe applications declaratively and in a reproducible manner. To create a Kafka broker by using YAML, you must create a YAML file that defines a **Broker** object, then apply it by using the **oc apply** command.

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.
- You have installed the OpenShift CLI (**oc**).

Procedure

1. Create a Kafka-based broker as a YAML file:

```
apiVersion: eventing.knative.dev/v1
kind: Broker
metadata:
  annotations:
    eventing.knative.dev/broker.class: Kafka 1
  name: example-kafka-broker
spec:
  config:
    apiVersion: v1
    kind: ConfigMap
    name: kafka-broker-config 2
    namespace: knative-eventing
```

1 The broker class. If not specified, brokers use the default class as configured by cluster administrators. To use the Kafka broker, this value must be **Kafka**.

2 The default config map for Knative Kafka brokers. This config map is created when the Kafka broker functionality is enabled on the cluster by a cluster administrator.

2. Apply the Kafka-based broker YAML file:

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

5.4.6.1.2. Creating a Kafka broker that uses an externally managed Kafka topic

If you want to use a Kafka broker without allowing it to create its own internal topic, you can use an externally managed Kafka topic instead. To do this, you must create a Kafka **Broker** object that uses the **kafka.eventing.knative.dev/external.topic** annotation.

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, and the **KnativeKafka** custom resource are installed on your OpenShift Container Platform cluster.
- You have access to a Kafka instance such as Red Hat AMQ Streams , and have created a Kafka topic.
- 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 installed the OpenShift CLI (**oc**).

Procedure

1. Create a Kafka-based broker as a YAML file:

```
apiVersion: eventing.knative.dev/v1
kind: Broker
metadata:
  annotations:
    eventing.knative.dev/broker.class: Kafka ❶
    kafka.eventing.knative.dev/external.topic: <topic_name> ❷
...
```

❶ The broker class. If not specified, brokers use the default class as configured by cluster administrators. To use the Kafka broker, this value must be **Kafka**.

❷ The name of the Kafka topic that you want to use.

2. Apply the Kafka-based broker YAML file:

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

5.4.6.1.3. Knative Broker implementation for Apache Kafka with isolated data plane

> **IMPORTANT**
>
> The Knative Broker implementation for Apache Kafka with isolated data plane 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 Technology Preview Features Support Scope .

The Knative Broker implementation for Apache Kafka has 2 planes:

Control plane

Consists of controllers that talk to the Kubernetes API, watch for custom objects, and manage the data plane.

Data plane

The collection of components that listen for incoming events, talk to Apache Kafka, and send events to the event sinks. The Knative Broker implementation for Apache Kafka data plane is where events flow. The implementation consists of **kafka-broker-receiver** and **kafka-broker-dispatcher** deployments.

When you configure a Broker class of **Kafka**, the Knative Broker implementation for Apache Kafka uses a shared data plane. This means that the **kafka-broker-receiver** and **kafka-broker-dispatcher** deployments in the **knative-eventing** namespace are used for all Apache Kafka Brokers in the cluster.

However, when you configure a Broker class of **KafkaNamespaced**, the Apache Kafka broker controller creates a new data plane for each namespace where a broker exists. This data plane is used by all **KafkaNamespaced** brokers in that namespace. This provides isolation between the data planes, so that the **kafka-broker-receiver** and **kafka-broker-dispatcher** deployments in the user namespace are only used for the broker in that namespace.

IMPORTANT

As a consequence of having separate data planes, this security feature creates more deployments and uses more resources. Unless you have such isolation requirements, use a **regular** Broker with a class of **Kafka**.

5.4.6.1.4. Creating a Knative broker for Apache Kafka that uses an isolated data plane

IMPORTANT

The Knative Broker implementation for Apache Kafka with isolated data plane 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 Technology Preview Features Support Scope .

To create a **KafkaNamespaced** broker, you must set the **eventing.knative.dev/broker.class** annotation to **KafkaNamespaced**.

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, and the **KnativeKafka** custom resource are installed on your OpenShift Container Platform cluster.
- You have access to an Apache Kafka instance, such as Red Hat AMQ Streams , and have created a Kafka topic.
- 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 installed the OpenShift CLI (**oc**).

Procedure

1. Create an Apache Kafka-based broker by using a YAML file:

```
apiVersion: eventing.knative.dev/v1
kind: Broker
metadata:
  annotations:
    eventing.knative.dev/broker.class: KafkaNamespaced 1
  name: default
  namespace: my-namespace 2
spec:
  config:
    apiVersion: v1
    kind: ConfigMap
    name: my-config 3
...
```

1 To use the Apache Kafka broker with isolated data planes, the broker class value must be **KafkaNamespaced**.

2 3 The referenced **ConfigMap** object **my-config** must be in the same namespace as the **Broker** object, in this case **my-namespace**.

2. Apply the Apache Kafka-based broker YAML file:

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

IMPORTANT

The **ConfigMap** object in **spec.config** must be in the same namespace as the **Broker** object:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: my-config
  namespace: my-namespace
data:
  ...
```

After the creation of the first **Broker** object with the **KafkaNamespaced** class, the **kafka-broker-receiver** and **kafka-broker-dispatcher** deployments are created in the namespace. Subsequently, all brokers with the **KafkaNamespaced** class in the same namespace will use the same data plane. If no brokers with the **KafkaNamespaced** class exist in the namespace, the data plane in the namespace is deleted.

5.4.6.2. Configuring Kafka broker settings

You can configure the replication factor, bootstrap servers, and the number of topic partitions for a Kafka broker, by creating a config map and referencing this config map in the Kafka **Broker** object.

Prerequisites

- You have cluster or dedicated administrator permissions on OpenShift Container Platform.
- The OpenShift Serverless Operator, Knative Eventing, and the **KnativeKafka** custom resource (CR) are installed on your OpenShift Container Platform cluster.
- You have created a project or have access to a project that has the appropriate roles and permissions to create applications and other workloads in OpenShift Container Platform.
- You have installed the OpenShift CLI (**oc**).

Procedure

1. Modify the **kafka-broker-config** config map, or create your own config map that contains the following configuration:

```
apiVersion: v1
kind: ConfigMap
```

```
metadata:
  name: <config_map_name> ①
  namespace: <namespace> ②
data:
  default.topic.partitions: <integer> ③
  default.topic.replication.factor: <integer> ④
  bootstrap.servers: <list_of_servers> ⑤
```

① The config map name.

② The namespace where the config map exists.

③ The number of topic partitions for the Kafka broker. This controls how quickly events can be sent to the broker. A higher number of partitions requires greater compute resources.

④ The replication factor of topic messages. This prevents against data loss. A higher replication factor requires greater compute resources and more storage.

⑤ A comma separated list of bootstrap servers. This can be inside or outside of the OpenShift Container Platform cluster, and is a list of Kafka clusters that the broker receives events from and sends events to.

IMPORTANT

The **default.topic.replication.factor** value must be less than or equal to the number of Kafka broker instances in your cluster. For example, if you only have one Kafka broker, the **default.topic.replication.factor** value should not be more than **"1"**.

Example Kafka broker config map

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: kafka-broker-config
  namespace: knative-eventing
data:
  default.topic.partitions: "10"
  default.topic.replication.factor: "3"
  bootstrap.servers: "my-cluster-kafka-bootstrap.kafka:9092"
```

2. Apply the config map:

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

3. Specify the config map for the Kafka **Broker** object:

Example Broker object

```
apiVersion: eventing.knative.dev/v1
kind: Broker
metadata:
  name: <broker_name> 1
  namespace: <namespace> 2
  annotations:
    eventing.knative.dev/broker.class: Kafka 3
spec:
  config:
    apiVersion: v1
    kind: ConfigMap
    name: <config_map_name> 4
    namespace: <namespace> 5
...
```

1. The broker name.
2. The namespace where the broker exists.
3. The broker class annotation. In this example, the broker is a Kafka broker that uses the class value **Kafka**.
4. The config map name.
5. The namespace where the config map exists.

4. Apply the broker:

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

5.4.6.3. Security configuration for Knative Kafka brokers

Kafka clusters are generally secured by using the TLS or SASL authentication methods. You can configure a Kafka broker or channel to work against a protected Red Hat AMQ Streams cluster by using TLS or SASL.

NOTE

Red Hat recommends that you enable both SASL and TLS together.

5.4.6.3.1. Configuring TLS authentication for Kafka brokers

Transport Layer Security (TLS) is used by Apache Kafka clients and servers to encrypt traffic between Knative and Kafka, as well as for authentication. TLS is the only supported method of traffic encryption for Knative Kafka.

Prerequisites

- You have cluster or dedicated administrator permissions on OpenShift Container Platform.
- The OpenShift Serverless Operator, Knative Eventing, and the **KnativeKafka** CR 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.

- You have a Kafka cluster CA certificate stored as a **.pem** file.
- You have a Kafka cluster client certificate and a key stored as **.pem** files.
- Install the OpenShift CLI (**oc**).

Procedure

1. Create the certificate files as a secret in the **knative-eventing** namespace:

```
$ oc create secret -n knative-eventing generic <secret_name> \
  --from-literal=protocol=SSL \
  --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. Edit the **KnativeKafka** CR and add a reference to your secret in the **broker** spec:

```
apiVersion: operator.serverless.openshift.io/v1alpha1
kind: KnativeKafka
metadata:
  namespace: knative-eventing
  name: knative-kafka
spec:
  broker:
    enabled: true
    defaultConfig:
      authSecretName: <secret_name>
...
```

5.4.6.3.2. Configuring SASL authentication for Kafka brokers

Simple Authentication and Security Layer (SASL) is used by Apache Kafka for authentication. If you use SASL authentication on your cluster, users must provide credentials to Knative for communicating with the Kafka cluster; otherwise events cannot be produced or consumed.

Prerequisites

- You have cluster or dedicated administrator permissions on OpenShift Container Platform.
- The OpenShift Serverless Operator, Knative Eventing, and the **KnativeKafka** CR 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.
- You have a username and password for a Kafka cluster.
- You have chosen 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.
- Install the OpenShift CLI (**oc**).

Procedure

1. Create the certificate files as a secret in the **knative-eventing** namespace:

```
$ oc create secret -n knative-eventing generic <secret_name> \
  --from-literal=protocol=SASL_SSL \
  --from-literal=sasl.mechanism=<sasl_mechanism> \
  --from-file=ca.crt=caroot.pem \
  --from-literal=password="SecretPassword" \
  --from-literal=user="my-sasl-user"
```

   - Use the key names **ca.crt**, **password**, and **sasl.mechanism**. Do not change them.
   - 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 -n <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"
```

2. Edit the **KnativeKafka** CR and add a reference to your secret in the **broker** spec:

```
apiVersion: operator.serverless.openshift.io/v1alpha1
kind: KnativeKafka
metadata:
  namespace: knative-eventing
  name: knative-kafka
spec:
  broker:
    enabled: true
    defaultConfig:
      authSecretName: <secret_name>
...
```

5.4.6.4. Additional resources

- Red Hat AMQ Streams documentation
- TLS and SASL on Kafka

5.4.7. Managing brokers

The Knative (**kn**) CLI provides commands that can be used to describe and list existing brokers.

5.4.7.1. Listing existing brokers by using the Knative CLI

Using the Knative (**kn**) CLI to list brokers provides a streamlined and intuitive user interface. You can use the **kn broker list** command to list existing brokers in your cluster 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 Knative (**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
  ```

5.4.7.2. Describing an existing broker by using the Knative CLI

Using the Knative (**kn**) CLI to describe brokers provides a streamlined and intuitive user interface. You can use the **kn broker describe** command to print information about existing brokers in your cluster 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 Knative (**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
```

5.4.8. Event delivery

You can configure event delivery parameters that are applied in cases where an event fails to be delivered to an event sink. Configuring event delivery parameters, including a dead letter sink, ensures that any events that fail to be delivered to an event sink are retried. Otherwise, undelivered events are dropped.

5.4.8.1. Event delivery behavior patterns for channels and brokers

Different channel and broker types have their own behavior patterns that are followed for event delivery.

5.4.8.1.1. Knative Kafka channels and brokers

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 the issue.

5.4.8.2. Configurable event delivery 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 stored in the specified event sink. Undelivered events that are not stored in a dead letter sink are dropped. The dead letter sink be any addressable object that conforms to the Knative Eventing sink contract, such as a Knative service, a Kubernetes service, or a URI.

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. For example, **PT1S** specifies a 1 second delay.

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 equal to **backoffDelay * <numberOfRetries>**. When using the **exponential** backoff policy, the back off delay is equal to **backoffDelay*2^<numberOfRetries>**.

5.4.8.3. Examples of configuring event delivery parameters

You can configure event delivery parameters for **Broker**, **Trigger**, **Channel**, and **Subscription** objects. If you configure event delivery parameters for a broker or channel, these parameters are propagated to triggers or subscriptions created for those objects. You can also set event delivery parameters for triggers or subscriptions to override the settings for the broker or channel.

Example Broker object

```
apiVersion: eventing.knative.dev/v1
kind: Broker
metadata:
...
spec:
  delivery:
    deadLetterSink:
      ref:
        apiVersion: eventing.knative.dev/v1alpha1
        kind: KafkaSink
        name: <sink_name>
    backoffDelay: <duration>
    backoffPolicy: <policy_type>
    retry: <integer>
...
```

Example Trigger object

```
apiVersion: eventing.knative.dev/v1
kind: Trigger
metadata:
...
spec:
  broker: <broker_name>
  delivery:
    deadLetterSink:
      ref:
        apiVersion: serving.knative.dev/v1
        kind: Service
        name: <sink_name>
    backoffDelay: <duration>
    backoffPolicy: <policy_type>
    retry: <integer>
...
```

Example Channel object

```
apiVersion: messaging.knative.dev/v1
kind: Channel
metadata:
...
spec:
  delivery:
    deadLetterSink:
      ref:
        apiVersion: serving.knative.dev/v1
        kind: Service
        name: <sink_name>
    backoffDelay: <duration>
    backoffPolicy: <policy_type>
    retry: <integer>
...
```

Example **Subscription** object

```
apiVersion: messaging.knative.dev/v1
kind: Subscription
metadata:
...
spec:
  channel:
    apiVersion: messaging.knative.dev/v1
    kind: Channel
    name: <channel_name>
  delivery:
    deadLetterSink:
      ref:
        apiVersion: serving.knative.dev/v1
        kind: Service
        name: <sink_name>
    backoffDelay: <duration>
    backoffPolicy: <policy_type>
    retry: <integer>
...
```

5.4.8.4. Configuring event delivery ordering for triggers

If you are using a Kafka broker, you can configure the delivery order of events from triggers to event sinks.

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, and Knative Kafka are installed on your OpenShift Container Platform cluster.
- Kafka broker is enabled for use on your cluster, and you have created a Kafka broker.
- 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 installed the OpenShift (**oc**) CLI.

Procedure

1. Create or modify a **Trigger** object and set the **kafka.eventing.knative.dev/delivery.order** annotation:

```
apiVersion: eventing.knative.dev/v1
kind: Trigger
metadata:
  name: <trigger_name>
  annotations:
    kafka.eventing.knative.dev/delivery.order: ordered
...
```

The supported consumer delivery guarantees are:

unordered

An unordered consumer is a non-blocking consumer that delivers messages unordered, while preserving proper offset management.

ordered

An ordered consumer is a per-partition blocking consumer that waits for a successful response from the CloudEvent subscriber before it delivers the next message of the partition.
The default ordering guarantee is **unordered**.

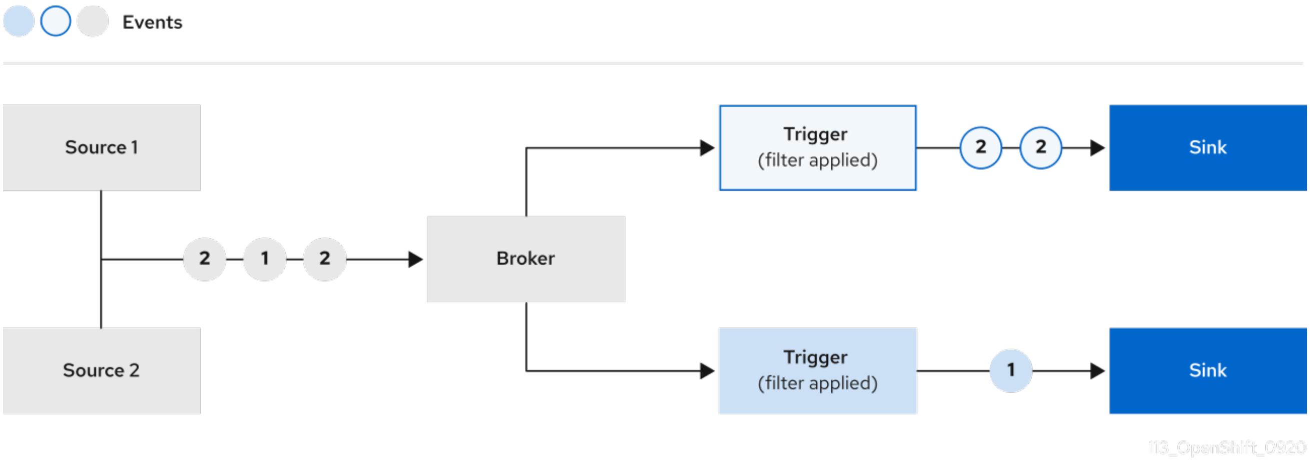
2. Apply the **Trigger** object:

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

5.5. TRIGGERS

5.5.1. Triggers overview

Brokers can be used in combination with triggers to deliver events from an event source to an event sink. Events are 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.



If you are using a Kafka broker, you can configure the delivery order of events from triggers to event sinks. See Configuring event delivery ordering for triggers .

5.5.1.1. Configuring event delivery ordering for triggers

If you are using a Kafka broker, you can configure the delivery order of events from triggers to event sinks.

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, and Knative Kafka are installed on your OpenShift Container Platform cluster.
- Kafka broker is enabled for use on your cluster, and you have created a Kafka broker.
- 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 installed the OpenShift (**oc**) CLI.

Procedure

1. Create or modify a **Trigger** object and set the **kafka.eventing.knative.dev/delivery.order** annotation:

```
apiVersion: eventing.knative.dev/v1
kind: Trigger
metadata:
  name: <trigger_name>
  annotations:
     kafka.eventing.knative.dev/delivery.order: ordered
...
```

The supported consumer delivery guarantees are:

unordered

An unordered consumer is a non-blocking consumer that delivers messages unordered, while preserving proper offset management.

ordered

An ordered consumer is a per-partition blocking consumer that waits for a successful response from the CloudEvent subscriber before it delivers the next message of the partition.
The default ordering guarantee is **unordered**.

2. Apply the **Trigger** object:

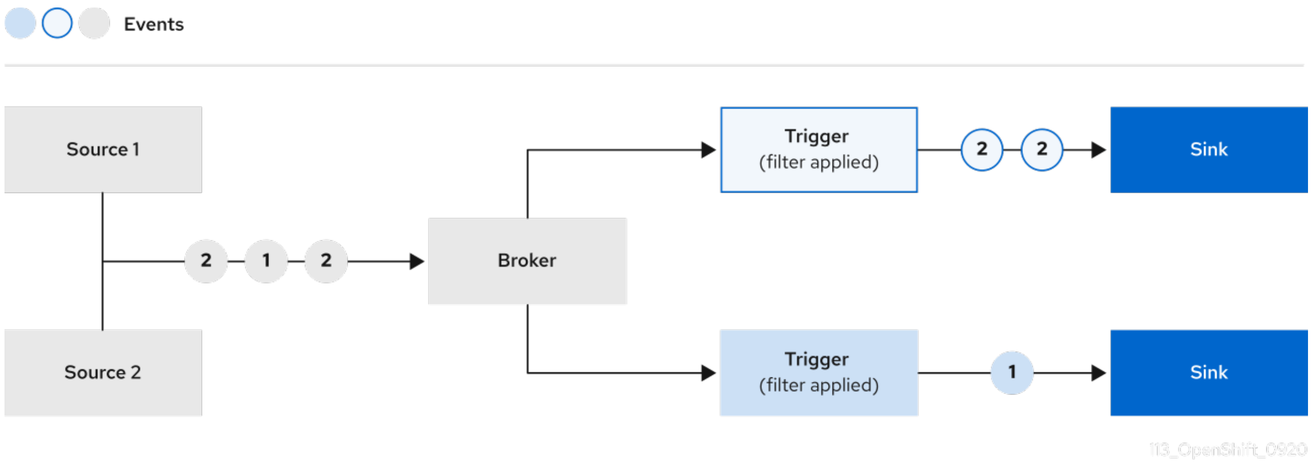
```
$ oc apply -f <filename>
```

5.5.1.2. Next steps

- Configure event delivery parameters that are applied in cases where an event fails to be delivered to an event sink. See Examples of configuring event delivery parameters.

5.5.2. Creating triggers

Brokers can be used in combination with triggers to deliver events from an event source to an event sink. Events are 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.



5.5.2.1. Creating a trigger by using the Administrator perspective

Using the OpenShift Container Platform web console provides a streamlined and intuitive user interface to create a trigger. After Knative Eventing is installed on your cluster and you have created a broker, you can create a trigger by using the web console.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have logged in to the web console and are in the **Administrator** perspective.
- You have cluster administrator permissions for OpenShift Container Platform.
- You have created a Knative 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**.

5.5.2.2. Creating a trigger by using the Developer perspective

Using the OpenShift Container Platform web console provides a streamlined and intuitive user interface to create a trigger. After Knative Eventing is installed on your cluster and you have created a broker, you can create a trigger by using the web console.

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 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 in the **Subscriber** list.
5. Click **Add**.

Verification

- After the subscription has been created, you can view it in the **Topology** page, where it is represented as a line that connects the broker to the event sink.

Deleting a trigger

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**.

5.5.2.3. Creating a trigger by using the Knative CLI

You can use the **kn trigger create** command to create a trigger.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the Knative (**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 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.

5.5.3. List triggers from the command line

Using the Knative (**kn**) CLI to list triggers provides a streamlined and intuitive user interface.

5.5.3.1. Listing triggers by using the Knative CLI

You can use the **kn trigger list** command to list existing triggers in your cluster.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the Knative (**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
```

5.5.4. Describe triggers from the command line

Using the Knative (**kn**) CLI to describe triggers provides a streamlined and intuitive user interface.

5.5.4.1. Describing a trigger by using the Knative CLI

You can use the **kn trigger describe** command to print information about existing triggers in your cluster 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 Knative (**kn**) CLI.
- You have created a trigger.

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
  ```

5.5.5. 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** object's resource spec.

Example of a Trigger object 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.

5.5.6. Filtering triggers from the command line

Using the Knative (**kn**) CLI to filter events by using triggers provides a streamlined and intuitive user interface. You can use the **kn trigger create** command, along with the appropriate flags, to filter events by using triggers.

5.5.6.1. Filtering events with triggers by using the Knative CLI

In the following trigger example, only events with the attribute **type: dev.knative.samples.helloworld** are sent to 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 by 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
```

5.5.7. Updating triggers from the command line

Using the Knative (**kn**) CLI to update triggers provides a streamlined and intuitive user interface.

5.5.7.1. 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 Knative (**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

- 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
    ```

5.5.8. Deleting triggers from the command line

Using the Knative (**kn**) CLI to delete a trigger provides a streamlined and intuitive user interface.

5.5.8.1. 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 Knative (**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

- Delete a trigger:

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

Verification

1. List existing triggers:

   ```
   $ kn trigger list
   ```

2. Verify that the trigger no longer exists:

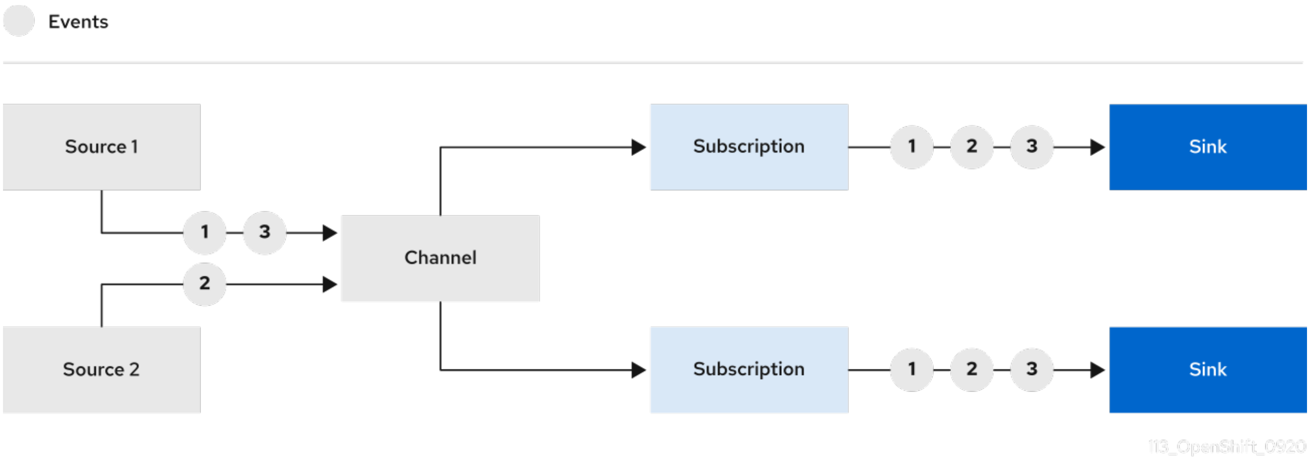
   Example output

```
No triggers found.
```

5.6. CHANNELS

5.6.1. Channels and subscriptions

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.



You can create channels by instantiating a supported **Channel** object, and configure re-delivery attempts by modifying the **delivery** spec in a **Subscription** 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
```

The channel controller then creates the backing channel instance based on the **spec.channelTemplate** configuration.

NOTE

The **spec.channelTemplate** properties cannot be changed after creation, because they are set by the default channel mechanism rather than by the user.

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.

5.6.1.1. Channel implementation types

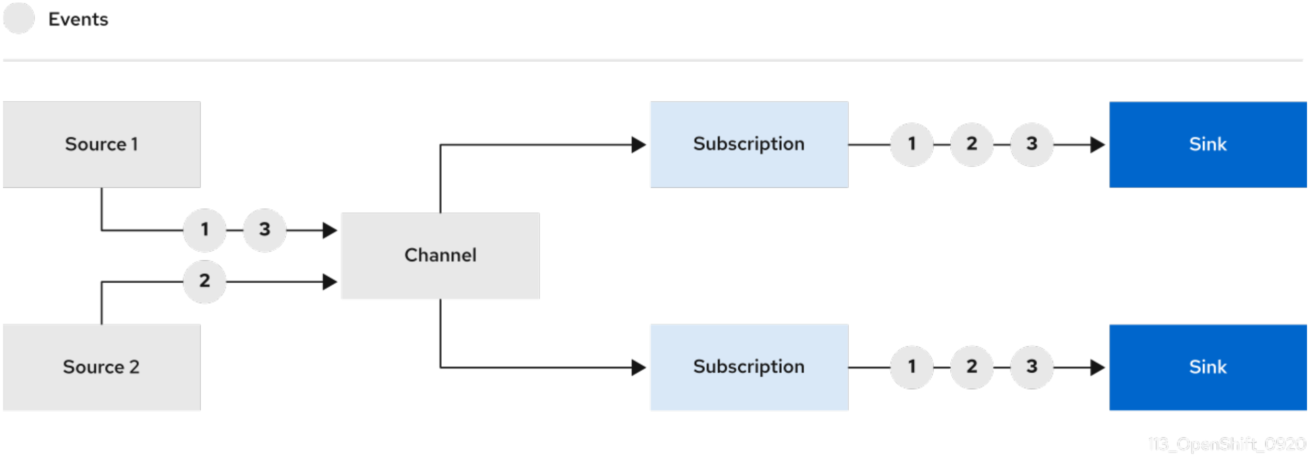
InMemoryChannel and **KafkaChannel** channel implementations can be used with OpenShift Serverless for development use.

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.

5.6.2. Creating 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.



You can create channels by instantiating a supported **Channel** object, and configure re-delivery attempts by modifying the **delivery** spec in a **Subscription** object.

5.6.2.1. Creating a channel by using the Administrator perspective

After Knative Eventing is installed on your cluster, you can create a channel by using the Administrator perspective.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have logged in to the web console and are in the **Administrator** perspective.
- 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 in the **Type** list.

   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**.

5.6.2.2. Creating a channel by using the Developer perspective

Using the OpenShift Container Platform web console provides a streamlined and intuitive user interface to create a channel. After Knative Eventing is installed on your cluster, you can create a channel by using the web console.

Prerequisites

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

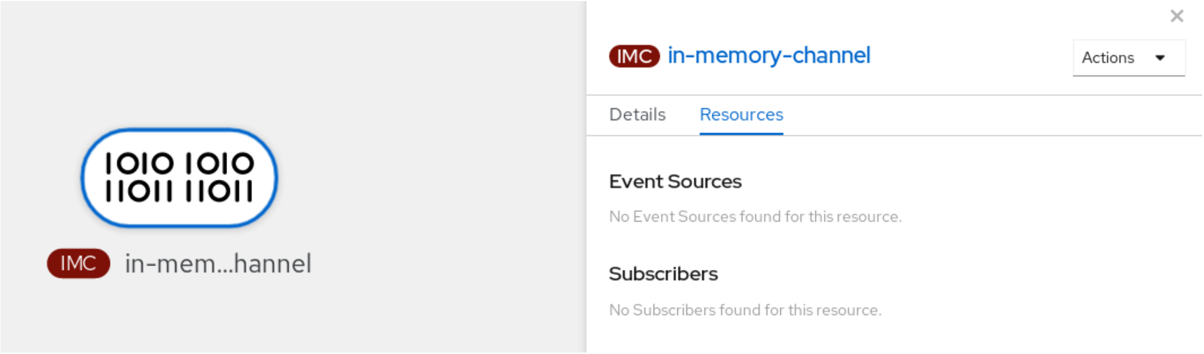
1. In the **Developer** perspective, navigate to **+Add** → **Channel**.

2. Select the type of **Channel** object that you want to create in the **Type** list.

3. Click **Create**.

Verification

- Confirm that the channel now exists by navigating to the **Topology** page.



Event Sources

No Event Sources found for this resource.

Subscribers

No Subscribers found for this resource.

5.6.2.3. Creating a channel by using the Knative CLI

Using the Knative (**kn**) CLI to create channels provides a more streamlined and intuitive user interface than modifying YAML files directly. You can use the **kn channel create** command to create a channel.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on the cluster.
- You have installed the Knative (**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
  ```

Deleting a channel

- Delete a channel:

  ```
  $ kn channel delete <channel_name>
  ```

5.6.2.4. Creating a default implementation channel by using YAML

Creating Knative resources by using YAML files uses a declarative API, which enables you to describe channels declaratively and in a reproducible manner. To create a serverless channel by using YAML, you must create a YAML file that defines a **Channel** object, then apply it by using the **oc apply** command.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on the cluster.
- Install the OpenShift CLI (**oc**).
- 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 **Channel** object as a YAML file:

```
apiVersion: messaging.knative.dev/v1
kind: Channel
metadata:
  name: example-channel
  namespace: default
```

2. Apply the YAML file:

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

5.6.2.5. Creating a Kafka channel by using YAML

Creating Knative resources by using YAML files uses a declarative API, which enables you to describe channels declaratively and in a reproducible manner. You can create a Knative Eventing channel that is backed by Kafka topics by creating a Kafka channel. To create a Kafka channel by using YAML, you must create a YAML file that defines a **KafkaChannel** object, then apply it by using the **oc apply** command.

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, and the **KnativeKafka** custom resource are installed on your OpenShift Container Platform cluster.
- Install the OpenShift CLI (**oc**).
- 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>
```

5.6.2.6. Next steps

- After you have created a channel, create a subscription that allows event sinks to subscribe to channels and receive events.
- Configure event delivery parameters that are applied in cases where an event fails to be delivered to an event sink. See Examples of configuring event delivery parameters.

5.6.3. Default channel implementation

You can use the **default-ch-webhook** config map to specify the default channel implementation of Knative Eventing. You can specify the default channel implementation for the entire cluster or for one or more namespaces. Currently the **InMemoryChannel** and **KafkaChannel** channel types are supported.

5.6.3.1. Configuring the default channel implementation

Prerequisites

- You have administrator permissions on OpenShift Container Platform.
- You have installed the OpenShift Serverless Operator and Knative Eventing on your cluster.
- If you want to use Kafka channels as the default channel implementation, you must also install the **KnativeKafka** CR on your cluster.

Procedure

- Modify the **KnativeEventing** custom resource to add configuration details for the **default-ch-webhook** config map:

```
apiVersion: operator.knative.dev/v1beta1
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.

5.6.4. Security configuration for Knative Kafka channels

5.6.4.1. Configuring TLS authentication for Kafka channels

Transport Layer Security (TLS) is used by Apache Kafka clients and servers to encrypt traffic between Knative and Kafka, as well as for authentication. TLS is the only supported method of traffic encryption for Knative Kafka.

Prerequisites

- You have cluster or dedicated administrator permissions on OpenShift Container Platform.
- The OpenShift Serverless Operator, Knative Eventing, and the **KnativeKafka** CR 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.
- You have a Kafka cluster CA certificate stored as a **.pem** file.
- You have a Kafka cluster client certificate and a key stored as **.pem** files.

- Install the OpenShift CLI (**oc**).

Procedure

1. Create the certificate files as secrets in your chosen namespace:

```
$ oc 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
```

5.6.4.2. Configuring SASL authentication for Kafka channels

Simple Authentication and Security Layer (SASL) is used by Apache Kafka for authentication. If you use SASL authentication on your cluster, users must provide credentials to Knative for communicating with the Kafka cluster; otherwise events cannot be produced or consumed.

Prerequisites

- You have cluster or dedicated administrator permissions on OpenShift Container Platform.
- The OpenShift Serverless Operator, Knative Eventing, and the **KnativeKafka** CR 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.
- You have a username and password for a Kafka cluster.
- You have chosen 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.
- Install the OpenShift CLI (**oc**).

Procedure

1. Create the certificate files as secrets in your chosen namespace:

   ```
   $ oc create secret -n <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"
   ```

   - Use the key names **ca.crt**, **password**, and **sasl.mechanism**. Do not change them.
   - 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 -n <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"
     ```

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
```

5.7. SUBSCRIPTIONS

5.7.1. Creating subscriptions

After you have created a channel and an event sink, you can create a subscription to enable event delivery. Subscriptions are created by configuring a **Subscription** object, which specifies the channel and the sink (also known as a *subscriber*) to deliver events to.

5.7.1.1. Creating a subscription by using the Administrator perspective

After you have created a channel and an event sink, also known as a *subscriber*, you can create a subscription to enable event delivery. Subscriptions are created by configuring a **Subscription** object, which specifies the channel and the subscriber to deliver events to. You can also specify some subscriber-specific options, such as how to handle failures.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have logged in to the web console and are in the **Administrator** perspective.
- You have cluster administrator permissions for OpenShift Container Platform.
- You have created a Knative 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 receives events from the channel.
5. Click **Add**.

5.7.1.2. Creating a subscription by using the Developer perspective

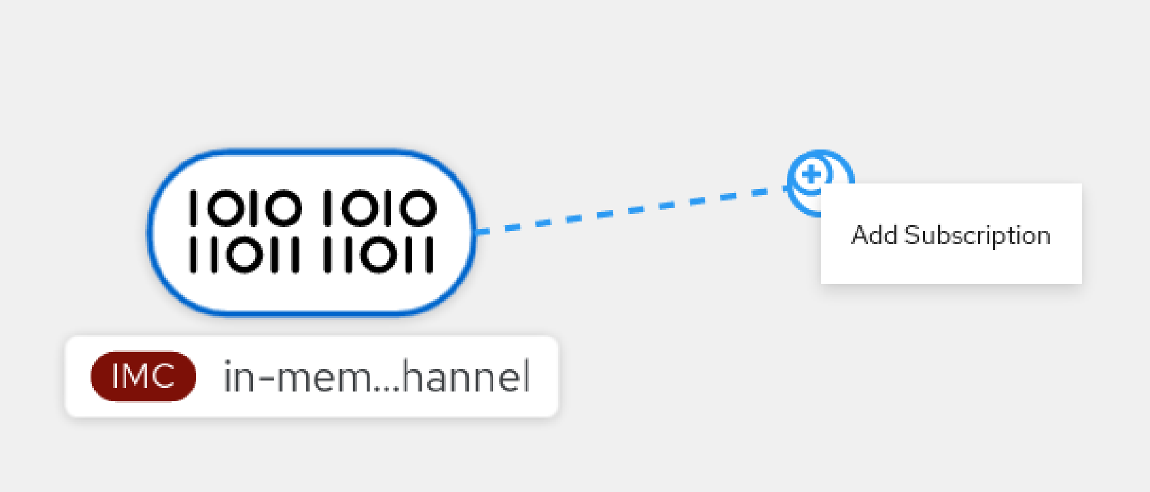
After you have created a channel and an event sink, you can create a subscription to enable event delivery. Using the OpenShift Container Platform web console provides a streamlined and intuitive user interface to create a subscription.

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 have created an event sink, such as a Knative service, and a channel.
- 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 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.



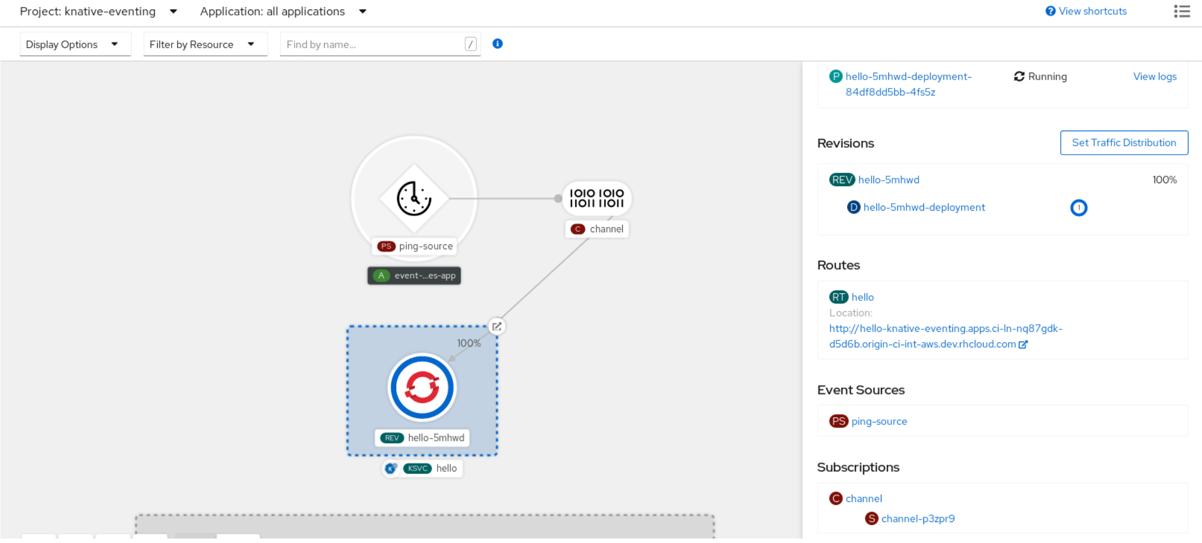
i. Select your sink in the **Subscriber** list.

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:



5.7.1.3. Creating a subscription by using YAML

After you have created a channel and an event sink, you can create a subscription to enable event delivery. Creating Knative resources by using YAML files uses a declarative API, which enables you to describe subscriptions declaratively and in a reproducible manner. To create a subscription by using YAML, you must create a YAML file that defines a **Subscription** object, then apply it by using the **oc apply** command.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on the cluster.

- Install the OpenShift CLI (**oc**).
- 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** 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>
```

5.7.1.4. Creating a subscription by using the Knative CLI

After you have created a channel and an event sink, you can create a subscription to enable event delivery. Using the Knative (**kn**) CLI to create subscriptions provides a more streamlined and intuitive user interface than modifying YAML files directly. You can use the **kn subscription create** command with the appropriate flags to create a subscription.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Container Platform cluster.
- You have installed the Knative (**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
  ```

Deleting a subscription

- Delete a subscription:

  ```
  $ kn subscription delete <subscription_name>
  ```

5.7.1.5. Next steps

- Configure event delivery parameters that are applied in cases where an event fails to be delivered to an event sink. See Examples of configuring event delivery parameters.

5.7.2. Managing subscriptions

5.7.2.1. Describing subscriptions by using the Knative CLI

You can use the **kn subscription describe** command to print information about a subscription in the terminal by using the Knative (**kn**) CLI. Using the Knative CLI to describe subscriptions provides a more streamlined and intuitive user interface than viewing YAML files directly.

Prerequisites

- You have installed the Knative (**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
```

5.7.2.2. Listing subscriptions by using the Knative CLI

You can use the **kn subscription list** command to list existing subscriptions on your cluster by using the Knative (**kn**) CLI. Using the Knative CLI to list subscriptions provides a streamlined and intuitive user interface.

Prerequisites

- You have installed the Knative (**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
```

5.7.2.3. Updating subscriptions by using the Knative CLI

You can use the **kn subscription update** command as well as the appropriate flags to update a subscription from the terminal by using the Knative (**kn**) CLI. Using the Knative CLI to update subscriptions provides a more streamlined and intuitive user interface than updating YAML files directly.

Prerequisites

- You have installed the Knative (**kn**) CLI.
- 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
```

5.8. EVENT DISCOVERY

5.8.1. Listing event sources and event source types

It is possible to view a list of all event sources or event source types that exist or are available for use on your OpenShift Container Platform cluster. You can use the Knative (**kn**) CLI or the **Developer** perspective in the OpenShift Container Platform web console to list available event sources or event source types.

5.8.2. Listing event source types from the command line

Using the Knative (**kn**) CLI provides a streamlined and intuitive user interface to view available event source types on your cluster.

5.8.2.1. Listing available event source types by using the Knative CLI

You can list event source types that can be created and used on your cluster by using the **kn source list-types** CLI command.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on the cluster.
- You have installed the Knative (**kn**) 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
```

5.8.3. Listing event source types from the Developer perspective

It is possible to view a list of all available event source types on your cluster. Using the OpenShift Container Platform web console provides a streamlined and intuitive user interface to view available event source types.

5.8.3.1. Viewing available event source types within the Developer perspective

Prerequisites

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

1. Access the **Developer** perspective.
2. Click **+Add**.
3. Click **Event Source**.
4. View the available event source types.

5.8.4. Listing event sources from the command line

Using the Knative (**kn**) CLI provides a streamlined and intuitive user interface to view existing event sources on your cluster.

5.8.4.1. Listing available event sources by using the Knative CLI

You can list existing event sources by using the **kn source list** command.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on the cluster.
- You have installed the Knative (**kn**) CLI.

Procedure

1. List the existing event sources in the terminal:

   ```
   $ 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
   ```

2. Optional: You can list event sources of a specific type only, by using the **--type** flag:

   ```
   $ kn source list --type <event_source_type>
   ```

   Example command

   ```
   $ kn source list --type PingSource
   ```

   Example output

   ```
   NAME   TYPE              RESOURCE                               SINK         READY
   p1     PingSource        pingsources.sources.knative.dev        ksvc:eshow1   True
   ```

5.9. TUNING EVENTING CONFIGURATION

5.9.1. Overriding Knative Eventing system deployment configurations

You can override the default configurations for some specific deployments by modifying the **deployments** spec in the **KnativeEventing** custom resource (CR). Currently, overriding default configuration settings is supported for the **eventing-controller**, **eventing-webhook**, and **imc-controller** fields, as well as for the **readiness** and **liveness** fields for probes.

IMPORTANT

The **replicas** spec cannot override the number of replicas for deployments that use the Horizontal Pod Autoscaler (HPA), and does not work for the **eventing-webhook** deployment.

NOTE

You can only override probes that are defined in the deployment by default.

All Knative Serving deployments define a readiness and a liveness probe by default, with these exceptions:

- **net-kourier-controller** and **3scale-kourier-gateway** only define a readiness probe.
- **net-istio-controller** and **net-istio-webhook** define no probes.

5.9.1.1. Overriding deployment configurations

Currently, overriding default configuration settings is supported for the **eventing-controller**, **eventing-webhook**, and **imc-controller** fields, as well as for the **readiness** and **liveness** fields for probes.

IMPORTANT

The **replicas** spec cannot override the number of replicas for deployments that use the Horizontal Pod Autoscaler (HPA), and does not work for the **eventing-webhook** deployment.

In the following example, a **KnativeEventing** CR overrides the **eventing-controller** deployment so that:

- The **readiness** probe timeout **eventing-controller** is set to be 10 seconds.
- The deployment has specified CPU and memory resource limits.
- The deployment has 3 replicas.
- The **example-label: label** label is added.
- The **example-annotation: annotation** annotation is added.
- The **nodeSelector** field is set to select nodes with the **disktype: hdd** label.

KnativeEventing CR example

```
apiVersion: operator.knative.dev/v1beta1
kind: KnativeEventing
metadata:
  name: knative-eventing
  namespace: knative-eventing
spec:
  deployments:
  - name: eventing-controller
    readinessProbes: 1
      - container: controller
        timeoutSeconds: 10
    resources:
    - container: eventing-controller
      requests:
        cpu: 300m
        memory: 100Mi
      limits:
        cpu: 1000m
        memory: 250Mi
    replicas: 3
    labels:
      example-label: label
    annotations:
      example-annotation: annotation
    nodeSelector:
      disktype: hdd
```

1 You can use the **readiness** and **liveness** probe overrides to override all fields of a probe in a container of a deployment as specified in the Kubernetes API except for the fields related to the probe handler: **exec**, **grpc**, **httpGet**, and **tcpSocket**.

NOTE

The **KnativeEventing** CR label and annotation settings override the deployment's labels and annotations for both the deployment itself and the resulting pods.

Additional resources

- Probe configuration section of the Kubernetes API documentation

5.9.2. High availability

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 readily available. This controller takes 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 called the leader.

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 called the leader.

5.9.2.1. Configuring high availability replicas for Knative Eventing

High availability (HA) is available by default for the Knative Eventing **eventing-controller**, **eventing-webhook**, **imc-controller**, **imc-dispatcher**, and **mt-broker-controller** components, which are configured to have two replicas each by default. You can change the number of replicas for these components by modifying the **spec.high-availability.replicas** value in the **KnativeEventing** custom resource (CR).

NOTE

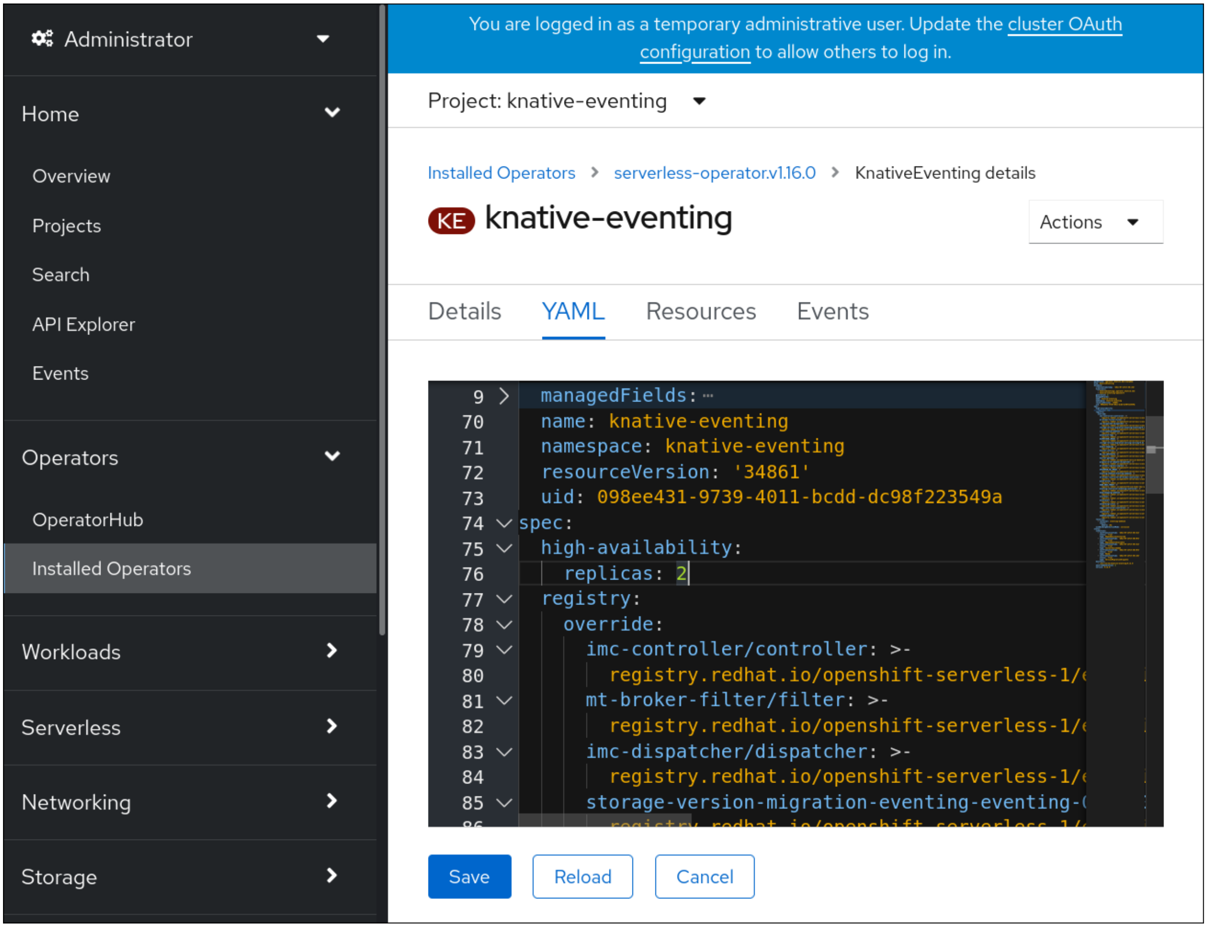
For Knative Eventing, the **mt-broker-filter** and **mt-broker-ingress** deployments are not scaled by HA. If multiple deployments are needed, scale these components manually.

Prerequisites

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



You are logged in as a temporary administrative user. Update the cluster OAuth configuration to allow others to log in.

```
  managedFields: ⋯
  name: knative-eventing
  namespace: knative-eventing
  resourceVersion: '34861'
  uid: 098ee431-9739-4011-bcdd-dc98f223549a
spec:
  high-availability:
    replicas: 2
  registry:
    override:
      imc-controller/controller: >-
        registry.redhat.io/openshift-serverless-1/e
      mt-broker-filter/filter: >-
        registry.redhat.io/openshift-serverless-1/e
      imc-dispatcher/dispatcher: >-
        registry.redhat.io/openshift-serverless-1/e
      storage-version-migration-eventing-eventing-(
```

5. Modify the number of replicas in the **KnativeEventing** CR:

Example YAML

```
apiVersion: operator.knative.dev/v1beta1
kind: KnativeEventing
metadata:
  name: knative-eventing
  namespace: knative-eventing
spec:
  high-availability:
    replicas: 3
```

5.9.2.2. Configuring high availability replicas for Knative Kafka

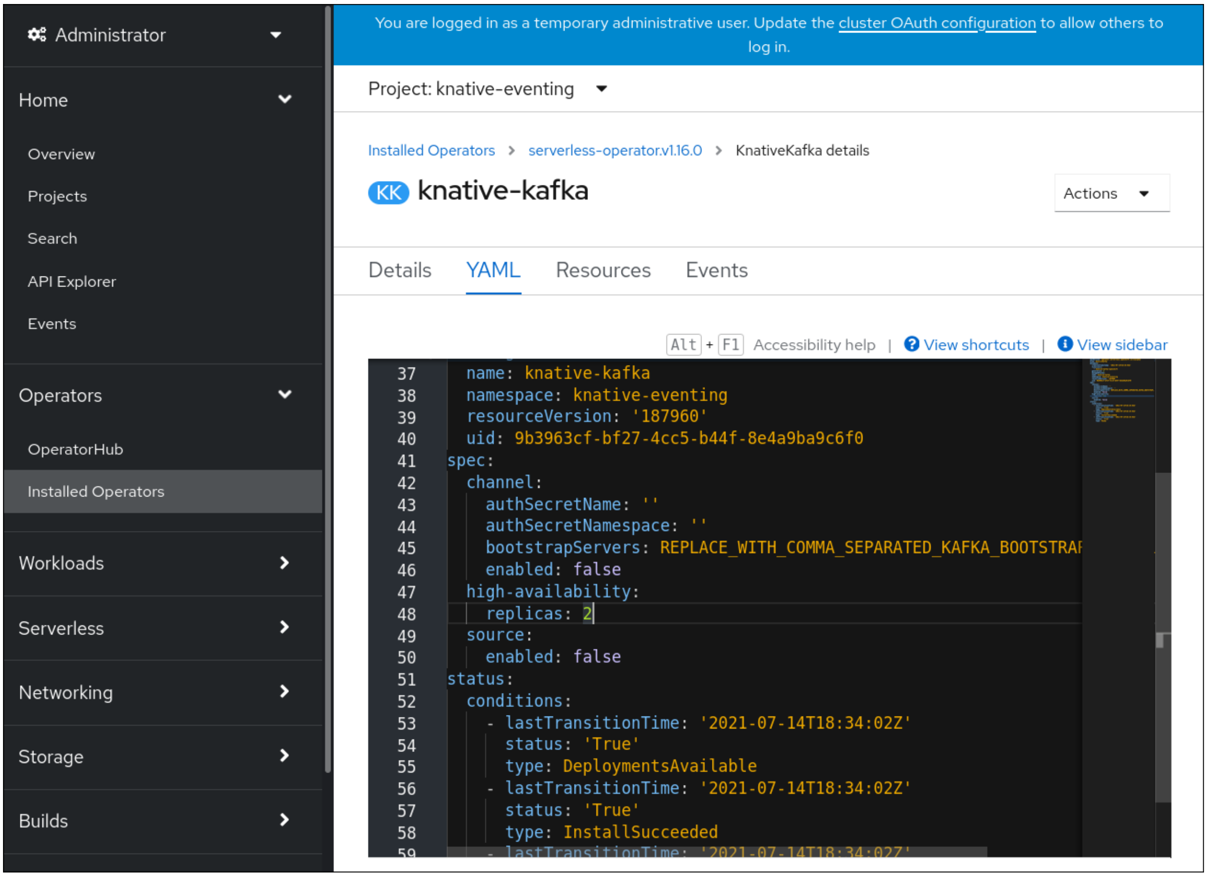
High availability (HA) is available by default for the Knative Kafka **kafka-controller** and **kafka-webhook-eventing** components, which are configured to have two each replicas by default. You can change the number of replicas for these components by modifying the **spec.high-availability.replicas** value in the **KnativeKafka** custom resource (CR).

Prerequisites

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



You are logged in as a temporary administrative user. Update the cluster OAuth configuration to allow others to log in.

```
  name: knative-kafka
  namespace: knative-eventing
  resourceVersion: '187960'
  uid: 9b3963cf-bf27-4cc5-b44f-8e4a9ba9c6f0
spec:
  channel:
    authSecretName: ''
    authSecretNamespace: ''
    bootstrapServers: REPLACE_WITH_COMMA_SEPARATED_KAFKA_BOOTSTRAP
    enabled: false
  high-availability:
    replicas: 2
  source:
    enabled: false
status:
  conditions:
    - lastTransitionTime: '2021-07-14T18:34:02Z'
      status: 'True'
      type: DeploymentsAvailable
    - lastTransitionTime: '2021-07-14T18:34:02Z'
      status: 'True'
      type: InstallSucceeded
    - lastTransitionTime: '2021-07-14T18:34:02Z'
```

5. Modify the number of replicas in the **KnativeKafka** CR:

Example YAML

```
apiVersion: operator.serverless.openshift.io/v1alpha1
kind: KnativeKafka
metadata:
  name: knative-kafka
  namespace: knative-eventing
spec:
  high-availability:
    replicas: 3
```

CHAPTER 6. FUNCTIONS

6.1. SETTING UP OPENSHIFT SERVERLESS FUNCTIONS

To improve the process of deployment of your application code, you can use OpenShift Serverless to deploy stateless, event-driven functions as a Knative service on OpenShift Container Platform. If you want to develop functions, you must complete the set up steps.

6.1.1. Prerequisites

To enable the use of OpenShift Serverless Functions on your cluster, you must complete the following steps:

- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.

  NOTE

  Functions are deployed as a Knative service. If you want to use event-driven architecture with your functions, you must also install Knative Eventing.

- You have the **oc** CLI installed.
- You have the Knative (**kn**) CLI installed. Installing the Knative 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 version 3.4.7 or higher.
- You have access to an available image registry, such as the OpenShift Container 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.

6.1.2. Setting up Podman

To use advanced container management features, you might want to use Podman with OpenShift Serverless Functions. To do so, you need to start the Podman service and configure the Knative (**kn**) CLI to connect to it.

Procedure

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 inside your function project directory with the **-v** flag to see verbose output. You should see a connection to your local UNIX socket:

```
$ kn func build -v
```

6.1.3. Setting up Podman on macOS

To use advanced container management features, you might want to use Podman with OpenShift Serverless Functions. To do so on macOS, you need to start the Podman machine and configure the Knative (**kn**) CLI to connect to it.

Procedure

1. Create the Podman machine:

```
$ podman machine init --memory=8192 --cpus=2 --disk-size=20
```

2. Start the Podman machine, which serves the Docker API on a UNIX socket:

```
$ podman machine start
Starting machine "podman-machine-default"
Waiting for VM ...
Mounting volume... /Users/myuser:/Users/user

[...truncated output...]

You can still connect Docker API clients by setting DOCKER_HOST using the
following command in your terminal session:

 export
DOCKER_HOST='unix:///Users/myuser/.local/share/containers/podman/machine/podman-machine-default/podman.sock'

Machine "podman-machine-default" started successfully
```

> **NOTE**
>
> On most macOS systems, this socket is located at **/Users/myuser/.local/share/containers/podman/machine/podman-machine-default/podman.sock**.

3. Establish the environment variable that is used to build a function:

```
$ export
DOCKER_HOST='unix:///Users/myuser/.local/share/containers/podman/machine/podman-machine-default/podman.sock'
```

4. Run the build command inside your function project directory with the **-v** flag to see verbose output. You should see a connection to your local UNIX socket:

   ```
   $ kn func build -v
   ```

6.1.4. Next steps

- For more information about Docker Container Engine or Podman, see Container build tool options.
- See Getting started with functions.

6.2. GETTING STARTED WITH FUNCTIONS

Function lifecycle management includes creating, building, and deploying a function. Optionally, you can also test a deployed function by invoking it. You can do all of these operations on OpenShift Serverless using the **kn func** tool.

6.2.1. 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.

6.2.2. Creating functions

Before you can build and deploy a function, you must create it by using the Knative (**kn**) CLI. You can specify the path, runtime, template, and image registry as flags on the command line, or use the **-c** flag to start the interactive experience in the terminal.

Prerequisites

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

Procedure

- Create a function project:

  ```
  $ kn func create -r <repository> -l <runtime> -t <template> <path>
  ```

  - Accepted runtime values include **quarkus**, **node**, **typescript**, **go**, **python**, **springboot**, and **rust**.
  - Accepted template values include **http** and **cloudevents**.

    Example command

    ```
    $ kn func create -l typescript -t cloudevents examplefunc
    ```

    Example output

    ```
    Created typescript function in /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

  ```
  Created node function in /home/user/demo/examplefunc
  ```

6.2.3. Running a function locally

You can use the **kn func run** command to run a function locally in the current directory or in the directory specified by the **--path** flag. If the function that you are running has never previously been built, or if the project files have been modified since the last time it was built, the **kn func run** command builds the function before running it by default.

Example command to run a function in the current directory

```
$ kn func run
```

Example command to run a function in a directory specified as a path

```
$ kn func run --path=<directory_path>
```

You can also force a rebuild of an existing image before running the function, even if there have been no changes to the project files, by using the **--build** flag:

Example run command using the build flag

```
$ kn func run --build
```

If you set the **build** flag as false, this disables building of the image, and runs the function using the previously built image:

Example run command using the build flag

```
$ kn func run --build=false
```

You can use the help command to learn more about **kn func run** command options:

Build help command

```
$ kn func help run
```

6.2.4. Building functions

Before you can run a function, you must build the function project. If you are using the **kn func run** command, the function is built automatically. However, you can use the **kn func build** command to build a function without running it, which can be useful for advanced users or debugging scenarios.

The **kn func build** command creates an OCI container image that can be run locally on your computer or on an OpenShift Container Platform cluster. This command uses the function project name and the image registry name to construct a fully qualified image name for your function.

6.2.4.1. Image container types

By default, **kn func build** creates a container image by using Red Hat Source-to-Image (S2I) technology.

Example build command using Red Hat Source-to-Image (S2I)

```
$ kn func build
```

6.2.4.2. Image registry types

The OpenShift Container Registry is used by default as the image registry for storing function images.

Example build command using OpenShift Container Registry

```
$ kn func build
```

Example output

```
Building function image
Function image has been built, image: registry.redhat.io/example/example-function:latest
```

You can override using OpenShift Container Registry as the default image registry by using the **--registry** flag:

Example build command overriding OpenShift Container Registry to use quay.io

```
$ kn func build --registry quay.io/username
```

Example output

```
Building function image
Function image has been built, image: quay.io/username/example-function:latest
```

6.2.4.3. Push flag

You can add the **--push** flag to a **kn func build** command to automatically push the function image after it is successfully built:

Example build command using OpenShift Container Registry

```
$ kn func build --push
```

6.2.4.4. Help command

You can use the help command to learn more about **kn func build** command options:

Build help command

```
$ kn func help build
```

6.2.5. 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

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (**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.
- You must have already created and initialized the function that you want to deploy.

Procedure

- Deploy a function:

  ```
  $ kn func deploy [-n <namespace> -p <path> -i <image>]
  ```

  ##### 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.

6.2.6. Invoking a deployed function with a test event

You can use the **kn func invoke** CLI command to send a test request to invoke a function either locally or on your OpenShift Container Platform cluster. You can use this command to test that a function is working and able to receive events correctly. Invoking a function locally is useful for a quick test during function development. Invoking a function on the cluster is useful for testing that is closer to the production environment.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.

- You have installed the Knative (**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.
- You must have already deployed the function that you want to invoke.

Procedure

- Invoke a function:

  ```
  $ kn func invoke
  ```

  - The **kn func invoke** command only works when there is either a local container image currently running, or when there is a function deployed in the cluster.
  - The **kn func invoke** command executes on the local directory by default, and assumes that this directory is a function project.

6.2.7. Deleting a function

You can delete a function by using the **kn func delete** command. This is useful when a function is no longer required, and can help to save resources on your cluster.

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.

6.2.8. Additional resources

- Exposing a default registry manually
- Marketplace page for the Intellij Knative plugin
- Marketplace page for the Visual Studio Code Knative plugin

6.2.9. Next steps

- See Using functions with Knative Eventing

6.3. ON-CLUSTER FUNCTION BUILDING AND DEPLOYING

Instead of building a function locally, you can build a function directly on the cluster. When using this workflow on a local development machine, you only need to work with the function source code. This is useful, for example, when you cannot install on-cluster function building tools, such as docker or podman.

6.3.1. Building and deploying functions on the cluster

You can use the Knative (**kn**) CLI to initiate a function project build and then deploy the function directly on the cluster. To build a function project in this way, the source code for your function project must exist in a Git repository branch that is accessible to your cluster.

Prerequisites

- Red Hat OpenShift Pipelines must be installed on your cluster.
- You have installed the OpenShift CLI (**oc**).
- You have installed the Knative (**kn**) CLI.

Procedure

1. In each namespace where you want to run Pipelines and deploy a function, you must create the following resources:

   a. Create the **s2i** Tekton task to be able to use Source-to-Image in the pipeline:

   ```
   $ oc apply -f https://raw.githubusercontent.com/openshift-knative/kn-plugin-func/serverless-1.28.0/pipelines/resources/tekton/task/func-s2i/0.1/func-s2i.yaml
   ```

   b. Create the **kn func** deploy Tekton task to be able to deploy the function in the pipeline:

   ```
   $ oc apply -f https://raw.githubusercontent.com/openshift-knative/kn-plugin-func/serverless-1.28.0/pipelines/resources/tekton/task/func-deploy/0.1/func-deploy.yaml
   ```

2. Create a function:

   ```
   $ kn func create <function_name> -l <runtime>
   ```

3. After you have created a new function project, you must add the project to a Git repository and ensure that the repository is available to the cluster. Information about this Git repository is used to update the **func.yaml** file in the next step.

4. Update the configuration in the **func.yaml** file for your function project to enable on-cluster builds for the Git repository:

   ```
   ...
   git:
     url: <git_repository_url> ①
     revision: main ②
     contextDir: <directory_path> ③
   ...
   ```

   ① Required. Specify the Git repository that contains your function's source code.

   ② Optional. Specify the Git repository revision to be used. This can be a branch, tag, or commit.

   ③ Optional. Specify the function's directory path if the function is not located in the Git repository root folder.

5. Implement the business logic of your function. Then, use Git to commit and push the changes.

6. Deploy your function:

   ```
   $ kn func deploy --remote
   ```

   If you are not logged into the container registry referenced in your function configuration, you are prompted to provide credentials for the remote container registry that hosts the function image:

   Example output and prompts

   ```
    Creating Pipeline resources
   Please provide credentials for image registry used by Pipeline.
   ? Server: https://index.docker.io/v1/
   ? Username: my-repo
   ? Password: ********
     Function deployed at URL: http://test-function.default.svc.cluster.local
   ```

7. To update your function, commit and push new changes by using Git, then run the **kn func deploy --remote** command again.

6.3.2. Specifying function revision

When building and deploying a function on the cluster, you must specify the location of the function code by specifying the Git repository, branch, and subdirectory within the repository. You do not need to specify the branch if you use the **main** branch. Similarly, you do not need to specify the subdirectory if your function is at the root of the repository. You can specify these parameters in the **func.yaml** configuration file, or by using flags with the **kn func deploy** command.

Prerequisites

- Red Hat OpenShift Pipelines must be installed on your cluster.
- You have installed the OpenShift (**oc**) CLI.
- You have installed the Knative (**kn**) CLI.

Procedure

- Deploy your function:

  ```
  $ kn func deploy --remote \ 1
                 --git-url <repo-url> \ 2
                 [--git-branch <branch>] \ 3
                 [--git-dir <function-dir>] 4
  ```

  1. With the **--remote** flag, the build runs remotely.
  2. Substitute **<repo-url>** with the URL of the Git repository.
  3. Substitute **<branch>** with the Git branch, tag, or commit. If using the latest commit on the **main** branch, you can skip this flag.

4 Substitute **<function-dir>** with the directory containing the function if it is different than the repository root directory.

For example:

```
$ kn func deploy --remote \
              --git-url https://example.com/alice/myfunc.git \
              --git-branch my-feature \
              --git-dir functions/example-func/
```

6.4. DEVELOPING QUARKUS FUNCTIONS

After you have created a Quarkus function project , you can modify the template files provided to add business logic to your function. This includes configuring function invocation and the returned headers and status codes.

6.4.1. Prerequisites

- Before you can develop functions, you must complete the setup steps in Setting up OpenShift Serverless Functions.

6.4.2. Quarkus function template structure

When you create a Quarkus function by using the Knative (**kn**) CLI, the project directory looks similar to a typical Maven project. Additionally, the project contains the **func.yaml** file, which is used for configuring the function.

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.

6.4.3. 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 6.1. 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**

Invocation method	Data type contained in the instance	Example of data
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
}
```

6.4.3.1. 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\"}"
  ```

6.4.4. 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();
    }
}
```

6.4.5. Quarkus function return values

Functions can return an instance of any type from the list of permitted types. Alternatively, they can return 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.

6.4.5.1. Permitted types

The input and output of a function can be any of the **void**, **String**, or **byte[]** types. Additionally, they can be primitive types and their wrappers, for example, **int** and **Integer**. They can also be the following complex objects: Javabeans, maps, lists, arrays, and the special **CloudEvents<T>** type.

Maps, lists, arrays, the **<T>** type parameter of the **CloudEvents<T>** type, and attributes of Javabeans can only be of types listed here.

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);
}
```

6.4.6. Testing Quarkus functions

Quarkus 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 the **src/test/** directory, which contains basic Maven tests. These tests can be extended as needed.

Prerequisites

- You have created a Quarkus function.

- You have installed the Knative (**kn**) CLI.

Procedure

1. Navigate to the project folder for your function.
2. Run the Maven tests:

```
$ ./mvnw test
```

6.4.7. Next steps

- Build and deploy a function.

6.5. DEVELOPING NODE.JS FUNCTIONS

After you have created a Node.js function project , you can modify the template files provided to add business logic to your function. This includes configuring function invocation and the returned headers and status codes.

6.5.1. Prerequisites

- Before you can develop functions, you must complete the steps in Setting up OpenShift Serverless Functions.

6.5.2. Node.js function template structure

When you create a Node.js function using the Knative (**kn**) CLI, the project directory looks like a typical Node.js project. The only exception is the additional **func.yaml** file, which is used to configure the function.

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.

6.5.3. About invoking Node.js functions

When using the Knative (**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.

6.5.3.1. Node.js context objects

Functions are invoked by providing a **context** object as the first parameter. This object provides access to the incoming HTTP request information.

Example context object

```
function handle(context, data)
```

This information includes 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**.

6.5.3.1.1. 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();
}
```

6.5.3.1.2. 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.

6.5.4. 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'
  })
}
```

6.5.4.1. 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 } };
}
```

6.5.4.2. 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;
  }
}
```

6.5.5. 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 by using **kn func create**, there is a **test** folder that contains some simple unit and integration tests.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (**kn**) CLI.
- You have created a function by using **kn func create**.

Procedure

1. Navigate to the **test** folder for your function.
2. Run the tests:

   ```
   $ npm test
   ```

6.5.6. Next steps

- See the Node.js context object reference documentation.
- Build and deploy a function.

6.6. DEVELOPING TYPESCRIPT FUNCTIONS

After you have created a TypeScript function project , you can modify the template files provided to add business logic to your function. This includes configuring function invocation and the returned headers and status codes.

6.6.1. Prerequisites

- Before you can develop functions, you must complete the steps in Setting up OpenShift Serverless Functions.

6.6.2. TypeScript function template structure

When you create a TypeScript function using the Knative (**kn**) CLI, the project directory looks like a typical TypeScript project. The only exception is the additional **func.yaml** file, which is used for configuring the function.

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.

6.6.3. About invoking TypeScript functions

When using the Knative (**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.

6.6.3.1. TypeScript context objects

To invoke a function, you provide a **context** object as the first parameter. Accessing properties of the **context** object can provide information about the incoming HTTP request.

Example context object

```
function handle(context:Context): string
```

This information includes 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**.

6.6.3.1.1. 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();
}
```

6.6.3.1.2. 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;
}
```

6.6.3.1.3. 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.

6.6.4. 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'
    })
  );
};
```

6.6.4.1. 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 } };
}
```

6.6.4.2. 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;
  }
}
```

6.6.5. 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.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (**kn**) CLI.
- You have created a function by using **kn func create**.

Procedure

1. If you have not previously run tests, install the dependencies first:

   ```
   $ npm install
   ```

2. Navigate to the **test** folder for your function.
3. Run the tests:

   ```
   $ npm test
   ```

6.6.6. Next steps

- See the TypeScript context object reference documentation.

- Build and deploy a function.
- See the Pino API documentation for more information about logging with functions.

6.7. DEVELOPING PYTHON FUNCTIONS

IMPORTANT

OpenShift Serverless Functions with Python 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 Technology Preview Features Support Scope .

After you have created a Python function project , you can modify the template files provided to add business logic to your function. This includes configuring function invocation and the returned headers and status codes.

6.7.1. Prerequisites

- Before you can develop functions, you must complete the steps in Setting up OpenShift Serverless Functions.

6.7.2. Python function template structure

When you create a Python function by using the Knative (**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.

6.7.3. 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
```

6.7.4. Python function return values

Functions can return any value supported by Flask. This is 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.

6.7.4.1. 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.

6.7.5. 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

1. Navigate to the folder for your function that contains the **test_func.py** file.
2. Run the tests:

   ```
   $ python3 test_func.py
   ```

6.7.6. Next steps

- Build and deploy a function.

6.8. USING FUNCTIONS WITH KNATIVE EVENTING

Functions are deployed as Knative services on an OpenShift Container Platform cluster. You can connect functions to Knative Eventing components so that they can receive incoming events.

6.8.1. Connect an event source to a function using the Developer perspective

Functions are deployed as Knative services on an OpenShift Container Platform cluster. When you create an event source by using the OpenShift Container Platform web console, you can specify a deployed function that events are sent to from that source.

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 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.
- You have created and deployed a function.

Procedure

1. Create an event source of any type, by navigating to **+Add → Event Source** and selecting the event source type that you want to create.
2. In the **Sink** section of the **Create Event Source** form view, select your function in the **Resource** list.
3. Click **Create**.

Verification

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

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

6.9. FUNCTION PROJECT CONFIGURATION IN FUNC.YAML

The **func.yaml** file contains the configuration for your function project. Values specified in **func.yaml** are used when you execute a **kn func** command. For example, when you run the **kn func build** command, the value in the **build** field is used. In some cases, you can override these values with command line flags or environment variables.

6.9.1. 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.

6.9.1.1. 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 }}'
```

6.9.1.2. 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.

6.9.1.3. builder

The **builder** field specifies the strategy used by the function to build the image. It accepts values of **pack** or **s2i**.

6.9.1.4. build

The **build** field indicates how the function should be built. The value **local** indicates that the function is built locally on your machine. The value **git** indicates that the function is built on a cluster by using the values specified in the **git** field.

6.9.1.5. 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**.

6.9.1.6. 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
```

6.9.1.7. 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.

6.9.1.8. imageDigest

The **imageDigest** field contains the SHA256 hash of the image manifest when the function is deployed. Do not modify this value.

6.9.1.9. 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 }}'
```

6.9.1.10. 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.

6.9.1.11. namespace

The **namespace** field specifies the namespace in which your function is deployed.

6.9.1.12. runtime

The **runtime** field specifies the language runtime for your function, for example, **python**.

6.9.2. Referencing local environment variables from func.yaml fields

If you want to avoid storing sensitive information such as an API key in the function configuration, you can add a reference to an environment variable available in the local environment. You can do this by modifying the **envs** field in the **func.yaml** file.

Prerequisites

- You need to have the function project created.
- The local environment needs to contain the variable that you want to reference.

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:

  Example function

  ```
  name: test
  namespace: ""
  ```

```
runtime: go
...
envs:
- name: MY_API_KEY
  value: '{{ env:API_KEY }}'
...
```

6.9.3. Additional resources

- Getting started with functions
- Accessing secrets and config maps from Serverless functions
- Knative documentation on Autoscaling
- Kubernetes documentation on managing resources for containers
- Knative documentation on configuring concurrency

6.10. ACCESSING SECRETS AND CONFIG MAPS FROM FUNCTIONS

After your functions have been deployed to the cluster, they 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, or by manually by editing the function configuration YAML file.

IMPORTANT

To access secrets and config maps, the function must 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.

6.10.1. 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. The available operations include listing, adding, and removing values stored in config maps and secrets as environment variables, as well as listing, adding, and removing volumes. This functionality enables you to manage what data stored on the cluster is accessible by your function.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (**kn**) CLI.
- You have created a function.

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
```

6.10.2. Modifying function access to secrets and config maps interactively by using 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>]
  ```

6.10.3. Adding function access to secrets and config maps manually

You can manually add configuration for accessing secrets and config maps to your function. This might be preferable to using the **kn func config** interactive utility and commands, for example when you have an existing configuration snippet.

6.10.3.1. Mounting a secret as a volume

You can mount a secret as a volume. Once a secret is mounted, you can access it from the function as a regular file. This enables you to store on the cluster data needed by the function, for example, a list of URIs that need to be accessed by the function.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (**kn**) CLI.
- You have created a function.

Procedure

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.
     For example, to mount the **addresses** secret, use the following YAML:

     ```
     name: test
     ```

```
namespace: ""
runtime: go
...
volumes:
- configMap: addresses
  path: /workspace/secret-addresses
```

3. Save the configuration.

6.10.3.2. Mounting a config map as a volume

You can mount a config map as a volume. Once a config map is mounted, you can access it from the function as a regular file. This enables you to store on the cluster data needed by the function, for example, a list of URIs that need to be accessed by the function.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (**kn**) CLI.
- You have created a function.

Procedure

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. For example, to mount the **addresses** config map, use the following YAML:

     ```
     name: test
     namespace: ""
     runtime: go
     ...
     volumes:
     - configMap: addresses
       path: /workspace/configmap-addresses
     ```

3. Save the configuration.

6.10.3.3. Setting environment variable from a key value defined in a secret

You can set an environment variable from a key value defined as a secret. A value previously stored in a secret can then be accessed as an environment variable by the function at runtime. This can be useful for getting access to a value stored in a secret, such as the ID of a user.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (**kn**) CLI.
- You have created a function.

Procedure

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.
     For example, to access the user ID that is stored in **userdetailssecret**, use the following YAML:

```
name: test
namespace: ""
runtime: go
...
envs:
- value: '{{ configMap:userdetailssecret:userid }}'
```

3. Save the configuration.

6.10.3.4. Setting environment variable from a key value defined in a config map

You can set an environment variable from a key value defined as a config map. A value previously stored in a config map can then be accessed as an environment variable by the function at runtime. This can be useful for getting access to a value stored in a config map, such as the ID of a user.

Prerequisites

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

- You have created a function.

Procedure

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.
     For example, to access the user ID that is stored in **userdetailsmap**, use the following YAML:

```
name: test
namespace: ""
runtime: go
...
envs:
- value: '{{ configMap:userdetailsmap:userid }}'
```

3. Save the configuration.

6.10.3.5. Setting environment variables from all values defined in a secret

You can set an environment variable from all values defined in a secret. Values previously stored in a secret can then be accessed as environment variables by the function at runtime. This can be useful for simultaneously getting access to a collection of values stored in a secret, for example, a set of data pertaining to a user.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (**kn**) CLI.
- You have created a function.

Procedure

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.

For example, to access all user data that is stored in **userdetailssecret**, use the following YAML:

```
name: test
namespace: ""
runtime: go
...
envs:
- value: '{{ configMap:userdetailssecret }}'
```

3. Save the configuration.

6.10.3.6. Setting environment variables from all values defined in a config map

You can set an environment variable from all values defined in a config map. Values previously stored in a config map can then be accessed as environment variables by the function at runtime. This can be useful for simultaneously getting access to a collection of values stored in a config map, for example, a set of data pertaining to a user.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (**kn**) CLI.
- You have created a function.

Procedure

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.

For example, to access all user data that is stored in **userdetailsmap**, use the following YAML:

```
name: test
namespace: ""
runtime: go
...
envs:
- value: '{{ configMap:userdetailsmap }}'
```

3. Save the file.

6.11. ADDING ANNOTATIONS TO FUNCTIONS

You can add Kubernetes annotations to a deployed Serverless function. Annotations enable you to attach arbitrary metadata to a function, for example, a note about the function's purpose. Annotations are added to the **annotations** section of the **func.yaml** configuration file.

There are two limitations of the function annotation feature:

- After 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 must remove the annotation from the Knative service by modifying the YAML file of the service directly, or by using the OpenShift Container Platform web console.

- You cannot set annotations that are set by Knative, for example, the **autoscaling** annotations.

6.11.1. Adding annotations to a function

You can add annotations to a function. Similar to a label, an annotation is defined as a key-value map. Annotations are useful, for example, for providing metadata about a function, such as the function's author.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.

- You have installed the Knative (**kn**) CLI.

- You have created 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.

6.12. FUNCTIONS DEVELOPMENT REFERENCE GUIDE

OpenShift Serverless Functions provides templates that can be used to create basic functions. A template initiates the function project boilerplate and prepares it for use with the **kn func** tool. Each function template is tailored for a specific runtime and follows its conventions. With a template, you can initiate your function project automatically.

Templates for the following runtimes are available:

- Node.js
- Quarkus
- TypeScript

6.12.1. Node.js context object reference

The **context** object has several properties that can be accessed by the function developer. Accessing these properties can provide information about HTTP requests and write output to the cluster logs.

6.12.1.1. 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 invoke** command:

Example command

```
$ kn func invoke --target '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.

6.12.1.2. 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 **kn func invoke** command:

Example command

```
$ kn func invoke --target 'http://example.com?name=tiger'
```

Example output

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"tiger"}
```

6.12.1.3. 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 invoke -d '{"Hello": "world"}'
```

Example output

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"world"}
```

6.12.1.4. 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 invoke** command:

Example command

```
$ kn func invoke --target 'http://example.function.com'
```

Example output

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"some-value"}
```

6.12.1.5. 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.

6.12.2. TypeScript context object reference

The **context** object has several properties that can be accessed by the function developer. Accessing these properties can provide information about incoming HTTP requests and write output to the cluster logs.

6.12.2.1. 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 invoke** command:

Example command

```
$ kn func invoke --target '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.

6.12.2.2. 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 invoke** command:

Example command

```
$ kn func invoke --target '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"}
```

6.12.2.3. 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 invoke** command:

Example command

```
$ kn func invoke --target 'http://example.function.com' --data '{"hello": "world"}'
```

Example output

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"w
orld"}
```

6.12.2.4. 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":"so
me-value"}
```

6.12.2.5. 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 7. KNATIVE CLI

7.1. KNATIVE SERVING CLI COMMANDS

7.1.1. kn service commands

You can use the following commands to create and manage Knative services.

7.1.1.1. Creating serverless applications by using the Knative CLI

Using the Knative (**kn**) CLI to create serverless applications provides a more streamlined and intuitive user interface over modifying YAML files directly. You can use the **kn service create** command to create a basic serverless application.

Prerequisites

- OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have installed the Knative (**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 Knative service:

  ```
  $ kn service create <service-name> --image <image> --tag <tag-value>
  ```

  Where:

  - **--image** is the URI of the image for the application.
  - **--tag** is an optional flag that can be used to add a tag to the initial revision that is created with the service.

    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
    ```

–

7.1.1.2. 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
  ```

7.1.1.3. 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>
```

7.1.1.4. 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
```

7.1.2. kn service commands in offline mode

7.1.2.1. About the Knative CLI offline mode

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. When you create a service in offline mode, no changes happen on the cluster, and instead the service descriptor file is created on your local machine.

IMPORTANT

The offline mode of the Knative 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 Technology Preview Features Support Scope .

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

7.1.2.2. Creating a service using offline mode

You can execute **kn service** commands in offline mode, so that no changes happen on the cluster, and instead the service descriptor file is created on your local machine. After the descriptor file is created, you can modify the file before propagating changes to the cluster.

IMPORTANT

The offline mode of the Knative 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 Technology Preview Features Support Scope .

Prerequisites

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

7.1.3. kn container commands

You can use the following commands to create and manage multiple containers in a Knative service spec.

7.1.3.1. 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.

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
  ```

7.1.4. kn domain commands

You can use the following commands to create and manage domain mappings.

7.1.4.1. Creating a custom domain mapping by using the Knative CLI

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 Knative (**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

- 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
  ```

  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.

- 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
  ```

7.1.4.2. 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 Knative (**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 Knative (**kn**) CLI tool.
- 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

- 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>
  ```

7.2. CONFIGURING THE KNATIVE CLI

You can customize your Knative (**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 Knative (**kn**) CLI looks for is **$XDG_CONFIG_HOME/kn**.
- If the **XDG_CONFIG_HOME** environment variable is not set, the Knative (**kn**) CLI looks for the configuration in the home directory of the user at **$HOME/.config/kn/config.yaml**.

For Windows systems, the default Knative (**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 Knative (**kn**) CLI should look for plugins in the **PATH** environment variable. This is a boolean configuration option. The default value is **false**.

2 Specifies the directory where the Knative (**kn**) CLI looks for plugins. The default path depends on the operating system, as described previously. 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 Knative (**kn**) CLI command.

4 The prefix you want to use to describe your sink. **svc** for a service, **channel**, and **broker** are predefined prefixes for the Knative (**kn**) CLI.

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**.

7.3. KNATIVE CLI PLUGINS

The Knative (**kn**) CLI supports the use of plugins, 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. Knative (**kn**) CLI plugins are used in the same way as the main **kn** functionality.

Currently, Red Hat supports the **kn-source-kafka** plugin and the **kn-event** plugin.

IMPORTANT

The **kn-event** plugin 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 Technology Preview Features Support Scope .

7.3.1. Building events by using the kn-event plugin

You can use the builder-like interface of the **kn event build** command to build an event. You can then send that event at a later time or use it in another context.

Prerequisites

- You have installed the Knative (**kn**) CLI.

Procedure

- Build an event:

  ```
  $ kn event build --field <field-name>=<value> --type <type-name> --id <id> --output <format>
  ```

  where:

  - The **--field** flag adds data to the event as a field-value pair. You can use it multiple times.
  - The **--type** flag enables you to specify a string that designates the type of the event.
  - The **--id** flag specifies the ID of the event.
  - You can use the **json** or **yaml** arguments with the **--output** flag to change the output format of the event.
    All of these flags are optional.

  #### Building a simple event

  ```
  $ kn event build -o yaml
  ```

  #### Resultant event in the YAML format

  ```
  data: {}
  datacontenttype: application/json
  id: 81a402a2-9c29-4c27-b8ed-246a253c9e58
  source: kn-event/v0.4.0
  specversion: "1.0"
  time: "2021-10-15T10:42:57.713226203Z"
  type: dev.knative.cli.plugin.event.generic
  ```

  #### Building a sample transaction event

  ```
  $ kn event build \
      --field operation.type=local-wire-transfer \
      --field operation.amount=2345.40 \
      --field operation.from=87656231 \
      --field operation.to=2344121 \
      --field automated=true \
      --field signature='FGzCPLvYWdEgsdpb3qXkaVp7Da0=' \
      --type org.example.bank.bar \
      --id $(head -c 10 < /dev/urandom | base64 -w 0) \
      --output json
  ```

  #### Resultant event in the JSON format

  ```
  {
    "specversion": "1.0",
    "id": "RjtL8UH66X+UJg==",
    "source": "kn-event/v0.4.0",
    "type": "org.example.bank.bar",
  ```

```
  "datacontenttype": "application/json",
  "time": "2021-10-15T10:43:23.113187943Z",
  "data": {
    "automated": true,
    "operation": {
      "amount": "2345.40",
      "from": 87656231,
      "to": 2344121,
      "type": "local-wire-transfer"
    },
    "signature": "FGzCPLvYWdEgsdpb3qXkaVp7Da0="
  }
}
```

7.3.2. Sending events by using the kn-event plugin

You can use the **kn event send** command to send an event. The events can be sent either to publicly available addresses or to addressable resources inside a cluster, such as Kubernetes services, as well as Knative services, brokers, and channels. The command uses the same builder-like interface as the **kn event build** command.

Prerequisites

- You have installed the Knative (**kn**) CLI.

Procedure

- Send an event:

  ```
  $ kn event send --field <field-name>=<value> --type <type-name> --id <id> --to-url <url> --to
  <cluster-resource> --namespace <namespace>
  ```

  where:

  - The **--field** flag adds data to the event as a field-value pair. You can use it multiple times.
  - The **--type** flag enables you to specify a string that designates the type of the event.
  - The **--id** flag specifies the ID of the event.
  - If you are sending the event to a publicly accessible destination, specify the URL using the **--to-url** flag.
  - If you are sending the event to an in-cluster Kubernetes resource, specify the destination using the **--to** flag.
    - Specify the Kubernetes resource using the **<Kind>:<ApiVersion>:<name>** format.
  - The **--namespace** flag specifies the namespace. If omitted, the namespace is taken from the current context.
    All of these flags are optional, except for the destination specification, for which you need to use either **--to-url** or **--to**.

    The following example shows sending an event to a URL:

Example command

```
$ kn event send \
    --field player.id=6354aa60-ddb1-452e-8c13-24893667de20 \
    --field player.game=2345 \
    --field points=456 \
    --type org.example.gaming.foo \
    --to-url http://ce-api.foo.example.com/
```

The following example shows sending an event to an in-cluster resource:

Example command

```
$ kn event send \
    --type org.example.kn.ping \
    --id $(uuidgen) \
    --field event.type=test \
    --field event.data=98765 \
    --to Service:serving.knative.dev/v1:event-display
```

7.4. KNATIVE EVENTING CLI COMMANDS

7.4.1. kn source commands

You can use the following commands to list, create, and manage Knative event sources.

7.4.1.1. Listing available event source types by using the Knative CLI

You can list event source types that can be created and used on your cluster by using the **kn source list-types** CLI command.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on the cluster.
- You have installed the Knative (**kn**) 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
```

7.4.1.2. Knative CLI sink flag

When you create an event source 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 sink can be any addressable or callable resource that can receive incoming events from other resources.

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**.

7.4.1.3. Creating and managing container sources by using the Knative CLI

You can use the **kn source container** commands to create and manage container sources by using the Knative (**kn**) CLI. Using the Knative CLI to create event sources provides a more streamlined and intuitive user interface than modifying YAML files directly.

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>
```

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

You can use the **kn source apiserver create** command to create an API server source by using the **kn** CLI. Using the **kn** CLI to create an API server source provides a more streamlined and intuitive user interface than modifying YAML files directly.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on the 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 installed the OpenShift CLI (**oc**).
- You have installed the Knative (**kn**) CLI.

PROCEDURE

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.

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

```
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>
```

3. Create an API server source that has an event sink. In the following example, the sink is a broker:

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

4. 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
```

5. If you used a broker as an event sink, create a trigger to filter events from the **default** broker to the service:

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

6. 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
```

7. 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",
  ...
}
```

Deleting the API server source

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
```

7.4.1.5. Creating a ping source by using the Knative CLI

You can use the **kn source ping create** command to create a ping source by using the Knative (**kn**) CLI. Using the Knative CLI to create event sources provides a more streamlined and intuitive user interface than modifying YAML files directly.

Prerequisites

- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on the cluster.
- You have installed the Knative (**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.
- Optional: If you want to use the verification steps for this procedure, install the OpenShift CLI (**oc**).

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!"
  }
```

Deleting the ping source

- Delete the ping source:

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

7.4.1.6. Creating a Kafka event source by using the Knative CLI

You can use the **kn source kafka create** command to create a Kafka source by using the Knative (**kn**) CLI. Using the Knative CLI to create event sources provides a more streamlined and intuitive user interface than modifying YAML files directly.

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.
- You have installed the Knative (**kn**) CLI.
- Optional: You have installed the OpenShift CLI (**oc**) if you want to use the verification steps in this procedure.

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!
```

7.5. KNATIVE FUNCTIONS CLI COMMANDS

7.5.1. kn functions commands

7.5.1.1. Creating functions

Before you can build and deploy a function, you must create it by using the Knative (**kn**) CLI. You can specify the path, runtime, template, and image registry as flags on the command line, or use the **-c** flag to start the interactive experience in the terminal.

Prerequisites

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

Procedure

- Create a function project:

  ```
  $ kn func create -r <repository> -l <runtime> -t <template> <path>
  ```

  - Accepted runtime values include **quarkus**, **node**, **typescript**, **go**, **python**, **springboot**, and **rust**.
  - Accepted template values include **http** and **cloudevents**.

    Example command

    ```
    $ kn func create -l typescript -t cloudevents examplefunc
    ```

    Example output

    ```
    Created typescript function in /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

```
Created node function in /home/user/demo/examplefunc
```

7.5.1.2. Running a function locally

You can use the **kn func run** command to run a function locally in the current directory or in the directory specified by the **--path** flag. If the function that you are running has never previously been built, or if the project files have been modified since the last time it was built, the **kn func run** command builds the function before running it by default.

Example command to run a function in the current directory

```
$ kn func run
```

Example command to run a function in a directory specified as a path

```
$ kn func run --path=<directory_path>
```

You can also force a rebuild of an existing image before running the function, even if there have been no changes to the project files, by using the **--build** flag:

Example run command using the build flag

```
$ kn func run --build
```

If you set the **build** flag as false, this disables building of the image, and runs the function using the previously built image:

Example run command using the build flag

```
$ kn func run --build=false
```

You can use the help command to learn more about **kn func run** command options:

Build help command

```
$ kn func help run
```

7.5.1.3. Building functions

Before you can run a function, you must build the function project. If you are using the **kn func run** command, the function is built automatically. However, you can use the **kn func build** command to build a function without running it, which can be useful for advanced users or debugging scenarios.

The **kn func build** command creates an OCI container image that can be run locally on your computer or on an OpenShift Container Platform cluster. This command uses the function project name and the image registry name to construct a fully qualified image name for your function.

7.5.1.3.1. Image container types

By default, **kn func build** creates a container image by using Red Hat Source-to-Image (S2I) technology.

Example build command using Red Hat Source-to-Image (S2I)

```
$ kn func build
```

7.5.1.3.2. Image registry types

The OpenShift Container Registry is used by default as the image registry for storing function images.

Example build command using OpenShift Container Registry

```
$ kn func build
```

Example output

```
Building function image
Function image has been built, image: registry.redhat.io/example/example-function:latest
```

You can override using OpenShift Container Registry as the default image registry by using the **--registry** flag:

Example build command overriding OpenShift Container Registry to use quay.io

```
$ kn func build --registry quay.io/username
```

Example output

```
Building function image
Function image has been built, image: quay.io/username/example-function:latest
```

7.5.1.3.3. Push flag

You can add the **--push** flag to a **kn func build** command to automatically push the function image after it is successfully built:

Example build command using OpenShift Container Registry

```
$ kn func build --push
```

7.5.1.3.4. Help command

You can use the help command to learn more about **kn func build** command options:

Build help command

```
$ kn func help build
```

7.5.1.4. 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

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (**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.
- You must have already created and initialized the function that you want to deploy.

Procedure

- Deploy a function:

  ```
  $ kn func deploy [-n <namespace> -p <path> -i <image>]
  ```

  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.

7.5.1.5. 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
```

7.5.1.6. 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
```

7.5.1.7. Invoking a deployed function with a test event

You can use the **kn func invoke** CLI command to send a test request to invoke a function either locally or on your OpenShift Container Platform cluster. You can use this command to test that a function is working and able to receive events correctly. Invoking a function locally is useful for a quick test during function development. Invoking a function on the cluster is useful for testing that is closer to the production environment.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (**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.
- You must have already deployed the function that you want to invoke.

Procedure

- Invoke a function:

```
$ kn func invoke
```

  - The **kn func invoke** command only works when there is either a local container image currently running, or when there is a function deployed in the cluster.
  - The **kn func invoke** command executes on the local directory by default, and assumes that this directory is a function project.

7.5.1.7.1. kn func invoke optional parameters

You can specify optional parameters for the request by using the following **kn func invoke** CLI command flags.

Flags	Description
-t, **--target**	Specifies the target instance of the invoked function, for example, **local** or **remote** or **https://staging.example.com/**. The default target is **local**.
-f, **--format**	Specifies the format of the message, for example, **cloudevent** or **http**.
--id	Specifies a unique string identifier for the request.
-n, **--namespace**	Specifies the namespace on the cluster.
--source	Specifies sender name for the request. This corresponds to the CloudEvent **source** attribute.
--type	Specifies the type of request, for example, **boson.fn**. This corresponds to the CloudEvent **type** attribute.
--data	Specifies content for the request. For CloudEvent requests, this is the CloudEvent **data** attribute.
--file	Specifies path to a local file containing data to be sent.
--content-type	Specifies the MIME content type for the request.
-p, **--path**	Specifies path to the project directory.
-c, **--confirm**	Enables prompting to interactively confirm all options.

Flags	Description
-v, **--verbose**	Enables printing verbose output.
-h, **--help**	Prints information on usage of **kn func invoke**.

7.5.1.7.1.1. Main parameters

The following parameters define the main properties of the **kn func invoke** command:

Event target (**-t**, **--target**)

The target instance of the invoked function. Accepts the **local** value for a locally deployed function, the **remote** value for a remotely deployed function, or a URL for a function deployed to an arbitrary endpoint. If a target is not specified, it defaults to **local**.

Event message format (**-f**, **--format**)

The message format for the event, such as **http** or **cloudevent**. This defaults to the format of the template that was used when creating the function.

Event type (**--type**)

The type of event that is sent. You can find information about the **type** parameter that is set in the documentation for each event producer. For example, the API server source might set the **type** parameter of produced events as **dev.knative.apiserver.resource.update**.

Event source (**--source**)

The unique event source that produced the event. This might be a URI for the event source, for example **https://10.96.0.1/**, or the name of the event source.

Event ID (**--id**)

A random, unique ID that is created by the event producer.

Event data (**--data**)

Allows you to specify a **data** value for the event sent by the **kn func invoke** 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 invoke**.

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 format, which captures the domain specific context of the event. By 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. In this case, specify the content type using **--content-type**.

Data content type (**--content-type**)

If you are using the **--data** flag to add data for events, you can use the **--content-type** flag to specify what type of data is carried by the event. In the previous example, the data is plain text, so you might specify **kn func invoke --data "Hello world!" --content-type "text/plain"**.

7.5.1.7.1.2. Example commands

This is the general invocation of the **kn func invoke** command:

```
$ kn func invoke --type <event_type> --source <event_source> --data <event_data> --content-type
<content_type> --id <event_ID> --format <format> --namespace <namespace>
```

For example, to send a "Hello world!" event, you can run:

```
$ kn func invoke --type ping --source example-ping --data "Hello world!" --content-type "text/plain" --
id example-ID --format http --namespace my-ns
```

7.5.1.7.1.2.1. Specifying the file with data

To specify the file on disk that contains the event data, use the **--file** and **--content-type** flags:

```
$ kn func invoke --file <path> --content-type <content-type>
```

For example, to send JSON data stored in the **test.json** file, use this command:

```
$ kn func invoke --file ./test.json --content-type application/json
```

7.5.1.7.1.2.2. Specifying the function project

You can specify a path to the function project by using the **--path** flag:

```
$ kn func invoke --path <path_to_function>
```

For example, to use the function project located in the **./example/example-function** directory, use this command:

```
$ kn func invoke --path ./example/example-function
```

7.5.1.7.1.2.3. Specifying where the target function is deployed

By default, **kn func invoke** targets the local deployment of the function:

```
$ kn func invoke
```

To use a different deployment, use the **--target** flag:

```
$ kn func invoke --target <target>
```

For example, to use the function deployed on the cluster, use the **--target remote** flag:

```
$ kn func invoke --target remote
```

To use the function deployed at an arbitrary URL, use the **--target <URL>** flag:

```
$ kn func invoke --target "https://my-event-broker.example.com"
```

You can explicitly target the local deployment. In this case, if the function is not running locally, the command fails:

```
$ kn func invoke --target local
```

7.5.1.8. Deleting a function

You can delete a function by using the **kn func delete** command. This is useful when a function is no longer required, and can help to save resources on your cluster.

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.

CHAPTER 8. OBSERVABILITY

8.1. ADMINISTRATOR METRICS

8.1.1. Serverless administrator metrics

Metrics enable cluster administrators to monitor how OpenShift Serverless cluster components and workloads are performing.

You can view different metrics for OpenShift Serverless by navigating to **Dashboards** in the OpenShift Container Platform web console **Administrator** perspective.

8.1.1.1. Prerequisites

- See the OpenShift Container Platform documentation on Managing metrics for information about enabling metrics for your cluster.
- You have access to an OpenShift Container Platform account with cluster administrator access.
- You have access to the **Administrator** perspective in the OpenShift Container Platform web console.

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 Enabling Knative Serving metrics when using Service Mesh with mTLS.

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.

8.1.2. Serverless 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)

Metric name	Description	Type	Tags	Unit
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
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

8.1.3. 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

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)
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

8.1.4. 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).

8.1.4.1. 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

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

8.1.4.2. 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

Metric name	Description	Type	Tags	Unit
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

8.1.4.3. 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
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

8.1.4.4. 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

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)
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)

8.1.5. Knative Serving metrics

Cluster administrators can view the following metrics for Knative Serving components.

8.1.5.1. 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)

Metric name	Description	Type	Tags	Unit
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)
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

8.1.5.2. 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)

Metric name	Description	Type	Tags	Unit
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)
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)

Metric name	Description	Type	Tags	Unit
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)
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)

8.1.5.3. 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

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)
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)

Metric name	Description	Type	Tags	Unit
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)
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)

Metric name	Description	Type	Tags	Unit
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)
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)

Metric name	Description	Type	Tags	Unit
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)

8.2. DEVELOPER METRICS

8.2.1. Serverless developer metrics overview

Metrics enable developers to monitor how Knative services are performing. You can use the OpenShift Container Platform monitoring stack to record and view health checks and metrics for your Knative services.

You can view different metrics for OpenShift Serverless by navigating to **Dashboards** in the OpenShift Container Platform 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 Enabling Knative Serving metrics when using Service Mesh with mTLS.
>
> 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.

8.2.1.1. Additional resources

- Monitoring overview
- Enabling monitoring for user-defined projects
- Specifying how a service is monitored

8.2.2. Knative service metrics exposed by default

Table 8.1. 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 8.2. 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"

8.2.3. 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.

8.2.4. 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 ❶
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 ❷
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 ❸
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.

8.2.5. 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.

Prerequisites

- You have logged in to the OpenShift Container Platform web console.
- You have installed the OpenShift Serverless Operator and Knative Serving.

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!
   ```

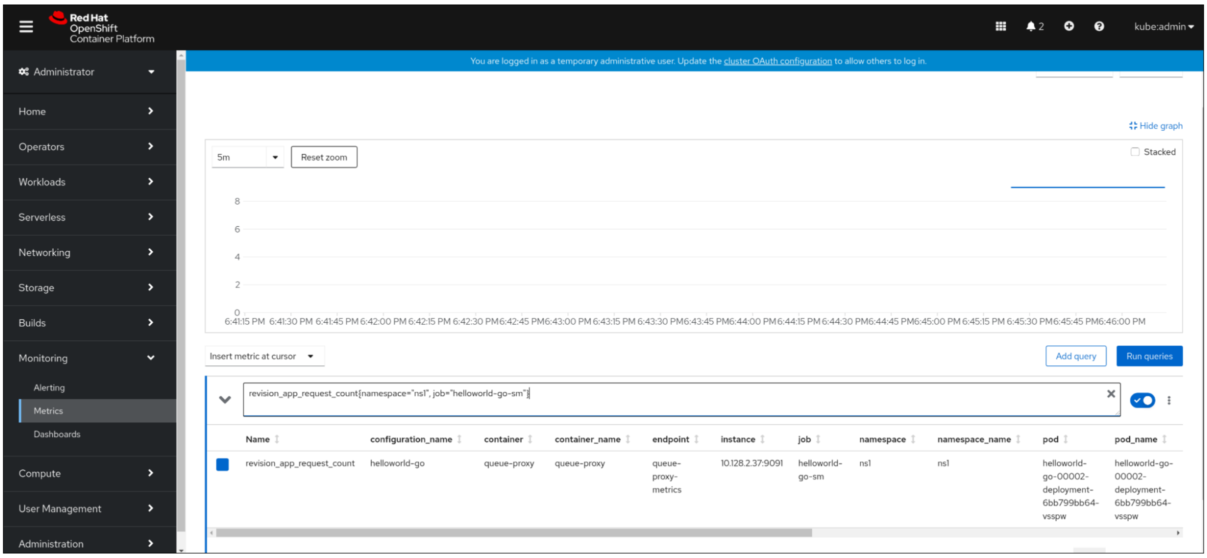
2. In the web console, navigate to the **Observe** → **Metrics** interface.
3. In the input field, enter the query for the metric you want to observe, for example:

   ```
   revision_app_request_count{namespace="ns1", job="helloworld-go-sm"}
   ```

   Another example:

   ```
   myapp_processed_ops_total{namespace="ns1", job="helloworld-go-sm"}
   ```

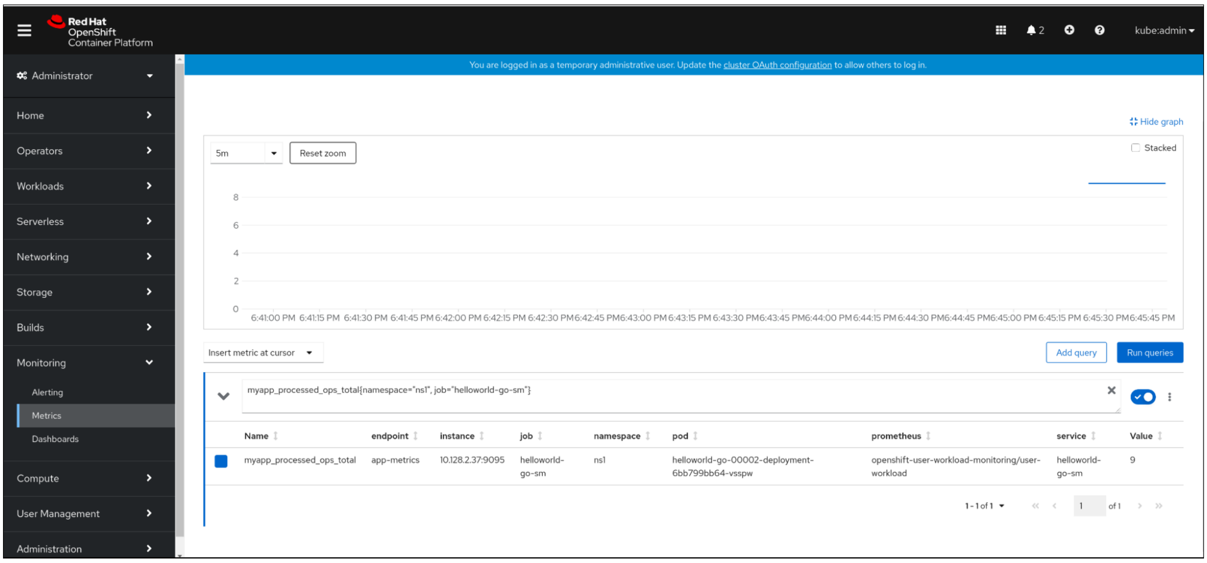
4. Observe the visualized metrics:



You are logged in as a temporary administrative user. Update the cluster OAuth configuration to allow others to log in.

```
revision_app_request_count{namespace="ns1", job="helloworld-go-sm"}
```

Name	configuration_name	container	container_name	endpoint	instance	job	namespace	namespace_name	pod	pod_name
revision_app_request_count	helloworld-go	queue-proxy	queue-proxy	queue-proxy-metrics	10.128.2.37:9091	helloworld-go-sm	ns1	ns1	helloworld-go-00002-deployment-6bb799bb64-vsspw	helloworld-go-00002-deployment-6bb799bb64-vsspw



You are logged in as a temporary administrative user. Update the cluster OAuth configuration to allow others to log in.

```
myapp_processed_ops_total{namespace="ns1", job="helloworld-go-sm"}
```

Name	endpoint	instance	job	namespace	pod	prometheus	service	Value
myapp_processed_ops_total	app-metrics	10.128.2.37:9095	helloworld-go-sm	ns1	helloworld-go-00002-deployment-6bb799bb64-vsspw	openshift-user-workload-monitoring/user-workload	helloworld-go-sm	9

8.2.5.1. 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)

Metric name	Description	Type	Tags	Unit
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
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)

8.2.6. Dashboard for service metrics

You can examine the metrics using a dedicated dashboard that aggregates queue proxy metrics by namespace.

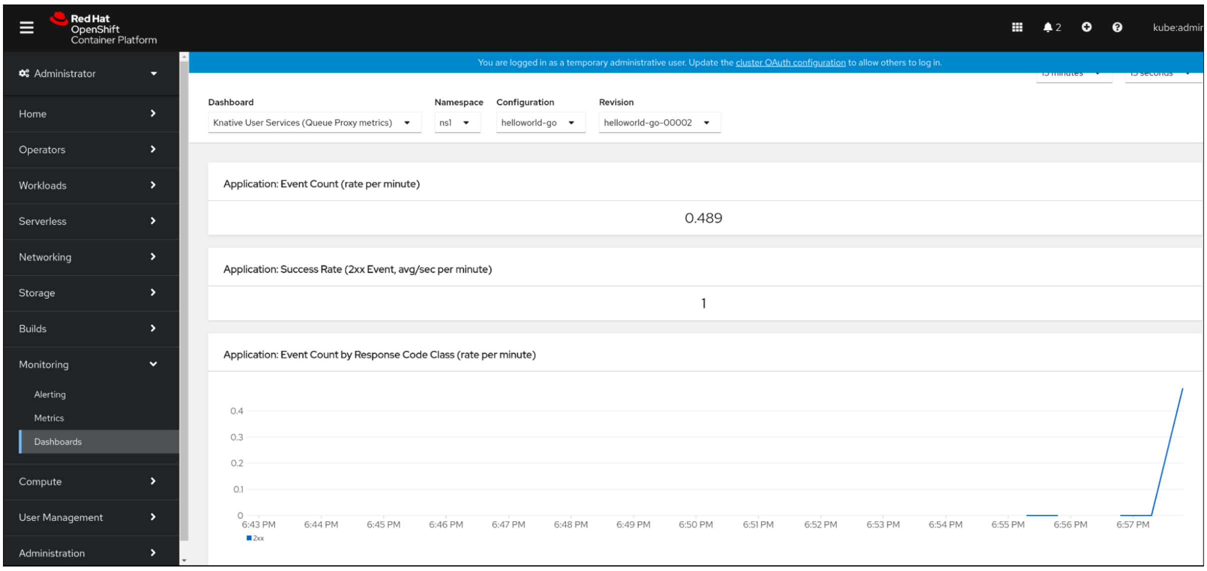
8.2.6.1. Examining metrics of a service in the dashboard

Prerequisites

- You have logged in to the OpenShift Container Platform web console.
- You have installed the OpenShift Serverless Operator and Knative Serving.

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:



You are logged in as a temporary administrative user. Update the cluster OAuth configuration to allow others to log in.

Dashboard: Knative User Services (Queue Proxy metrics)
Namespace: ns1
Configuration: helloworld-go
Revision: helloworld-go-00002

Application: Event Count (rate per minute)

0.489

Application: Success Rate (2xx Event, avg/sec per minute)

1

Application: Event Count by Response Code Class (rate per minute)

8.3. CLUSTER LOGGING

8.3.1. Using OpenShift Logging with OpenShift Serverless

8.3.1.1. About deploying the logging subsystem for Red Hat OpenShift

OpenShift Container Platform cluster administrators can deploy the logging subsystem 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 logging subsystem pods and other resources necessary to support the logging subsystem. The Operators are responsible for deploying, upgrading, and maintaining the logging subsystem.

The **ClusterLogging** CR defines a complete logging subsystem environment that includes all the components of the logging stack to collect, store and visualize logs. The Red Hat OpenShift Logging Operator watches the logging subsystem CR and adjusts the logging deployment accordingly.

Administrators and application developers can view the logs of the projects for which they have view access.

8.3.1.2. About deploying and configuring the logging subsystem for Red Hat OpenShift

The logging subsystem 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 logging subsystem instance and configure your logging subsystem environment.

If you want to use the default logging subsystem 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.

8.3.1.2.1. Configuring and Tuning the logging subsystem

You can configure your logging subsystem 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.

8.3.1.2.2. 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
```

8.3.2. Finding logs for Knative Serving components

You can find the logs for Knative Serving components using the following procedure.

8.3.2.1. Using OpenShift Logging to find logs for Knative Serving components

Prerequisites

- Install the OpenShift CLI (**oc**).

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.

8.3.3. Finding logs for Knative Serving services

You can find the logs for Knative Serving services using the following procedure.

8.3.3.1. 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.

Prerequisites

- Install the OpenShift CLI (**oc**).

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.

8.4. TRACING

8.4.1. Tracing requests

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.

8.4.1.1. Distributed tracing overview

As a service owner, you can use distributed tracing to instrument your services to gather insights into your service architecture. You can use distributed tracing for monitoring, network profiling, and troubleshooting the interaction between components in modern, cloud-native, microservices-based applications.

With distributed tracing you can perform the following functions:

- Monitor distributed transactions
- Optimize performance and latency
- Perform root cause analysis

Red Hat OpenShift distributed tracing consists of two main components:

- **Red Hat OpenShift distributed tracing platform** - This component is based on the open source Jaeger project.
- **Red Hat OpenShift distributed tracing data collection**- This component is based on the open source OpenTelemetry project.

Both of these components are based on the vendor-neutral OpenTracing APIs and instrumentation.

8.4.1.2. Additional resources

- Red Hat OpenShift distributed tracing architecture
- Installing distributed tracing

8.4.2. Using Red Hat OpenShift distributed tracing

You can use Red Hat OpenShift distributed tracing with OpenShift Serverless to monitor and troubleshoot serverless applications.

8.4.2.1. Using Red Hat OpenShift distributed tracing to enable distributed tracing

Red Hat OpenShift distributed tracing is made up of several components that work together to collect, store, and display tracing data.

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- You have not yet installed the OpenShift Serverless Operator, Knative Serving, and Knative Eventing. These must be installed after the Red Hat OpenShift distributed tracing installation.
- You have installed Red Hat OpenShift distributed tracing by following the OpenShift Container Platform "Installing distributed tracing" documentation.
- You have installed the OpenShift CLI (**oc**).
- 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 **OpenTelemetryCollector** custom resource (CR):

   Example OpenTelemetryCollector CR

```
apiVersion: opentelemetry.io/v1alpha1
kind: OpenTelemetryCollector
metadata:
  name: cluster-collector
  namespace: <namespace>
spec:
  mode: deployment
  config: |
    receivers:
      zipkin:
    processors:
    exporters:
      jaeger:
        endpoint: jaeger-all-in-one-inmemory-collector-headless.tracing-system.svc:14250
        tls:
          ca_file: "/var/run/secrets/kubernetes.io/serviceaccount/service-ca.crt"
      logging:
    service:
      pipelines:
        traces:
          receivers: [zipkin]
          processors: []
          exporters: [jaeger, logging]
```

2. Verify that you have two pods running in the namespace where Red Hat OpenShift distributed tracing is installed:

```
$ oc get pods -n <namespace>
```

Example output

```
NAME                                      READY   STATUS    RESTARTS   AGE
cluster-collector-collector-85c766b5c-b5g99   1/1     Running   0          5m56s
jaeger-all-in-one-inmemory-ccbc9df4b-ndkl5    2/2     Running   0          15m
```

3. Verify that the following headless services have been created:

```
$ oc get svc -n <namespace> | grep headless
```

Example output

```
cluster-collector-collector-headless            ClusterIP   None            <none>        9411/TCP
7m28s
jaeger-all-in-one-inmemory-collector-headless   ClusterIP   None            <none>
9411/TCP,14250/TCP,14267/TCP,14268/TCP   16m
```

These services are used to configure Jaeger, Knative Serving, and Knative Eventing. The name of the Jaeger service may vary.

4. Install the OpenShift Serverless Operator by following the "Installing the OpenShift Serverless Operator" documentation.

5. Install Knative Serving by creating the following **KnativeServing** CR:

Example KnativeServing CR

```
apiVersion: operator.knative.dev/v1beta1
kind: KnativeServing
metadata:
    name: knative-serving
    namespace: knative-serving
spec:
  config:
    tracing:
      backend: "zipkin"
      zipkin-endpoint: "http://cluster-collector-collector-headless.tracing-
system.svc:9411/api/v2/spans"
      debug: "false"
      sample-rate: "0.1" ①
```

① The **sample-rate** defines sampling probability. Using **sample-rate: "0.1"** means that 1 in 10 traces are sampled.

6. Install Knative Eventing by creating the following **KnativeEventing** CR:

Example KnativeEventing CR

```
apiVersion: operator.knative.dev/v1beta1
kind: KnativeEventing
```

```
metadata:
    name: knative-eventing
    namespace: knative-eventing
spec:
  config:
    tracing:
      backend: "zipkin"
      zipkin-endpoint: "http://cluster-collector-collector-headless.tracing-
system.svc:9411/api/v2/spans"
      debug: "false"
      sample-rate: "0.1" 1
```

1 The **sample-rate** defines sampling probability. Using **sample-rate: "0.1"** means that 1 in 10 traces are sampled.

7. Create a Knative service:

Example service

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: helloworld-go
spec:
  template:
    metadata:
      labels:
        app: helloworld-go
      annotations:
        autoscaling.knative.dev/minScale: "1"
        autoscaling.knative.dev/target: "1"
    spec:
      containers:
      - image: quay.io/openshift-knative/helloworld:v1.2
        imagePullPolicy: Always
        resources:
          requests:
            cpu: "200m"
        env:
        - name: TARGET
          value: "Go Sample v1"
```

8. Make some requests to the service:

Example HTTPS request

```
$ curl https://helloworld-go.example.com
```

9. Get the URL for the Jaeger web console:

Example command

```
$ oc get route jaeger-all-in-one-inmemory  -o jsonpath='{.spec.host}' -n <namespace>
```

You can now examine traces by using the Jaeger console.

8.4.3. Using Jaeger distributed tracing

If you do not want to install all of the components of Red Hat OpenShift distributed tracing, you can still use distributed tracing on OpenShift Container Platform with OpenShift Serverless.

8.4.3.1. Configuring Jaeger to enable distributed tracing

To enable distributed tracing using Jaeger, you must install and configure Jaeger as a standalone integration.

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- You have installed the OpenShift Serverless Operator, Knative Serving, and Knative Eventing.
- You have installed the Red Hat OpenShift distributed tracing platform Operator.
- You have installed the OpenShift CLI (**oc**).
- 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 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 for Serving

   ```
   apiVersion: operator.knative.dev/v1beta1
   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 are 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.

3. Enable tracing for Knative Eventing by editing the **KnativeEventing** CR:

Tracing YAML example for Eventing

```
apiVersion: operator.knative.dev/v1beta1
kind: KnativeEventing
metadata:
  name: knative-eventing
  namespace: knative-eventing
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 are sampled.

2. Set **backend** to **zipkin**.

3. Point the **zipkin-endpoint** 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 -n default
```

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.

CHAPTER 9. INTEGRATIONS

9.1. INTEGRATING SERVICE MESH WITH OPENSHIFT SERVERLESS

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, such as mTLS functionality.

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.

9.1.1. Prerequisites

- 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.

9.1.2. 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.

Prerequisites

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

- You have installed the OpenShift Serverless Operator and Knative Serving.

- Install the OpenShift CLI (**oc**).

- 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 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.

9.1.3. Integrating Service Mesh with OpenShift Serverless

You can integrate Service Mesh with OpenShift Serverless without using Kourier as the default ingress. To do this, do not install the Knative Serving component before completing the following procedure. There are additional steps required when creating the **KnativeServing** custom resource definition (CRD) to integrate Knative Serving with Service Mesh, which are not covered in the general Knative Serving installation procedure. This procedure might be useful if you want to integrate Service Mesh as the default and only ingress for your OpenShift Serverless installation.

Prerequisites

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

- 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.

- Install the Red Hat OpenShift Service Mesh Operator and create a **ServiceMeshControlPlane** resource in the **istio-system** namespace. If you want to use mTLS functionality, you must also set the **spec.security.dataPlane.mtls** field for the **ServiceMeshControlPlane** resource to **true**.

IMPORTANT

Using OpenShift Serverless with Service Mesh is only supported with Red Hat OpenShift Service Mesh version 2.0.5 or later.

- Install the OpenShift Serverless Operator.
- Install the OpenShift CLI (**oc**).

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: 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.

2. Apply the **ServiceMeshMemberRoll** resource:

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

3. 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 the secret that contains the 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>
```

4. Apply the **Gateway** resources:

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

5. Install Knative Serving by creating the following **KnativeServing** custom resource definition (CRD), which also enables the Istio integration:

```
apiVersion: operator.knative.dev/v1beta1
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.

6. Apply the **KnativeServing** resource:

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

7. 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.

8. 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!
```

9.1.4. 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 and Knative Serving on your cluster.
- You have installed Red Hat OpenShift Service Mesh with the mTLS functionality enabled.
- You have access to an OpenShift Container Platform account with cluster administrator access.
- Install the OpenShift CLI (**oc**).

- 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. 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
...
```

9.1.5. Integrating Service Mesh with OpenShift Serverless when Kourier is enabled

You can use Service Mesh with OpenShift Serverless even if Kourier is already enabled. This procedure might be useful if you have already installed Knative Serving with Kourier enabled, but decide to add a Service Mesh integration later.

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- 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.
- Install the OpenShift CLI (**oc**).
- Install the OpenShift Serverless Operator and Knative Serving on your cluster.
- Install 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.

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. 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:
             knative.openshift.io/part-of: "openshift-serverless"
     podSelector: {}
     policyTypes:
     - Ingress
   ...
   ```

1 Add the namespace that you want to integrate with Service Mesh.

NOTE

The **knative.openshift.io/part-of: "openshift-serverless"** label was added in OpenShift Serverless 1.22.0. If you are using OpenShift Serverless 1.21.1 or earlier, add the **knative.openshift.io/part-of** label to the **knative-serving** and **knative-serving-ingress** namespaces.

Add the label to the **knative-serving** namespace:

```
$ oc label namespace knative-serving knative.openshift.io/part-of=openshift-serverless
```

Add the label to the **knative-serving-ingress** namespace:

```
$ oc label namespace knative-serving-ingress knative.openshift.io/part-of=openshift-serverless
```

b. Apply the **NetworkPolicy** resource:

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

9.1.6. Improving net-istio memory usage by using secret filtering for Service Mesh

By default, the informers implementation for the Kubernetes **client-go** library fetches all resources of a particular type. This can lead to a substantial overhead when many resources are available, which can cause the Knative **net-istio** ingress controller to fail on large clusters due to memory leaking. However, a filtering mechanism is available for the Knative **net-istio** ingress controller, which enables the controller to only fetch Knative related secrets. You can enable this mechanism by adding an annotation to the **KnativeServing** custom resource (CR).

IMPORTANT

If you enable secret filtering, all of your secrets need to be labeled with **networking.internal.knative.dev/certificate-uid: "<id>"**. Otherwise, Knative Serving does not detect them, which leads to failures. You must label both new and existing secrets.

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- 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.
- Install 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 later.
- Install the OpenShift Serverless Operator and Knative Serving.

- Install the OpenShift CLI (**oc**).

Procedure

- Add the **serverless.openshift.io/enable-secret-informer-filtering** annotation to the **KnativeServing** CR:

  Example KnativeServing CR

  ```
  apiVersion: operator.knative.dev/v1beta1
  kind: KnativeServing
  metadata:
    name: knative-serving
    namespace: knative-serving
    annotations:
      serverless.openshift.io/enable-secret-informer-filtering: "true" 1
  spec:
    ingress:
      istio:
        enabled: true
    deployments:
      - annotations:
          sidecar.istio.io/inject: "true"
          sidecar.istio.io/rewriteAppHTTPProbers: "true"
        name: activator
      - annotations:
          sidecar.istio.io/inject: "true"
          sidecar.istio.io/rewriteAppHTTPProbers: "true"
        name: autoscaler
  ```

  1 Adding this annotation injects an environment variable, **ENABLE_SECRET_INFORMER_FILTERING_BY_CERT_UID=true**, to the **net-istio** controller pod.

  NOTE

  This annotation is ignored if you set a different value by overriding deployments.

9.2. INTEGRATING SERVERLESS WITH THE COST MANAGEMENT SERVICE

Cost management is an OpenShift Container Platform service that enables you to better understand and track costs for clouds and containers. It is based on the open source Koku project.

9.2.1. Prerequisites

- You have cluster administrator permissions.

- You have set up cost management and added an OpenShift Container Platform source.

9.2.2. Using labels for cost management queries

Labels, also known as *tags* in cost management, can be applied for nodes, namespaces or pods. Each label is a key and value pair. You can use a combination of multiple labels to generate reports. You can access reports about costs by using the Red Hat hybrid console .

Labels are inherited from nodes to namespaces, and from namespaces to pods. However, labels are not overridden if they already exist on a resource. For example, Knative services have a default **app=<revision_name>** label:

Example Knative service default label

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: example-service
spec:
...
      labels:
        app: <revision_name>
...
```

If you define a label for a namespace, such as **app=my-domain**, the cost management service does not take into account costs coming from a Knative service with the tag **app=<revision_name>** when querying the application using the **app=my-domain** tag. Costs for Knative services that have this tag must be queried under the **app=<revision_name>** tag.

9.2.3. Additional resources

- Configure tagging for your sources
- Use the Cost Explorer to visualize your costs

9.3. USING NVIDIA GPU RESOURCES WITH SERVERLESS APPLICATIONS

NVIDIA supports using GPU resources on OpenShift Container Platform. See GPU Operator on OpenShift for more information about setting up GPU resources on OpenShift Container Platform.

9.3.1. 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 Knative (**kn**) CLI.

Prerequisites

- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on the cluster.
- You have installed the Knative (**kn**) CLI.
- GPU resources are enabled for 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.

NOTE

Using NVIDIA GPU resources is not supported for IBM Z and IBM Power.

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
   ```

9.3.2. Additional resources

- Setting resource quotas for extended resources

CHAPTER 10. REMOVING SERVERLESS

10.1. REMOVING OPENSHIFT SERVERLESS OVERVIEW

If you need to remove OpenShift Serverless from your cluster, you can do so by manually removing the OpenShift Serverless Operator and other OpenShift Serverless components. Before you can remove the OpenShift Serverless Operator, you must remove Knative Serving and Knative Eventing.

After uninstalling the OpenShift Serverless, you can remove the Operator and API custom resource definitions (CRDs) that remain on the cluster.

The steps for fully removing OpenShift Serverless are detailed in the following procedures:

- Uninstalling Knative Eventing.
- Uninstalling Knative Serving.
- Removing the OpenShift Serverless Operator.
- Deleting OpenShift Serverless custom resource definitions .

10.2. UNINSTALLING OPENSHIFT SERVERLESS KNATIVE EVENTING

Before you can remove the OpenShift Serverless Operator, you must remove Knative Eventing. To uninstall Knative Eventing, you must remove the **KnativeEventing** custom resource (CR) and delete the **knative-eventing** namespace.

10.2.1. Uninstalling Knative Eventing

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- Install the OpenShift CLI (**oc**).

Procedure

1. Delete the **KnativeEventing** CR:

```
$ 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
```

10.3. UNINSTALLING OPENSHIFT SERVERLESS KNATIVE SERVING

Before you can remove the OpenShift Serverless Operator, you must remove Knative Serving. To uninstall Knative Serving, you must remove the **KnativeServing** custom resource (CR) and delete the **knative-serving** namespace.

10.3.1. Uninstalling Knative Serving

Prerequisites

- You have access to an OpenShift Container Platform account with cluster administrator access.
- Install the OpenShift CLI (**oc**).

Procedure

1. Delete the **KnativeServing** CR:

```
$ 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
```

10.4. REMOVING THE OPENSHIFT SERVERLESS OPERATOR

After you have removed Knative Serving and Knative Eventing, you can remove the OpenShift Serverless Operator. You can do this by using the OpenShift Container Platform web console or the **oc** CLI.

10.4.1. Deleting Operators from a cluster using the web console

Cluster administrators can delete installed Operators from a selected namespace by using the web console.

Prerequisites

- Access to an OpenShift Container Platform cluster web console using an account with **cluster-admin** permissions.

Procedure

1. Navigate to the **Operators → Installed Operators** page.
2. Scroll or enter a keyword into the **Filter by name** field to find the Operator that you want to remove. Then, click on it.
3. On the right side of the **Operator Details** page, select **Uninstall Operator** from the **Actions** list.
   An **Uninstall Operator?** dialog box is displayed.
4. Select **Uninstall** to remove the Operator, Operator deployments, and pods. Following this action, the Operator stops running and no longer receives updates.

NOTE

This action does not remove resources managed by the Operator, including custom resource definitions (CRDs) and custom resources (CRs). Dashboards and navigation items enabled by the web console and off-cluster resources that continue to run might need manual clean up. To remove these after uninstalling the Operator, you might need to manually delete the Operator CRDs.

10.4.2. Deleting Operators from a cluster using the CLI

Cluster administrators can delete installed Operators from a selected namespace by using the CLI.

Prerequisites

- Access to an OpenShift Container Platform cluster using an account with **cluster-admin** permissions.
- **oc** command installed on workstation.

Procedure

1. Check the current version of the subscribed Operator (for example, **jaeger**) in the **currentCSV** field:

   ```
   $ oc get subscription jaeger -n openshift-operators -o yaml | grep currentCSV
   ```

   #### Example output

   ```
     currentCSV: jaeger-operator.v1.8.2
   ```

2. Delete the subscription (for example, **jaeger**):

   ```
   $ oc delete subscription jaeger -n openshift-operators
   ```

   #### Example output

   ```
   subscription.operators.coreos.com "jaeger" deleted
   ```

3. Delete the CSV for the Operator in the target namespace using the **currentCSV** value from the previous step:

   ```
   $ oc delete clusterserviceversion jaeger-operator.v1.8.2 -n openshift-operators
   ```

   #### Example output

   ```
   clusterserviceversion.operators.coreos.com "jaeger-operator.v1.8.2" deleted
   ```

10.4.3. Refreshing failing subscriptions

In Operator Lifecycle Manager (OLM), if you subscribe to an Operator that references images that are not accessible on your network, you can find jobs in the **openshift-marketplace** namespace that are failing with the following errors:

Example output

```
ImagePullBackOff for
Back-off pulling image "example.com/openshift4/ose-elasticsearch-operator-
bundle@sha256:6d2587129c846ec28d384540322b40b05833e7e00b25cca584e004af9a1d292e"
```

Example output

```
rpc error: code = Unknown desc = error pinging docker registry example.com: Get
"https://example.com/v2/": dial tcp: lookup example.com on 10.0.0.1:53: no such host
```

As a result, the subscription is stuck in this failing state and the Operator is unable to install or upgrade.

You can refresh a failing subscription by deleting the subscription, cluster service version (CSV), and other related objects. After recreating the subscription, OLM then reinstalls the correct version of the Operator.

Prerequisites

- You have a failing subscription that is unable to pull an inaccessible bundle image.
- You have confirmed that the correct bundle image is accessible.

Procedure

1. Get the names of the **Subscription** and **ClusterServiceVersion** objects from the namespace where the Operator is installed:

   ```
   $ oc get sub,csv -n <namespace>
   ```

   ### Example output

   ```
   NAME                                                    PACKAGE                SOURCE           CHANNEL
   subscription.operators.coreos.com/elasticsearch-operator   elasticsearch-operator   redhat-
   operators   5.0

   NAME                                                              DISPLAY                          VERSION
   REPLACES   PHASE
   clusterserviceversion.operators.coreos.com/elasticsearch-operator.5.0.0-65   OpenShift
   Elasticsearch Operator   5.0.0-65              Succeeded
   ```

2. Delete the subscription:

   ```
   $ oc delete subscription <subscription_name> -n <namespace>
   ```

3. Delete the cluster service version:

   ```
   $ oc delete csv <csv_name> -n <namespace>
   ```

4. Get the names of any failing jobs and related config maps in the **openshift-marketplace** namespace:

```
$ oc get job,configmap -n openshift-marketplace
```

Example output

```
NAME                                                                    COMPLETIONS   DURATION   AGE
job.batch/1de9443b6324e629ddf31fed0a853a121275806170e34c926d69e53a7fcbccb   1/1
26s        9m30s

NAME                                                                    DATA   AGE
configmap/1de9443b6324e629ddf31fed0a853a121275806170e34c926d69e53a7fcbccb   3
9m30s
```

5. Delete the job:

   ```
   $ oc delete job <job_name> -n openshift-marketplace
   ```

   This ensures pods that try to pull the inaccessible image are not recreated.

6. Delete the config map:

   ```
   $ oc delete configmap <configmap_name> -n openshift-marketplace
   ```

7. Reinstall the Operator using OperatorHub in the web console.

Verification

- Check that the Operator has been reinstalled successfully:

  ```
  $ oc get sub,csv,installplan -n <namespace>
  ```

10.5. 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 by using them, including Knative services.

10.5.1. Removing OpenShift Serverless Operator and API CRDs

Delete the Operator and API CRDs using the following procedure.

Prerequisites

- Install the OpenShift CLI (**oc**).
- You have access to an OpenShift Container Platform account with cluster administrator access.
- You have 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 11. OPENSHIFT SERVERLESS SUPPORT

If you experience difficulty with a procedure described in this documentation, visit the Red Hat Customer Portal at http://access.redhat.com. You can use the Red Hat Customer Portal to search or browse through the Red Hat Knowledgebase of technical support articles about Red Hat products. You can also submit a support case to Red Hat Global Support Services (GSS), or access other product documentation.

If you have a suggestion for improving this guide or have found an error, you can submit a Jira issue for the most relevant documentation component. Provide specific details, such as the section number, guide name, and OpenShift Serverless version so we can easily locate the content.

11.1. ABOUT THE RED HAT KNOWLEDGEBASE

The Red Hat Knowledgebase provides rich content aimed at helping you make the most of Red Hat’s products and technologies. The Red Hat Knowledgebase consists of articles, product documentation, and videos outlining best practices on installing, configuring, and using Red Hat products. In addition, you can search for solutions to known issues, each providing concise root cause descriptions and remedial steps.

11.2. SEARCHING THE RED HAT KNOWLEDGEBASE

In the event of an OpenShift Container Platform issue, you can perform an initial search to determine if a solution already exists within the Red Hat Knowledgebase.

Prerequisites

- You have a Red Hat Customer Portal account.

Procedure

1. Log in to the Red Hat Customer Portal .
2. In the main Red Hat Customer Portal search field, input keywords and strings relating to the problem, including:
   - OpenShift Container Platform components (such as **etcd**)
   - Related procedure (such as **installation**)
   - Warnings, error messages, and other outputs related to explicit failures
3. Click **Search**.
4. Select the **OpenShift Container Platform** product filter.
5. Select the **Knowledgebase** content type filter.

11.3. SUBMITTING A SUPPORT CASE

Prerequisites

- You have installed the OpenShift CLI (**oc**).

- You have a Red Hat Customer Portal account.
- You have access to OpenShift Cluster Manager.

Procedure

1. Log in to the Red Hat Customer Portal and select **SUPPORT CASES → Open a case**.
2. Select the appropriate category for your issue (such as **Defect / Bug**), product (**OpenShift Container Platform**), and product version (**4.9**, if this is not already autofilled).
3. Review the list of suggested Red Hat Knowledgebase solutions for a potential match against the problem that is being reported. If the suggested articles do not address the issue, click **Continue**.
4. Enter a concise but descriptive problem summary and further details about the symptoms being experienced, as well as your expectations.
5. Review the updated list of suggested Red Hat Knowledgebase solutions for a potential match against the problem that is being reported. The list is refined as you provide more information during the case creation process. If the suggested articles do not address the issue, click **Continue**.
6. Ensure that the account information presented is as expected, and if not, amend accordingly.
7. Check that the autofilled OpenShift Container Platform Cluster ID is correct. If it is not, manually obtain your cluster ID.
   - To manually obtain your cluster ID using the OpenShift Container Platform web console:
     a. Navigate to **Home → Dashboards → Overview**.
     b. Find the value in the **Cluster ID** field of the **Details** section.
   - Alternatively, it is possible to open a new support case through the OpenShift Container Platform web console and have your cluster ID autofilled.
     a. From the toolbar, navigate to **(?) Help → Open Support Case**.
     b. The **Cluster ID** value is autofilled.
   - To obtain your cluster ID using the OpenShift CLI (**oc**), run the following command:

     ```
     $ oc get clusterversion -o jsonpath='{.items[].spec.clusterID}{"\n"}'
     ```
8. Complete the following questions where prompted and then click **Continue**:
   - Where are you experiencing the behavior? What environment?
   - When does the behavior occur? Frequency? Repeatedly? At certain times?
   - What information can you provide around time-frames and the business impact?
9. Upload relevant diagnostic data files and click **Continue**. It is recommended to include data gathered using the **oc adm must-gather** command as a starting point, plus any issue specific data that is not collected by that command.

10. Input relevant case management details and click **Continue**.

11. Preview the case details and click **Submit**.

11.4. GATHERING DIAGNOSTIC INFORMATION FOR SUPPORT

When you open 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.

11.4.1. 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 plugin 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
...
```

11.4.2. 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.

Prerequisites

- Install the OpenShift CLI (**oc**).

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
  ```