OpenShift Container Platform 4.3 Serverless applications

OpenShift Serverless installation, usage, and release notes
Abstract

This document provides information on how to use OpenShift Serverless in OpenShift Container Platform
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CHAPTER 1. OPENSHIFT SERVERLESS RELEASE NOTES

For an overview of OpenShift Serverless functionality, see Getting started with OpenShift Serverless.

1.1. GETTING SUPPORT

If you experience difficulty with a procedure described in this documentation, visit the Red Hat Customer Portal at http://access.redhat.com. Through the customer portal, you can:

- Search or browse through the Red Hat Knowledgebase of technical support articles about Red Hat products
- Submit a support case to Red Hat Global Support Services (GSS)
- Access other product documentation

If you have a suggestion for improving this guide or have found an error, please submit a Bugzilla report at http://bugzilla.redhat.com against Product for the Documentation component. Please provide specific details, such as the section number, guide name, and OpenShift Serverless version so we can easily locate the content.

1.2. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.7.0

1.2.1. New features

- OpenShift Serverless 1.7.0 is now Generally Available (GA) on OpenShift Container Platform 4.3 and newer versions. In previous versions, OpenShift Serverless was a Technology Preview.
- OpenShift Serverless now uses Knative Serving 0.13.2.
- OpenShift Serverless now uses Knative Serving Operator 0.13.2.
- OpenShift Serverless now uses Knative kn CLI 0.13.2.
- Knative kn CLI downloads now support disconnected, or restricted network installations.
- Knative kn CLI libraries are now signed by Red Hat.
- Knative Eventing is now available as a Technology Preview with OpenShift Serverless. OpenShift Serverless uses Knative Eventing 0.13.2.

IMPORTANT

Before upgrading to the latest Serverless release, you must remove the community Knative Eventing Operator if you have previously installed it. Having the Knative Eventing Operator installed will prevent you from being able to install the latest Technology Preview version of Knative Eventing that is included with OpenShift Serverless 1.7.0.

- High availability (HA) is now enabled by default for the autoscaler-hpa, controller, activator, kourier-control, and kourier-gateway components.
If you have installed a previous version of OpenShift Serverless, after the KnativeServing custom resource (CR) is updated, the deployment will default to a HA configuration with KnativeServing.spec.high-availability.replicas = 2.
You can disable HA for these components by completing the procedure in the Configuring high availability components documentation.

- OpenShift Serverless now supports the trustedCA setting in OpenShift Container Platform’s cluster-wide proxy, and is now fully compatible with OpenShift Container Platform’s proxy settings.

- OpenShift Serverless now supports HTTPS using the wildcard certificate that is registered for OpenShift Container Platform routes. For more information on http and https on Knative Serving, see the documentation on Verifying your serverless application deployment.

1.2.2. Fixed issues

- In previous versions, requesting KnativeServing custom resources (CRs) without specifying an API group, for example, `oc get knativeserving -n knative-serving`, occasionally caused errors. This issue is fixed in OpenShift Serverless 1.7.0.

- In previous versions, the Knative Serving controller was not notified when a new service CA certificate was generated due to service CA certificate rotation. New revisions created after a service CA certificate rotation were failing with the error:

  Revision “foo-1” failed with message: Unable to fetch image “image-registry.openshift-image-registry.svc:5000/eap/eap-app”: failed to resolve image to digest: failed to fetch image information: Get https://image-registry.openshift-image-registry.svc:5000/v2/: x509: certificate signed by unknown authority.

The OpenShift Serverless Operator now restarts the Knative Serving controller whenever a new service CA certificate is generated, which ensures that the controller is always configured to use the current service CA certificate. For more information, see the OpenShift Container Platform documentation on Securing service traffic using service serving certificate secrets under Authentication.

1.2.3. Known issues

- When upgrading from OpenShift Serverless 1.6.0 to 1.7.0, support for HTTPS requires a change to the format of routes. Knative services created on OpenShift Serverless 1.6.0 are no longer reachable at the old format URLs. You must retrieve the new URL for each service after upgrading OpenShift Serverless. For more information, see the documentation on Upgrading OpenShift Serverless.

- If you are using Knative Eventing on an Azure cluster, it is possible that the imc-dispatcher pod may not start. This is due to the pod’s default resources settings. As a work-around, you can remove the resources settings.

- If you have 1000 Knative services on a cluster, and then perform a reinstall or upgrade of Knative Serving, there will be a delay when you create the first new service after KnativeServing becomes Ready. 3scale-kourier-control reconciles all previous Knative services before processing the creation of a new service, which causes the new service to spend approximately 800 seconds in an IngressNotConfigured or Unknown state before the state will update to Ready.

1.3. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS TECHNOLOGY PREVIEW 1.6.0
1.3.1. New features

- OpenShift Serverless 1.6.0 is available on OpenShift Container Platform 4.3 and newer versions.
- OpenShift Serverless now uses Knative Serving 0.13.1.
- OpenShift Serverless now uses Knative `kn` CLI 0.13.1.
- OpenShift Serverless now uses Knative Serving Operator 0.13.1.
- The `serving.knative.dev` API group has now been fully deprecated and is replaced by the `operator.knative.dev` API group.

You must complete the steps that are described in the OpenShift Serverless 1.4.0 release notes, that replace the `serving.knative.dev` API group with the `operator.knative.dev` API group, before you can upgrade to the latest version of OpenShift Serverless.

**IMPORTANT**

This change causes commands without a fully qualified APIGroup and kind, such as `oc get knativeserving`, to become unreliable and not always work correctly.

After upgrading to OpenShift Serverless 1.6.0, you must remove the old CRD to fix this issue. You can remove the old CRD by entering the following command:

```bash
$ oc delete crd knativeservings.serving.knative.dev
```

- The Subscription Update Channel for new OpenShift Serverless releases was updated from `techpreview` to `preview-4.3`.

**IMPORTANT**

You must update your channel by following the upgrade documentation to use the latest OpenShift Serverless version.

- OpenShift Serverless now supports the use of `HTTP_PROXY`.
- OpenShift Serverless now supports `HTTPS_PROXY` cluster-proxy settings.

**NOTE**

This `HTTP_PROXY` support does not include using custom certificates.

- The `KnativeServing` CRD is now hidden from the Developer Catalog by default so that only users with cluster administrator permissions can view it.
- Parts of the `KnativeServing` control plane and data plane are now deployed as highly available (HA) by default.
- Kourier is now actively watched and reconciles changes automatically.
- OpenShift Serverless now supports use on OpenShift Container Platform nightly builds.

1.3.2. Fixed issues
In previous versions, the **oc explain** command did not work correctly. The structural schema of the **KnativeServing** CRD was updated in OpenShift Serverless 1.6.0 so that the **oc explain** command now works correctly.

In previous versions, it was possible to create more than one **KnativeServing** CR. Multiple **KnativeServing** CRs are now prevented synchronously in OpenShift Serverless 1.6.0. Attempting to create more than one **KnativeServing** CR now results in an error.

In previous versions, OpenShift Serverless was not compatible with OpenShift Container Platform deployments on GCP. This issue was fixed in OpenShift Serverless 1.6.0.

In previous releases, the Knative Serving webhook crashed with an out of memory error if the cluster had more than 170 namespaces. This issue was fixed in OpenShift Serverless 1.6.0.

In previous releases, OpenShift Serverless did not automatically fix an OpenShift Container Platform route that it created if the route was changed by another component. This issue was fixed in OpenShift Serverless 1.6.0.

In previous versions, deleting a **KnativeServing** CR occasionally caused the system to hang. This issue was fixed in OpenShift Serverless 1.6.0.

Due to the ingress migration from Service Mesh to Kourier that occurred in OpenShift Serverless 1.5.0, orphaned VirtualServices sometimes remained on the system. In OpenShift Serverless 1.6.0, orphaned VirtualServices are automatically removed.

### 1.3.3. Known issues

- In OpenShift Serverless 1.6.0, if a cluster administrator uninstalls OpenShift Serverless by following the uninstall procedure provided in the documentation, the **Serverless** dropdown is still visible in the **Administrator** perspective of the OpenShift Container Platform web console, and the **Knative Service** resource is still visible in the **Developer** perspective of the OpenShift Container Platform web console. Although you can create Knative services by using this option, these Knative services do not work.

  To prevent OpenShift Serverless from being visible in the OpenShift Container Platform web console, the cluster administrator must delete additional CRDs from the deployment after removing the Knative Serving CR.

  Cluster administrators can remove these CRDs by entering the following command:

  ```bash
  $ oc get crd -oname | grep -E '(serving|internal).knative.dev' | xargs oc delete
  ```

### 1.4. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS TECHNOLOGY PREVIEW 1.5.0

#### 1.4.1. New features

- OpenShift Serverless 1.5.0 is available on OpenShift Container Platform 4.3 and newer versions.
- OpenShift Serverless now uses Knative Serving 0.12.1.
- OpenShift Serverless now uses Knative **kn** CLI 0.12.0.
- OpenShift Serverless now uses Knative Serving Operator 0.12.1.
1.4.2. Fixed issues

- In previous releases, OpenShift Container Platform scale from zero latency caused a delay of approximately 10 seconds when creating pods. This issue was fixed in the OpenShift Container Platform 4.3.5 bug fix update.

1.4.3. Known issues

- Deleting `KnativeServing.operator.knative.dev` from the `knative-serving` namespace may cause the deletion process to hang. This is due to a race condition between deletion of the CRD and `knative-openshift-ingress` removing finalizers.

1.5. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS TECHNOLOGY PREVIEW 1.4.0

**IMPORTANT**

OpenShift Serverless 1.4.0 contains a bad owner reference that causes the Kubernetes Garbage Collector to incorrectly remove the entire Knative control plane, including all of your services. You must install OpenShift Serverless 1.4.1 to fix this issue.

1.5.1. New features

- OpenShift Serverless 1.4.0 is available on OpenShift Container Platform 4.2 and newer versions.
- OpenShift Serverless now uses Knative Serving 0.11.1.
- OpenShift Serverless now uses Knative `kn` CLI 0.11.0.
- OpenShift Serverless now uses Knative Serving Operator 0.11.1.
- The `kn` CLI is now available for download through the Command Line Tools page in the OpenShift Container Platform web console.
- The `KnativeServing` object’s API group has changed in this release from `serving.knative.dev` to `operator.knative.dev`. You will need to adjust any of your scripts or applications that rely on the old API group to use the new API group. The OpenShift Serverless installation instructions have been updated to use the new API group. If you must keep using the old group temporarily, you can use the old custom resource (CR) as before. However, this CR is deprecated and will eventually be removed.

After you update references to the new API group, you can remove any older CR versions and use the newly deployed `KnativeServing` CR instead. To safely do this without downtime, remove the owner reference from the newly deployed `KnativeServing` CR using:

```
$ oc edit knativeserving.operator.knative.dev knative-serving -n knative-serving
```

After the owner reference has been removed, you can safely remove any older CR versions and start using the new one.
1.5.2. Fixed issues

- Connecting to a private, cluster local Knative Service from a namespace that was not part of the `knative-serving-ingress` Service Mesh was failing on `I/o timeout`. This issue is now fixed.

- The `container_name` and `pod_name` metric labels were removed in OpenShift Container Platform 4.3. The documentation has been updated to use the new `container` and `pod` metric labels instead. If you are using metering with Serverless on OpenShift Container Platform 4.3 or later, you must update your Prometheus queries according to the current version of the Serverless metering documentation.

1.5.3. Known issues

- Unqualified usage of `knativeserving` in `oc` commands no longer works because of the migration to a new API group. For example, this command will not work:

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

  Use the explicit fully-qualified format instead. For example:

  ```
  $ oc get knativeserving.operator.knative.dev -n knative-serving
  ```

- OpenShift Container Platform scale from zero latency causes a delay of approximately 10 seconds when creating pods. This is a current OpenShift Container Platform limitation.

1.6. ADDITIONAL RESOURCES

OpenShift Serverless is based on the open source Knative project.

- For details about the latest Knative Serving release, see the [Knative Serving releases page](#).

- For details about the latest Knative Serving Operator release, see the [Knative Serving Operator releases page](#).

- For details about the latest Knative CLI release, see the [Knative client releases page](#).

- For details about the latest Knative Eventing release, see the [Knative Eventing releases page](#).
CHAPTER 2. OPENSHIFT SERVERLESS SUPPORT

When opening a support case, it is helpful to provide debugging information about your cluster to Red Hat Support.

The **must-gather** tool enables you to collect diagnostic information about your OpenShift Container Platform cluster, including data related to OpenShift Serverless.

For prompt support, supply diagnostic information for both OpenShift Container Platform and OpenShift Serverless.

### 2.1. ABOUT THE MUST-GATHER TOOL

The **oc adm must-gather** CLI command collects the information from your cluster that is most likely needed for debugging issues, such as:

- Resource definitions
- Audit logs
- Service logs

You can specify one or more images when you run the command by including the **--image** argument. When you specify an image, the tool collects data related to that feature or product.

When you run **oc adm must-gather**, a new Pod is created 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.

### 2.2. ABOUT COLLECTING OPENSHIFT SERVERLESS DATA

You can use the **oc adm must-gather** CLI command to collect information about your cluster, including features and objects associated with OpenShift Serverless.

To collect OpenShift Serverless data with **must-gather**, you must specify the OpenShift Serverless image:

```
$ oc adm must-gather --image=registry.redhat.io/openshift-serverless-1/svls-must-gather-rhel8
```
CHAPTER 3. GETTING STARTED WITH OPENSHIFT SERVERLESS

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

3.1. HOW OPENSHIFT SERVERLESS WORKS

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

OpenShift Serverless on OpenShift Container Platform enables stateless serverless workloads to all run on a single multi-cloud container platform with automated operations. Developers can use a single platform for hosting their microservices, legacy, and serverless applications.

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

3.2. SUPPORTED CONFIGURATIONS

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

3.3. OPENSHIFT SERVERLESS COMPONENTS

This section describes the components of OpenShift Serverless.

3.3.1. Knative Serving

Knative Serving on OpenShift Container Platform builds on Kubernetes and Kourier to support deploying and managing serverless applications.

It creates a set of Kubernetes custom resource definitions (CRDs) that are used to define and control the behavior of serverless workloads on an OpenShift Container Platform cluster.

These CRDs are building blocks to address complex use cases, for example:

- Rapidly deploying serverless containers.
- Automatically scaling pods.
- Viewing point-in-time snapshots of deployed code and configurations.

3.3.2. Knative Eventing

Knative Eventing on OpenShift Container Platform enables developers to more easily declare how components of their system communicate, using an event-driven architecture for serverless applications. Event-driven architecture is based on the concept of decoupled relationships between event producers and event consumers.

For more information about event-driven architecture, see What is event-driven architecture?
CHAPTER 4. INSTALLING OPENSOURCE SERVERLESS

4.1. INSTALLING OPENSOURCE SERVERLESS

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

**NOTE**

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

### 4.1.1. Cluster sizing requirements

To run OpenShift Serverless, the OpenShift Container Platform cluster must be sized correctly. The minimum requirement to use OpenShift Serverless is a cluster with 10 CPUs and 40GB memory.

The total size requirements to run OpenShift Serverless are dependent on the applications deployed. By default, each pod requests ~400m of CPU, so the minimum requirements are based on this value.

In the size requirement provided, an application can scale up to 10 replicas. Lowering the actual CPU request of applications can increase the number of possible replicas.

You can use the 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 MachineSets by two additional machines.

For more information on using the MachineSet API, see the documentation on Creating MachineSets.

For more information on scaling a MachineSet manually, see the documentation on manually scaling MachineSets.

**NOTE**

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

**NOTE**

The following limitations apply to all OpenShift Serverless deployments:

- Maximum number of Knative services: 1000
- Maximum number of Knative revisions: 1000

### 4.1.1.1. 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 components.

**IMPORTANT**

Before upgrading to the latest Serverless release, you must remove the community Knative Eventing operator if you have previously installed it. Having the Knative Eventing operator installed will prevent you from being able to install the latest Technology Preview version of Knative Eventing that is included with OpenShift Serverless 1.7.0.

### 4.1.2. Installing the OpenShift Serverless Operator

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

**Procedure**

1. In the OpenShift Container Platform web console, navigate to the Catalog → 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 Create Operator Subscription page:

- **The Installation Mode** is **All namespaces on the cluster (default)**. This mode installs the Operator in the default `openshift-operators` namespace to watch and be made available to all namespaces in the cluster.

- **The Installed Namespace** will be **`openshift-operators`**.

- **Select an Update Channel**
  
  - i. **The 4.3 channel** will enable installation of the latest stable release of the OpenShift Serverless Operator.
  
  - ii. **The preview-4.3 channel** enables installation of the latest preview version of the OpenShift Serverless Operator, which may contain features that are not yet available from the 4.3 update channel.

- **d. Select Automatic or Manual approval strategy.**

5. **Click Subscribe** 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 steps**

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-operators** project on the **Workloads → Pods** page that are reporting issues to troubleshoot further.

**Additional resources**

- For more information on installing Operators, see the OpenShift Container Platform documentation on [Adding Operators to a cluster](https://docs.openshift.com/container-platform/4.3/cluster-administration/using-operators.html).

**4.1.3. Next steps**

- After the OpenShift Serverless Operator is installed, you can install the Knative Serving component. See the documentation on [Installing Knative Serving](https://docs.openshift.com/container-platform/4.3/developer-reference/tools/knative-serving.html).

- After the OpenShift Serverless Operator is installed, you can install the Knative Eventing component. See the documentation on [Installing Knative Eventing](https://docs.openshift.com/container-platform/4.3/developer-reference/tools/knative-eventing.html).

**4.2. INSTALLING KNATIVE SERVING**
After you install the OpenShift Serverless Operator, you can install Knative Serving by following the procedures described in this guide.

4.2.1. Creating the **knative-serving** namespace

When you create the **knative-serving** namespace, a **knative-serving** project will also be created.

**IMPORTANT**

You must complete this procedure before installing Knative Serving.

If the **KnativeServing** object created during Knative Serving’s installation is not created in the **knative-serving** namespace, it will be ignored.

**Prerequisites**

- An OpenShift Container Platform account with cluster administrator access
- Installed OpenShift Serverless Operator

4.2.1.1. Creating the **knative-serving** namespace using the web console

**Procedure**

1. In the OpenShift Container Platform web console, navigate to **Administration → Namespaces**.

2. Enter **knative-serving** as the **Name** for the project. The other fields are optional.
3. Click Create.

4.2.1.2. Creating the knative-serving namespace using the CLI

Procedure

1. Create the knative-serving namespace by entering:

   $ oc create namespace knative-serving

4.2.2. Installing Knative Serving

Prerequisites

- An OpenShift Container Platform account with cluster administrator access.
- Installed OpenShift Serverless Operator.
- Created the knative-serving namespace.

4.2.2.1. Installing Knative Serving using the web console

Procedure

1. In the OpenShift Container Platform web console, navigate to the Catalog → OperatorHub → Installed Operators page.

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 the Create Knative Serving button.

5. In the Create Knative Serving page, you can choose to configure the KnativeServing 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 KnativeServing object creation.
  Optional. If you are configuring the KnativeServing object using the form, make any changes that you want to implement for your Knative Serving deployment.

After you complete the form, click Create.
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.

Optional. If you are configuring the KnativeServing object by editing the YAML, make any changes to the YAML that you want to implement for your Knative Serving deployment.

After you have finished modifying the YAML, click Create.

6. After you have installed Knative Serving, the KnativeServing object is created, and you will be automatically directed to the Knative Serving tab.
You will see knative-serving in the list of resources.

**Verification steps**

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

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

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

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

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

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

4.2.2.2. Installing Knative Serving using YAML

Procedure

1. Create a file named `serving.yaml`.

2. Copy the following sample YAML into `serving.yaml`:

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

3. Apply the `serving.yaml` file:

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

Verification steps

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}}'

The output should be similar to:

- DependenciesInstalled=True
- DeploymentsAvailable=True
- InstallSucceeded=True
- Ready=True

**NOTE**

It may take a few seconds for the Knative Serving 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 Serving resources have been created by entering:

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

   The output should look similar to:

<table>
<thead>
<tr>
<th>NAME</th>
<th>READY</th>
<th>STATUS</th>
<th>RESTARTS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>activator-5c596cf8d6-5i86c</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>9m37s</td>
</tr>
<tr>
<td>activator-5c596cf8d6-gkn5k</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>9m22s</td>
</tr>
<tr>
<td>autoscaler-5854f586f6-gi597</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>9m36s</td>
</tr>
<tr>
<td>autoscaler-hpa-78665569b8-qmlmn</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>9m26s</td>
</tr>
<tr>
<td>autoscaler-hpa-78665569b8-tqww</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>9m26s</td>
</tr>
<tr>
<td>controller-7fd5655f49-9gzz5</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>9m32s</td>
</tr>
<tr>
<td>controller-7fd5655f49-pncv5</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>9m14s</td>
</tr>
<tr>
<td>kn-cli-downloads-8c65d4cbf-mt4t7</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>9m42s</td>
</tr>
<tr>
<td>webhook-5c7d878c7c-n267j</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>9m35s</td>
</tr>
</tbody>
</table>

4.2.3. Next steps

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

- Install the Knative CLI to use `kn` commands with Knative Serving. For example, `kn service` commands. See the documentation on [Installing the Knative CLI (kn)](#).

### 4.3. INSTALLING KNATIVE EVENTING

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

#### 4.3.1. Creating the knative-eventing namespace

When you create the `knative-eventing` namespace, a `knative-eventing` project will also be created.
IMPORTANT

You must complete this procedure before installing Knative Eventing.

If the KnativeEventing object created during Knative Eventing’s installation is not created in the knative-eventing namespace, it will be ignored.

Prerequisites

- An OpenShift Container Platform account with cluster administrator access
- Installed OpenShift Serverless Operator

4.3.1.1. Creating the knative-eventing namespace using the web console

Procedure

1. In the OpenShift Container Platform web console, navigate to Administration → Namespaces.

2. Click Create Namespace

3. Enter knative-eventing as the Name for the project. The other fields are optional.
4. Click **Create**.

### 4.3.1.2. Creating the knative-eventing namespace using the CLI

**Procedure**

1. Create the **knative-eventing** namespace by entering:

   ```
   $ oc create namespace knative-eventing
   ```

### 4.3.2. Installing Knative Eventing

**Prerequisites**

- An OpenShift Container Platform account with cluster administrator access
- Installed OpenShift Serverless Operator
- Created the **knative-eventing** namespace

#### 4.3.2.1. Installing Knative Eventing using the web console

**Procedure**

1. In the OpenShift Container Platform web console, navigate to the **Catalog → OperatorHub → Installed Operators** page.

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 the **Create Knative Eventing** button.

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 the 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 will be automatically directed to the Knative Eventing tab.
You will see `knative-eventing` in the list of resources.

Verification steps

1. Click on `knative-eventing` in the Knative Eventing tab.
2. You will be automatically directed to the Knative Eventing Overview page.
3. Scroll down to look at the list of Conditions.
4. You should see a list of conditions with a status of True, as shown in the example image.
NOTE

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

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

4.3.2.2. Installing Knative Eventing using YAML

Procedure

1. Create a file named `eventing.yaml`.

2. Copy the following sample YAML into `eventing.yaml`:

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

3. Optional. Make any changes to the YAML that you want to implement for your Knative Eventing deployment.

4. Apply the `eventing.yaml` file by entering:

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

Verification steps
1. To verify the installation is complete, enter:

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

The output should be similar to:

```
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
```

The output should look similar to:

<table>
<thead>
<tr>
<th>NAME</th>
<th>READY</th>
<th>STATUS</th>
<th>RESTARTS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>broker-controller-58765d9d49-g9zp6</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>7m21s</td>
</tr>
<tr>
<td>eventing-controller-65fd66b54-jw7bh</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>7m31s</td>
</tr>
<tr>
<td>eventing-webhook-57fd74b5bd-6hlh</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>7m31s</td>
</tr>
<tr>
<td>imc-controller-5b75d458fc-3pvm2</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>7m19s</td>
</tr>
<tr>
<td>imc-dispatcher-64f6df5cc-bm-kkc4c</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>7m18s</td>
</tr>
</tbody>
</table>

4.3.3. Next steps

- For services and serving functionality on OpenShift Serverless, you can install the Knative Serving component. See the documentation on [Installing Knative Serving](#).

- Install the Knative CLI to use `kn` commands with Knative Eventing. For example, `kn source` commands. See the documentation on [Installing the Knative CLI (kn)](#).

4.4. UPGRADING OPENSHIFT SERVERLESS

If you have previously installed a Technology Preview version of OpenShift Serverless, follow the instructions in this guide to upgrade to the latest version.

**IMPORTANT**

Before upgrading to the latest Serverless release, you must remove the community Knative Eventing operator if you have previously installed it. Having the Knative Eventing operator installed will prevent you from being able to install the latest Technology Preview version of Knative Eventing.

4.4.1. Updating Knative services URL formats
When upgrading from older versions of OpenShift Serverless to 1.7.0, support for HTTPS requires a change to the format of routes. Knative services created on OpenShift Serverless 1.6.0 or older versions are no longer reachable at the old format URLs. You must retrieve the new URL for each service after upgrading OpenShift Serverless.

For more information on retrieving Knative services URLs, see the documentation on Interacting with your serverless application.

4.4.2. Upgrading the Subscription Channel

In OpenShift Serverless version 1.6.0, the only available Subscription Update Channel was **preview-4.3**. To upgrade from 1.6.0 to the latest version, you must update the channel to **4.3**.

If you are upgrading from OpenShift Serverless version 1.5.0, or earlier, to version 1.7.0, you must complete the following steps:

- Upgrade to OpenShift Serverless version 1.5.0, by selecting the **techpreview** channel.
- After you have upgraded to 1.5.0, upgrade to 1.6.0 by selecting the **preview-4.3** channel.
- Finally, after you have upgraded to 1.6.0, upgrade to the latest version by selecting the **4.3** channel.

**IMPORTANT**

After each channel change, wait for the pods in the **knative-serving** namespace to get upgraded before changing the channel again.

**Prerequisites**

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

**NOTE**

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

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

**Procedure**

1. Select the **openshift-operators** namespace in the OpenShift Container Platform web console.
2. Navigate to the **Operators → Installed Operators** page.
3. Select the **OpenShift Serverless Operator Operator**.
4. Click **Subscription → Channel**.
5. In the **Change Subscription Update Channel** window, select **4.3**, and then click **Save**.
6. Wait until all pods have been upgraded in the `knative-serving` namespace and the KnativeServing custom resource reports the latest Knative Serving version.

**Verification steps**

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

1. Check the status of the pods by entering the following command:
   
   ```bash
   $ oc get knativeserving.operator.knative.dev knative-serving -n knative-serving -o=jsonpath='{.status.conditions[?(@.type=="Ready")].status}'
   ```

   The previous command should return a status of `True`.

2. Check the version of the KnativeServing CR by entering the following command:
   
   ```bash
   $ oc get knativeserving.operator.knative.dev knative-serving -n knative-serving -o=jsonpath='{.status.version}'
   ```

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

**4.4.3. Updating the API group**

In OpenShift Serverless 1.4.0 and newer versions, the `KnativeServing` object’s API group changed from `serving.knative.dev` to `operator.knative.dev`. You must adjust any of your scripts or applications that rely on the old API group to use the new API group.

**Procedure**

1. Update your scripts or applications that rely on the old API group to use the new API group.

2. After you update references to the new API group, you must remove any older custom resource (CR) versions and use the newly deployed `KnativeServing` CR instead.

   To safely do this without downtime, remove the owner reference from the newly deployed `KnativeServing` CR by entering the following command:
   
   ```bash
   $ oc edit knativeserving.operator.knative.dev knative-serving -n knative-serving
   ```

3. After the owner reference has been removed, you can safely remove any older CR versions and start using the new one.

4. This change to the API group causes commands without a fully qualified API group and kind, such as `oc get knativeserving`, to become unreliable and not always work correctly.

   After upgrading to OpenShift Serverless 1.6.0, you must remove the old custom resource definition (CRD) to fix this issue.

   You can remove the old CRD by entering the following command:
   
   ```bash
   $ oc delete crd knativeservings.serving.knative.dev
   ```
IMPORTANT

If a previous version of the CR exists, changes to the new CR will be overwritten by the OpenShift Serverless Operator. While the old CR is still active, all changes need to be made to that CR.

4.5. INSTALLING THE KNATIVE CLI (kn)

NOTE

kn does not have its own login mechanism. To log in to the cluster, you must install the oc CLI and use oc login.

Installation options for the oc CLI will vary depending on your operating system.

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

4.5.1. Installing the kn CLI using the OpenShift Container Platform web console

Once the OpenShift Serverless Operator is installed, you will see a link to download the kn CLI for Linux, macOS and Windows from the Command Line Tools page in the OpenShift Container Platform web console.

You can access the Command Line Tools page by clicking the icon in the top right corner of the web console and selecting Command Line Tools in the drop down menu.

Procedure

1. Download the kn CLI from the Command Line Tools page.

2. Unpack the archive:

   $ tar -xf <file>

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

4. To check your path, run:

   $ echo $PATH

NOTE

If you do not use RHEL or Fedora, ensure that libc is installed in a directory on your library path. If libc is not available, you might see the following error when you run CLI commands:

   $ kn: No such file or directory

4.5.2. Installing the kn CLI for Linux using an RPM
For Red Hat Enterprise Linux (RHEL), you can install **kn** as an RPM if you have an active OpenShift Container Platform subscription on your Red Hat account.

**Procedure**

- Use the following command to install **kn**:

```
# subscription-manager register
# subscription-manager refresh
# subscription-manager attach --pool=<pool_id> ①
# subscription-manager repos --enable="openshift-serverless-1-for-rhel-8-x86_64-rpms"
# yum install openshift-serverless-clients
```

① Pool ID for an active OpenShift Container Platform subscription

### 4.5.3. Installing the **kn** CLI for Linux

For Linux distributions, you can download the CLI directly as a **tar.gz** archive.

**Procedure**

1. Download the **CLI**.
2. Unpack the archive:
   ```
   $ tar -xf <file>
   ```
3. Move the **kn** binary to a directory on your PATH.
4. To check your path, run:
   ```
   $ echo $PATH
   ```

**NOTE**

If you do not use RHEL or Fedora, ensure that **libc** is installed in a directory on your library path. If **libc** is not available, you might see the following error when you run CLI commands:

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

### 4.5.4. Installing the **kn** CLI for macOS

**kn** for macOS is provided as a **tar.gz** archive.

**Procedure**

1. Download the **CLI**.
2. Unpack and unzip the archive.
3. Move the `kn` binary to a directory on your PATH.

4. To check your PATH, open a terminal window and run:

```
$ echo $PATH
```

### 4.5.5. Installing the `kn` CLI for Windows

The CLI for Windows is provided as a zip archive.

**Procedure**

1. Download the `CLII`.
2. Unzip 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
```

### 4.6. REMOVING OPENSSHIFT SERVERLESS

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

**NOTE**

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

#### 4.6.1. Uninstalling Knative Serving

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

**Procedure**

1. To remove Knative Serving, enter the following command:

```
$ 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 by entering the following command:

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

#### 4.6.2. Uninstalling Knative Eventing

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

1. To remove Knative Eventing, enter the following command:

   ```bash
   $ 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 by entering the following command:

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

4.6.3. Removing the OpenShift Serverless Operator

You can remove the OpenShift Serverless Operator from the host cluster by following the documentation on [deleting Operators from a cluster](#).

4.6.4. Deleting OpenShift Serverless CRDs

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

**IMPORTANT**

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

**Prerequisites**

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

**Procedure**

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

   ```bash
   $ oc get crd -oname | grep 'knative.dev' | xargs oc delete
   ```
5.1. GETTING STARTED WITH KNATIVE CLI (kn)

The Knative CLI (kn) extends the functionality of the oc or kubectl tools to enable interaction with Knative components on OpenShift Container Platform. kn allows developers to deploy and manage applications without editing YAML files directly.

5.1.1. Basic workflow using kn

Use this basic workflow to create, read, update, delete (CRUD) operations on a service. The following example deploys a simple Hello World service that reads the environment variable TARGET and prints its output.

Procedure

1. Create a service in the default namespace from an image.

   ```
   $ kn service create hello --image gcr.io/knative-samples/helloworld-go --env TARGET=Knative
   Creating service 'hello' in namespace 'default':
   0.085s The Route is still working to reflect the latest desired specification.
   0.101s Configuration "hello" is waiting for a Revision to become ready.
   11.590s ...
   11.650s Ingress has not yet been reconciled.
   11.726s Ready to serve.
   Service 'hello' created with latest revision 'hello-gsdks-1' and URL:
   http://hello.default.apps-crc.testing
   ```

2. List the service.

   ```
   $ kn service list
   NAME    URL                                     LATEST          AGE     CONDITIONS   READY
   REASON
   hello   http://hello.default.apps-crc.testing   hello-gsdks-1   8m35s   3 OK / 3     True
   ```

3. Check if the service is working by using the curl service endpoint command:

   ```
   $ curl http://hello.default.apps-crc.testing
   Hello Knative!
   ```

4. Update the service.

   ```
   $ kn service update hello --env TARGET=Kn
   Updating Service 'hello' in namespace 'default':
   10.136s Traffic is not yet migrated to the latest revision.
   10.175s Ingress has not yet been reconciled.
   10.348s Ready to serve.
   ```
Service 'hello' updated with latest revision 'hello-dghll-2' and URL: http://hello.default.apps-crc.testing

The service’s environment variable TARGET is now set to Kn.

5. Describe the service.

$ kn service describe hello
Name:       hello
Namespace:  default
Age:        13m
URL:        http://hello.default.apps-crc.testing
Address:    http://hello.default.svc.cluster.local

Revisions:
100%  @latest (hello-dghll-2) [2] (1m)
    Image:  gcr.io/knative-samples/helloworld-go (pinned to 5ea96b)

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

6. Delete the service.

$ kn service delete hello
Service 'hello' successfully deleted in namespace 'default'.

You can then verify that the hello service is deleted by attempting to list it.

$ kn service list hello
No services found.

5.1.2. Autoscaling workflow using kn

You can access autoscaling capabilities by using kn to modify Knative services without editing YAML files directly.

Use the service create and service update commands with the appropriate flags to configure the autoscaling behavior.

<table>
<thead>
<tr>
<th>Flag</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>--concurrency-limit int</td>
<td>Hard limit of concurrent requests to be processed by a single replica.</td>
</tr>
<tr>
<td>--concurrency-target int</td>
<td>Recommendation for when to scale up based on the concurrent number of incoming requests. Defaults to --concurrency-limit.</td>
</tr>
<tr>
<td>--max-scale int</td>
<td>Maximum number of replicas.</td>
</tr>
</tbody>
</table>
5.1.3. Traffic splitting using kn

kn helps you control which revisions get routed traffic on your Knative service.

Knative service allows for traffic mapping, which is the mapping of revisions of the service to an allocated portion of traffic. It offers the option to create unique URLs for particular revisions and has the ability to assign traffic to the latest revision.

With every update to the configuration of the service, a new revision is created with the service route pointing all the traffic to the latest ready revision by default.

You can change this behavior by defining which revision gets a portion of the traffic.

Procedure

- Use the kn service update command with the --traffic flag to update the traffic.

NOTE

--traffic RevisionName=Percent uses the following syntax:

- The --traffic flag requires two values separated by separated by an equals sign (=).
- The RevisionName string refers to the name of the revision.
- Percent integer denotes the traffic portion assigned to the revision.
- Use identifier @latest for the RevisionName to refer to the latest ready revision of the service. You can use this identifier only once with the --traffic flag.
- If the service update command updates the configuration values for the service along with traffic flags, the @latest reference will point to the created revision to which the updates are applied.
- --traffic flag can be specified multiple times and is valid only if the sum of the Percent values in all flags totals 100.

NOTE

For example, to route 10% of traffic to your new revision before putting all traffic on, use the following command:

$ kn service update svc --traffic @latest=10 --traffic svc-vwxyz=90

5.1.3.1. Assigning tag revisions
A tag in a traffic block of service creates a custom URL, which points to a referenced revision. A user can define a unique tag for an available revision of a service which creates a custom URL by using the format http(s)://TAG-SERVICE.DOMAIN.

A given tag must be unique to its traffic block of the service. kn supports assigning and unassigning custom tags for revisions of services as part of the kn service update command.

**NOTE**

If you have assigned a tag to a particular revision, a user can reference the revision by its tag in the --traffic flag as --traffic Tag=Percent.

**Procedure**

- Use the following command:

```bash
$ kn service update svc --tag @latest=candidate --tag svc-vwxyz=current
```

**NOTE**

--tag RevisionName=Tag uses the following syntax:

- --tag flag requires two values separated by a =.
- RevisionName string refers to name of the Revision.
- Tag string denotes the custom tag to be given for this Revision.
- Use the identifier @latest for the RevisionName to refer to the latest ready revision of the service. You can use this identifier only once with the --tag flag.
- If the service update command is updating the configuration values for the Service (along with tag flags), @latest reference will be pointed to the created Revision after applying the update.
- --tag flag can be specified multiple times.
- --tag flag may assign different tags to the same revision.

5.1.3.2. Unassigning tag revisions

Tags assigned to revisions in a traffic block can be unassigned. Unassigning tags removes the custom URLs.

**NOTE**

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

**Procedure**

- A user can unassign the tags for revisions using the kn service update command:

```bash
$ kn service update svc --untag candidate
```
NOTE

--untag Tag uses the following syntax:

- The --untag flag requires one value.
- The tag string denotes the unique tag in the traffic block of the service which needs to be unassigned. This also removes the respective custom URL.
- The --untag flag can be specified multiple times.

5.1.3.3. Traffic flag operation 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.

5.1.3.4. Traffic splitting flags

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

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

<table>
<thead>
<tr>
<th>Flag</th>
<th>Value(s)</th>
<th>Operation</th>
<th>Repetition</th>
</tr>
</thead>
<tbody>
<tr>
<td>--traffic</td>
<td>RevisionName=Percent</td>
<td>Gives Percent traffic to RevisionName</td>
<td>Yes</td>
</tr>
<tr>
<td>--traffic</td>
<td>Tag=Percent</td>
<td>Gives Percent traffic to the Revision having Tag</td>
<td>Yes</td>
</tr>
<tr>
<td>--traffic</td>
<td>@latest=Percent</td>
<td>Gives Percent traffic to the latest ready Revision</td>
<td>No</td>
</tr>
<tr>
<td>--tag</td>
<td>RevisionName=Tag</td>
<td>Gives Tag to RevisionName</td>
<td>Yes</td>
</tr>
<tr>
<td>--tag</td>
<td>@latest=Tag</td>
<td>Gives Tag to the latest ready Revision</td>
<td>No</td>
</tr>
<tr>
<td>--untag</td>
<td>Tag</td>
<td>Removes Tag from Revision</td>
<td>Yes</td>
</tr>
</tbody>
</table>
CHAPTER 6. KNATIVE SERVING

6.1. HOW KNATIVE SERVING WORKS

Knative Serving on OpenShift Container Platform builds on Kubernetes and Kourier to support deploying and managing serverless applications.

It creates a set of Kubernetes custom resource definitions (CRDs) that are used to define and control the behavior of serverless workloads on an OpenShift Container Platform cluster.

These CRDs are building blocks to address complex use cases, for example:

- Rapidly deploying serverless containers.
- Automatically scaling pods.
- Viewing point-in-time snapshots of deployed code and configurations.

6.1.1. Knative Serving resources

The resources described in this section are required for Knative Serving to be configured and run correctly.

Knative service resource

The `service.serving.knative.dev` resource automatically manages the whole lifecycle of a serverless workload on a cluster. It controls the creation of other objects to ensure that an app has a route, a configuration, and a new revision for each update of the service. Services can be defined to always route traffic to the latest revision or to a pinned revision.

Knative route resource

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

Knative configuration resource

The `configuration.serving.knative.dev` resource maintains the required state for your deployment. Modifying a configuration creates a new revision.

Knative revision resource

The `revision.serving.knative.dev` resource 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 needed. Cluster administrators can modify the `revision.serving.knative.dev` resource to enable automatic scaling of Pods in your OpenShift Container Platform cluster.

6.2. GETTING STARTED WITH KNATIVE SERVICES

Knative services are Kubernetes services that a user creates to deploy a serverless application. Each Knative service is defined by a route and a configuration, contained in a `.yaml` file.

6.2.1. Creating a Knative service

To create a service, you must create the `service.yaml` file.

You can copy the sample below. This sample will create a sample golang application called `helloworld-go` and allows you to specify the image for that application.
### 6.2.2. Deploying a serverless application

To deploy a serverless application, you must apply the `service.yaml` file.

**Procedure**

1. Navigate to the directory where the `service.yaml` file is contained.
2. Deploy the application by applying the `service.yaml` file.

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

Now that the service has been created and the application has been deployed, Knative will create a new immutable revision for this version of the application.

Knative will also perform network programming to create a route, ingress, service, and load balancer for your application, and will automatically scale your pods up and down based on traffic, including inactive pods.

### 6.2.3. Connecting Knative Services to existing Kubernetes deployments

Knative Services can call a Kubernetes deployment in any namespace, provided that there are no existing additional network barriers.

A Kubernetes deployment can call a Knative Service if:

- The Kubernetes deployment is in the same namespace as the target Knative Service.
• The Kubernetes deployment is in a namespace that was manually added to the ServiceMeshMemberRoll in `knative-serving-ingress`.

• The Kubernetes deployment uses the target Knative Service’s public URL.

**NOTE**

Knative Services are accessed using a public URL by default. The target Knative Service must not be configured as a private, `cluster-local` visibility service if you want to connect it to your existing Kubernetes deploying using a public URL.

### 6.3. CREATING SERVERLESS APPLICATIONS

You can create serverless applications by using the **Developer** perspective in the OpenShift Container Platform web console.

**Prerequisites**

To create serverless applications using the **Developer** perspective ensure that:

• You have **logged in to the web console**.

• You are in the **Developer** perspective.

• You have the appropriate **roles and permissions** in a project to create applications and other workloads in OpenShift Container Platform.

• You have **installed the OpenShift Serverless Operator**.

• You have **created a knative-serving namespace and a KnativeServing resource in the knative-serving namespace**.

**6.3.1. Importing a codebase from Git to create an application**

The following procedure walks you through the **Import from Git** option in the **Developer** perspective to create an application.

Create, build, and deploy an application on OpenShift Container Platform using an existing codebase in GitHub as follows:

**Procedure**

1. In the **Add** view, click **From Git** to see the **Import from git** form.
2. In the Git section, enter the Git repository URL for the codebase you want to use to create an application. For example, enter the URL of this sample Node.js application https://github.com/sclorg/nodejs-ex. The URL is then validated.

3. Optionally, you can click Show Advanced Git Options to add details such as:
   - **Git Reference** to point to code in a specific branch, tag, or commit to be used to build the application.
   - **Context Dir** to specify the subdirectory for the application source code you want to use to build the application.
   - **Source Secret** to create a **Secret Name** with credentials for pulling your source code from a private repository.

4. In the Builder section, after the URL is validated, an appropriate builder image is detected, indicated by a star, and automatically selected. For the https://github.com/sclorg/nodejs-ex Git URL, the Node.js builder image is selected by default. If required, you can change the version using the **Builder Image Version** drop-down list.

5. In the General section:
   a. In the **Application** field, enter a unique name for the application grouping, for example, **myapp**. Ensure that the application name is unique in a namespace.
   b. The **Name** field to identify the resources created for this application is automatically populated based on the Git repository URL.
NOTE

The resource name must be unique in a namespace. Modify the resource name if you get an error.

6. In the Resources section, select:
   - Deployment, to create an application in plain Kubernetes style.
   - Deployment Config, to create an OpenShift style application.
   - Knative Service, to create a microservice.

NOTE

The Knative Service option is displayed in the Import from git form only if the Serverless Operator is installed in your cluster. For further details refer to documentation on installing OpenShift Serverless.

7. In the Advanced Options section, the Create a route to the application is selected by default so that you can access your application using a publicly available URL. You can clear the check box if you do not want to expose your application on a public route.

8. Optionally, you can use the following advanced options to further customize your application:

Routing

Click the Routing link to:

- Customize the hostname for the route.
- Specify the path the router watches.
- Select the target port for the traffic from the drop-down list.
- Secure your route by selecting the Secure Route check box. Select the required TLS termination type and set a policy for insecure traffic from the respective drop-down lists.

For serverless applications, the Knative Service manages all the routing options above. However, you can customize the target port for traffic, if required. If the target port is not specified, the default port of 8080 is used.

Build and Deployment Configuration

Click the Build Configuration and Deployment Configuration links to see the respective configuration options. Some of the options are selected by default; you can customize them further by adding the necessary triggers and environment variables. For serverless applications, the Deployment Configuration option is not displayed as the Knative configuration resource maintains the desired state for your deployment instead of a DeploymentConfig.

Scaling

Click the Scaling link to define the number of Pods or instances of the application you want to deploy initially.

For serverless applications, you can:
Set the upper and lower limit for the number of pods that can be set by the autoscaler. If the lower limit is not specified, it defaults to zero.

Define the soft limit for the required number of concurrent requests per instance of the application at a given time. It is the recommended configuration for autoscaling. If not specified, it takes the value specified in the cluster configuration.

Define the hard limit for the number of concurrent requests allowed per instance of the application at a given time. This is configured in the revision template. If not specified, it defaults to the value specified in the cluster configuration.

**Resource Limit**
Click the Resource Limit link to set the amount of CPU and Memory resources a container is guaranteed or allowed to use when running.

**Labels**
Click the Labels link to add custom labels to your application.

9. Click **Create** to create the application and see its build status in the **Topology** view.

### 6.4. INTERACTING WITH YOUR SERVERLESS APPLICATION

This section provides information about various tasks that can be performed once you have successfully created a serverless application.

#### 6.4.1. 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.

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

**Procedure**

1. Find the application URL by entering:

   ```bash
   $ oc get ksvc helloworld-go
   ```

   **Example output**

   ```text
   NAME            URL                                        LATESTCREATED         LATESTREADY   READY   REASON
   helloworld-go   http://helloworld-go.default.example.com   helloworld-go-4wsd2   helloworld-go-4wsd2   True
   ```

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

   **Example HTTP request**
$ curl http://helloworld-go.default.example.com
Hello World: Go Sample v1!

Example HTTPS request

$ curl https://helloworld-go.default.example.com
Hello World: Go Sample v1!

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

\begin{flushleft}
\textbf{IMPORTANT}
\end{flushleft}

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

Example

$ curl https://helloworld-go.default.example.com --insecure
Hello World: Go Sample v1!

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 \texttt{--cacert} flag.

Example

$ curl https://helloworld-go.default.example.com --cacert <file>
Hello World: Go Sample v1!

\subsection*{6.4.2. Interacting with a serverless application using HTTP2 / gRPC}

OpenShift Container Platform routes do not support HTTP2, and therefore do not support gRPC as this 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.

\textbf{Procedure}

1. Find the application host. See the instructions in \textit{Verifying your serverless application deployment}.

2. The ingress gateway’s public address can be determined using this command:

\begin{verbatim}
$ oc -n knative-serving-ingress get svc kourier
\end{verbatim}

The output will be similar to this example:

\begin{verbatim}
NAME PORT(S) TYPE CLUSTER-IP EXTERNAL-IP AGE
\end{verbatim}
The public address is surfaced in the **EXTERNAL-IP** field, and in this case would be:

```
| LoadBalancer | 172.30.51.103 | a83e86291bced11e993af02b7a65e514-33544245.us-east-1.elb.amazonaws.com | 80:31380/TCP,443:31390/TCP | 67m |
```

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.

Here is an example, using the information obtained from the steps in **Verifying your serverless application deployment**:

```bash
$ curl -H "Host: helloworld-go.default.example.com" a83e86291bced11e993af02b7a65e514-33544245.us-east-1.elb.amazonaws.com
```

Hello Go Sample v1!

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

Here is an example of what that looks like in the Golang gRPC client:

```
NOTE
Ensure that you append the respective port (80 by default) to both hosts as shown in the example.
```

```go
grpc.Dial(
    "a83e86291bced11e993af02b7a65e514-33544245.us-east-1.elb.amazonaws.com:80",
grpc.WithAuthority("helloworld-go.default.example.com:80"),
grpc.WithInsecure(),
)
```

## 6.5. Configuring Knative Serving Autoscaling

OpenShift Serverless provides capabilities for automatic Pod scaling, including scaling inactive Pods to zero, by enabling the Knative Serving autoscaling system in an OpenShift Container Platform cluster.

To enable autoscaling for Knative Serving, you must configure concurrency and scale bounds in the revision template.

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

### 6.5.1. Configuring concurrent requests for Knative Serving autoscaling

You can specify the number of concurrent requests that should be handled by each instance of an application (revision container) by adding the **target** annotation or the **containerConcurrency** field in the revision template.
Here is an example of **target** being used in a revision template:

```yaml
apiVersion: serving.knative.dev/v1alpha1
kind: Service
metadata:
  name: myapp
spec:
template:
  metadata:
    annotations:
      autoscaling.knative.dev/target: 50
spec:
  containers:
    - image: myimage
```

Here is an example of **containerConcurrency** being used in a revision template:

```yaml
apiVersion: serving.knative.dev/v1alpha1
kind: Service
metadata:
  name: myapp
spec:
template:
  metadata:
    annotations:
      containerConcurrency: 100
spec:
  containers:
    - image: myimage
```

Adding a value for both **target** and **containerConcurrency** will target the **target** number of concurrent requests, but impose a hard limit of the **containerConcurrency** number of requests.

For example, if the **target** value is 50 and the **containerConcurrency** value is 100, the targeted number of requests will be 50, but the hard limit will be 100.

If the **containerConcurrency** value is less than the **target** value, the **target** value will be tuned down, since there is no need to target more requests than the number that can actually be handled.

**NOTE**

**containerConcurrency** should only be used if there is a clear need to limit how many requests reach the application at a given time. Using **containerConcurrency** is only advised if the application needs to have an enforced constraint of concurrency.

6.5.1.1. Configuring concurrent requests using the target annotation

The default target for the number of concurrent requests is **100**, but you can override this value by adding or modifying the **autoscaling.knative.dev/target** annotation value in the revision template.

Here is an example of how this annotation is used in the revision template to set the target to **50**.

```yaml
autoscaling.knative.dev/target: 50
```
6.5.1.2. Configuring concurrent requests using the containerConcurrency field

`containerConcurrency` sets a hard limit on the number of concurrent requests handled.

```
containerConcurrency: 0 | 1 | 2-N
```

- **0** allows unlimited concurrent requests.
- **1** guarantees that only one request is handled at a time by a given instance of the revision container.
- **2 or more** will limit request concurrency to that value.

**NOTE**

If there is no `target` annotation, autoscaling is configured as if `target` is equal to the value of `containerConcurrency`.

6.5.2. Configuring scale bounds Knative Serving autoscaling

The `minScale` and `maxScale` annotations can be used to configure the minimum and maximum number of Pods that can serve applications. These annotations can be used to prevent cold starts or to help control computing costs.

**minScale**

If the `minScale` annotation is not set, Pods will scale to zero (or to 1 if `enable-scale-to-zero` is false per the ConfigMap).

**maxScale**

If the `maxScale` annotation is not set, there will be no upper limit for the number of Pods created.

`minScale` and `maxScale` can be configured as follows in the revision template:

```
spec:
  template:
    metadata:
      autoscaling.knative.dev/minScale: "2"
      autoscaling.knative.dev/maxScale: "10"
```

Using these annotations in the revision template will propagate this configuration to `PodAutoscaler` objects.

**NOTE**

These annotations apply for the full lifetime of a revision. Even when a revision is not referenced by any route, the minimal Pod count specified by `minScale` will still be provided. Keep in mind that non-routeable revisions may be garbage collected, which enables Knative to reclaim the resources.

6.6. CLUSTER LOGGING WITH OPENSHIFT SERVERLESS
6.6.1. Cluster logging

OpenShift Container Platform cluster administrators can deploy cluster logging using a few CLI commands and the OpenShift Container Platform web console to install the Elasticsearch Operator and Cluster Logging Operator. When the operators are installed, create a Cluster Logging Custom Resource (CR) to schedule cluster logging pods and other resources necessary to support cluster logging. The operators are responsible for deploying, upgrading, and maintaining cluster logging.

You can configure cluster logging by modifying the Cluster Logging Custom Resource (CR), named instance. The CR defines a complete cluster logging deployment that includes all the components of the logging stack to collect, store and visualize logs. The Cluster Logging Operator watches the ClusterLogging Custom Resource and adjusts the logging deployment accordingly.

Administrators and application developers can view the logs of the projects for which they have view access.

6.6.2. About deploying and configuring cluster logging

OpenShift Container Platform cluster logging is designed to be used with the default configuration, which is tuned for small to medium sized OpenShift Container Platform clusters.

The installation instructions that follow include a sample Cluster Logging Custom Resource (CR), which you can use to create a cluster logging instance and configure your cluster logging deployment.

If you want to use the default cluster logging install, you can use the sample CR directly.

If you want to customize your deployment, make changes to the sample CR as needed. The following describes the configurations you can make when installing your cluster 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 Cluster Logging Custom Resource.

6.6.2.1. Configuring and Tuning Cluster Logging

You can configure your cluster logging environment by modifying the Cluster Logging 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: "1"
          memory: "16Gi"
        requests:
          cpu: 1
          memory: "16Gi"
      type: "elasticsearch"
```

Elasticsearch storage

You can configure a persistent storage class and size for the Elasticsearch cluster using the `storageClass` name and size parameters. The Cluster Logging Operator creates a `PersistentVolumeClaim` for each data node in the Elasticsearch cluster based on these parameters.

This example specifies each data node in the cluster will be bound to a `PersistentVolumeClaim` 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.

```yaml
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.

### Curator schedule

You specify the schedule for Curator in the *cron format*.

```yaml
spec:
  curation:
    type: "curator"
    resources:
      curator:
        schedule: "30 3 * * *"
```

### 6.6.2.2. Sample modified Cluster Logging Custom Resource

The following is an example of a Cluster Logging Custom Resource modified using the options previously described.

```yaml
apiVersion: "logging.openshift.io/v1"
kind: "ClusterLogging"
metadata:
  name: "instance"
  namespace: "openshift-logging"
spec:
  managementState: "Managed"
  logStore:
    type: "elasticsearch"
    elasticsearch:
      nodeCount: 2
```
6.6.3. Using cluster logging to find logs for Knative Serving components

Procedure

1. To open the Kibana UI, the visualization tool for Elasticsearch, use the following command to 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. Ensure the index is set to .all. If the index is not set to .all, only the OpenShift system logs will be listed.

4. You can 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 cluster logging Fluentd settings. This makes the logs more searchable and enables filtering on the log level to quickly identify issues.

6.6.4. Using cluster logging to find logs for services deployed with Knative Serving

With OpenShift Cluster Logging, the logs that your applications write to the console are collected in Elasticsearch. The following procedure outlines how to apply these capabilities to applications deployed by using Knative Serving.

Procedure

1. Use the following command to find the URL to Kibana:
   
   ```
   $ oc -n cluster-logging get route kibana
   ```

2. Enter the URL in your browser to open the Kibana UI.

3. Ensure 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 Kubernetes namespace your service is deployed in. Add a filter to identify the service itself:
   
   `kubernetes.namespace_name:default AND kubernetes.labels.serving_knative_dev/service:{SERVICE_NAME}`

   
   **NOTE**
   
   You can also filter by using /configuration or /revision.

5. You can 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.

6.7. SPLITTING TRAFFIC BETWEEN REVISIONS

6.7.1. Splitting traffic between revisions using the Developer perspective

After you create a serverless application, the serverless application is displayed in the Topology view of the Developer perspective. The application revision is represented by the node and the serverless resource service is indicated by a quadrilateral around the node.

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

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

1. Click the serverless resource service, indicated by the quadrilateral, to see its overview in the side panel.

2. Click the **Resources** tab, to see a list of **Revisions** and **Routes** for the service.

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 the **Set Traffic Distribution** button 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.
CHAPTER 7. KNATIVE EVENTING

7.1. HOW KNATIVE EVENTING WORKS

Knative Eventing on OpenShift Container Platform enables developers to more easily declare how components of their system communicate, using an event-driven architecture for serverless applications.

Event-driven architecture is based on the concept of decoupled relationships between event producers and event consumers.

For more information about event-driven architecture, see What is event-driven architecture?

7.1.1. Knative Eventing workflows

In a Knative Eventing workflow, event producers send information to an event source about changes to system state. Examples of event producers include a Kafka cluster or the Kubernetes API server.

An event source is a resource object, which is the link between an event producer and a sink (or consumer) that receives those events. Currently, OpenShift Serverless supports the following event source types:

- **ApiServerSource**
  Connects a sink to the Kubernetes API server.

- **PingSource**
  Periodically sends ping events with a constant payload. It can be used as a timer.

SinkBinding is also supported, which allows you to connect core Kubernetes resources such as Deployment, Job, or StatefulSet with a sink.

Examples of sinks are Knative services and channels. Events can also be sent to:

- A broker, where they can be filtered using triggers before being sent to a sink. Using the broker and trigger together enables an event delivery mechanism that hides the details of event routing from the event producer and event consumer.

- A channel, where Knative services can "subscribe" to receive events of a certain type.

7.1.2. Additional resources

- For more information about brokers, see Using brokers.
- For more information about triggers, see Using triggers.
- For more information about channels, see Using channels.

7.2. USING THE KN CLI TO LIST EVENT SOURCES AND EVENT SOURCE TYPES

You can use the **kn** CLI to list and manage available event sources or event source types for use with Knative Eventing.

Currently, **kn** supports management of the following event source types:
**ApiServerSource**

Connects a sink to the Kubernetes API server.

**PingSource**

Periodically sends ping events with a constant payload. It can be used as a timer.

### 7.2.1. Listing available event source types using `kn`

You can list the available event source types in the terminal by using the following command:

```bash
$ kn source list-types
```

The default output for this command will look like:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ApiServerSource</td>
<td>apiserversources.sources.knative.dev</td>
<td>Watch and send Kubernetes API events to a sink</td>
</tr>
<tr>
<td>PingSource</td>
<td>pingsources.sources.knative.dev</td>
<td>Periodically send ping events to a sink</td>
</tr>
<tr>
<td>SinkBinding</td>
<td>sinkbindings.sources.knative.dev</td>
<td>Binding for connecting a PodSpecable to a sink</td>
</tr>
</tbody>
</table>

It is also possible to list available event source types in YAML format:

```bash
$ kn source list-types -o yaml
```

### 7.2.2. Listing available event sources using `kn`

You can list available event sources by using the following command:

```bash
$ kn source list
```

Here is an example output:

<table>
<thead>
<tr>
<th>NAME</th>
<th>TYPE</th>
<th>RESOURCE</th>
<th>SINK</th>
<th>READY</th>
</tr>
</thead>
<tbody>
<tr>
<td>a1</td>
<td>ApiServerSource</td>
<td>apiserversources.sources.knative.dev</td>
<td>svc:eshow2</td>
<td>True</td>
</tr>
<tr>
<td>b1</td>
<td>SinkBinding</td>
<td>sinkbindings.sources.knative.dev</td>
<td>svc:eshow3</td>
<td>False</td>
</tr>
<tr>
<td>p1</td>
<td>PingSource</td>
<td>pingsources.sources.knative.dev</td>
<td>svc:eshow1</td>
<td>True</td>
</tr>
</tbody>
</table>

#### 7.2.2.1. Listing event sources of a specific type only

You can list event sources of a specific type only, by using the **--type** flag. For example, to list all event sources of type **PingSource**:

```bash
$ kn source list --type PingSource
```

Here is an example output:

<table>
<thead>
<tr>
<th>NAME</th>
<th>TYPE</th>
<th>RESOURCE</th>
<th>SINK</th>
<th>READY</th>
</tr>
</thead>
<tbody>
<tr>
<td>p1</td>
<td>PingSource</td>
<td>pingsources.sources.knative.dev</td>
<td>svc:eshow1</td>
<td>True</td>
</tr>
</tbody>
</table>

**Next steps**
7.3. USING APISERVERSOURCE

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

NOTE

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

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

7.3.1. Using the ApiserverSource with the Knative CLI (kn)

This guide describes the steps required to create, manage, and delete an ApiserverSource using kn commands.

Prerequisites

- You will need to have a Knative Serving and Eventing installation.
- You will need to have created the default broker in the same namespace that the ApiserverSource will be installed in.
- You will need to have the kn CLI installed.

Procedure

1. Create a service account, role, and role binding for the ApiserverSource.
   You can do this by creating a file named authentication.yaml and copying the following sample code into it:

   ```yaml
   apiVersion: v1
   kind: ServiceAccount
   metadata:
     name: events-sa
     namespace: default
   ---
   apiVersion: rbac.authorization.k8s.io/v1
   kind: Role
   metadata:
     name: event-watcher
     namespace: default
   rules:
   - apiGroups: ""
     resources: [events]  
   ```
verbs:
- get
- list
- watch

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

Change this namespace to the namespace that you have selected for installing ApiServerSource.

NOTE
If you want to re-use an existing service account with the appropriate permissions, you must modify the `authentication.yaml` for that service account.

Create the service account, role binding and cluster binding by entering the following command:

```bash
$ oc apply --filename authentication.yaml
```

2. Create an ApiServerSource event source by entering the following command:

```bash
$ kn source apiserver create testevents --sink broker:default --resource "event:v1" --service-account events-sa --mode Resource
```

3. To check that the ApiServerSource is set up correctly, create a Knative service that dumps incoming messages to its log by entering the following command:

```bash
$ kn service create event-display --image quay.io/openshift-knative/knative-eventing-sources-event-display:v0.13.2
```

4. Create a trigger from the `default` broker to filter events to the service created in the previous step by entering the following `kn` command:

```bash
$ kn trigger create event-display-trigger --sink svc:event-display
```

5. Create events by launching a pod in the default namespace. You can do this by entering the following command:

```bash
$ oc create deployment hello-node --image=gcr.io/hello-minikube-zero-install/hello-node
```
6. Check that the controller is mapped correctly by entering the following command and inspecting the output:

```
$ kn source apiserver describe testevents
```

The output should be similar to:

```
Name:                testevents
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/v1alpha1)
Resources:
  Kind:       event (v1)
  Controller:  false
Conditions:
  OK TYPE                  AGE REASON
  ++ Ready                 3m
  ++ Deployed               3m
  ++ SinkProvided           3m
  ++ SufficientPermissions  3m
  ++ EventTypeProvided      3m
```

**Verification steps**

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

You can 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
```

The logs should contain lines similar to the following:

```json
export 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",
... }

7.3.1.1. Deleting the ApiServerSource

You can delete the ApiServerSource, trigger, service, service account, cluster role, and cluster binding created in this guide by entering the following `kn` and `oc` commands:

```
$ kn trigger delete event-display-trigger
$ kn service delete event-display
$ kn source apisher delete testevents
$ oc delete -f authentication.yaml
```

7.3.2. Using the ApiServerSource with the YAML method

This guide describes the steps required to create, manage, and delete an ApiServerSource using YAML files.

**Prerequisites**

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

**Procedure**

1. Create a service account, role, and role binding for the ApiServerSource.
   You can do this by creating a file named `authentication.yaml` and copying the following sample code into it:

   ```yaml
   apiVersion: v1
   kind: ServiceAccount
   metadata:
     name: events-sa
     namespace: default
   ---
   apiVersion: rbac.authorization.k8s.io/v1
   kind: Role
   metadata:
     name: event-watcher
   ```
Change this namespace to the namespace that you have selected for installing ApiServerSource.

NOTE
If you want to re-use an existing service account with the appropriate permissions, you must modify the `authentication.yaml` for that service account.

After you have created the `authentication.yaml` file, apply it by entering the following command:

```bash
$ oc apply --filename authentication.yaml
```

2. Create an ApiServerSource event source.
You can do this by creating a file named `k8s-events.yaml` and copying the following sample code into it:

```yaml
apiVersion: sources.knative.dev/v1alpha1
kind: ApiServerSource
metadata:
  name: testevents
spec:
  serviceAccountName: events-sa
  mode: Resource
  resources:
    - apiVersion: v1
      kind: Event
```
After you have created the `k8s-events.yaml` file, apply it by entering the following command:

```
$ oc apply --filename k8s-events.yaml
```

3. To check that the ApiServerSource is set up correctly, create a Knative service that dumps incoming messages to its log.

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

```yaml
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:v0.13.2
```

After you have created the `service.yaml` file, apply it by entering the following command:

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

4. Create a trigger from the `default` broker to filter events to the service created in the previous step.

You can create the trigger by creating a file named `trigger.yaml` and copying the following sample code into it:

```yaml
apiVersion: eventing.knative.dev/v1alpha1
kind: Trigger
metadata:
  name: event-display-trigger
  namespace: default
spec:
  subscriber:
    ref:
      apiVersion: serving.knative.dev/v1
      kind: Service
      name: event-display
```

After you have created the `trigger.yaml` file, apply it by entering the following command:

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

5. Create events by launching a pod in the default namespace. You can do this by entering the following command:
$ oc create deployment hello-node --image=gcr.io/hello-minikube-zero-install/hello-node

6. 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

   The output should be similar to:

   ```yaml
   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/testevents
     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/v1beta1
             kind: Broker
             name: default
   ```

   **Verification steps**

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

   You can view the message dumper function logs by entering the following commands:

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

   The logs should contain lines similar to the following:

   ```bash
   $ 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",
  ...
}

7.3.2.1. Deleting the ApiServerSource
You can delete the ApiServerSource, trigger, service, service account, cluster role, and cluster binding created in this guide by entering the following **oc** commands:

$ oc delete --filename trigger.yaml
$ oc delete --filename service.yaml
$ oc delete --filename k8s-events.yaml
$ oc delete --filename authentication.yaml

7.4. USING A PINGSOURCE
A PingSource is used to periodically send ping events with a constant payload to an event consumer.

A PingSource can be used to schedule sending events, similar to a timer, as shown in the example:

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

1. The schedule of the event specified using **CRON expression**.

2. The event message body expressed as a JSON encoded data string.

3. These are the details of the event consumer. In this example, we are using a Knative service named **event-display**.

### 7.4.1. Using a PingSource with the `kn` CLI

The following sections describe how to create, verify and remove a basic PingSource using the `kn` CLI.

#### Prerequisites

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

#### Procedure

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

   ```bash
   $ kn service create event-display \
      --image quay.io/openshift-knative/knative-eventing-sources-event-display:v0.13.2
   ```

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

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

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

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

   The output should be similar to:

   ```
   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:
<table>
<thead>
<tr>
<th>OK TYPE</th>
<th>AGE</th>
<th>REASON</th>
</tr>
</thead>
<tbody>
<tr>
<td>++ Ready</td>
<td>8s</td>
<td></td>
</tr>
<tr>
<td>++ Deployed</td>
<td>8s</td>
<td></td>
</tr>
<tr>
<td>++ SinkProvided</td>
<td>15s</td>
<td></td>
</tr>
<tr>
<td>++ ValidSchedule</td>
<td>15s</td>
<td></td>
</tr>
<tr>
<td>++ EventTypeProvided</td>
<td>15s</td>
<td></td>
</tr>
<tr>
<td>++ ResourcesCorrect</td>
<td>15s</td>
<td></td>
</tr>
</tbody>
</table>

Verification steps

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:
   
   ```bash
   $ watch oc get pods
   ```

2. Cancel watching the pods using Ctrl+C, then look at the logs of the created pod:
   
   ```bash
   $ oc logs $(oc get pod -o name | grep event-display) -c user-container
   ```

   The logs should contain lines similar to the following:

   ```
   ☁ 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!"
   }
   ```

7.4.1. Remove the PingSource

You can delete the PingSource and the service that you created by entering the following commands:

```bash
$ kn delete pingsources.sources.knative.dev test-ping-source
$ kn delete service.serving.knative.dev event-display
```
The following sections describe how to create, verify and remove a basic PingSource using YAML files.

Prerequisites

- You have Knative Serving and Eventing installed.

NOTE

The following procedure requires you to create YAML files.

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

Procedure

1. To verify that the PingSource is working, create a simple Knative service that dumps incoming messages to the service’s logs.
   
   a. Copy the example YAML into a file named `service.yaml`:

   ```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:v0.13.2
   
   b. Create the service:

   ```

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

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

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

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

   ```

   ```bash
   $ oc apply --filename ping-source.yaml
   ```
3. Check that the controller is mapped correctly by entering the following command and inspecting the output:

   $ oc get pingsource.sources.knative.dev test-ping-source -o yaml

The output should be similar to:

   apiVersion: sources.knative.dev/v1alpha2
   kind: PingSource
   metadata:
     annotations:
       sources.knative.dev/creator: developer
       sources.knative.dev/lastModifier: developer
       creationTimestamp: "2020-04-07T16:11:14Z"
     generation: 1
     name: test-ping-source
     namespace: default
     resourceVersion: "55257"
     selfLink: /apis/sources.knative.dev/v1alpha2/namespaces/default/pingsources/test-ping-source
     uid: 3d80d50b-f8c7-4c1b-99f7-3ec00e0a8164
   spec:
     jsonData: '{ value: "hello" }'
     schedule: "*/2 * * * *"
     sink:
       ref:
         apiVersion: serving.knative.dev/v1
         kind: Service
         name: event-display
         namespace: default

Verification steps

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

The logs should contain lines similar to the following:

   ☁ 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!"
}

7.4.2.1. Remove the PingSource
You can delete the PingSource and the service that you created by entering the following commands:

$ oc delete --filename service.yaml
$ oc delete --filename ping-source.yaml

7.5. USING SINKBINDING
SinkBinding is used to connect event producers, or event sources, to an event consumer, or event sink, for example, a Knative service or application.

NOTE
Both of the following procedures require you to create YAML files.
If you change the names of the YAML files from those used in the examples, you must ensure that you also update the corresponding CLI commands.

7.5.1. Using SinkBinding with the Knative CLI (kn)
This guide describes the steps required to create, manage, and delete a SinkBinding instance using kn commands.

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

Procedure
1. To check that SinkBinding 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:v0.13.2

2. Create a SinkBinding that directs events to the service:
$ kn source binding create bind-heartbeat --subject Job:batch/v1:app=heartbeat-cron --sink svc:event-display

3. Create a CronJob.

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

```yaml
apiVersion: batch/v1beta1
kind: CronJob
metadata:
  name: heartbeat-cron
spec:
  schedule: "* * * * *"
  jobTemplate:
    metadata:
      labels:
        app: heartbeat-cron
    spec:
      template:
        spec:
          restartPolicy: Never
          containers:
            - name: single-heartbeat
              image: quay.io/openshift-knative/knative-eventing-sources-heartbeats:v0.13.2
              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
```

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

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

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

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

The output should be similar to:

```
Name:         bind-heartbeat
Namespace:    demo-2
Annotations:  sources.knative.dev/creator=minikube-user,
```
Veriﬁcation steps

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

You can view the message dumper function logs by entering:

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

The logs should contain lines similar to the following:

```
☁ 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
    contenttype: application/json
  Extensions,
    beats: true
    heart: yes
    the: 42
  Data,
  
```

7.5.2. Using SinkBinding with the YAML method

This guide describes the steps required to create, manage, and delete a SinkBinding instance using YAML ﬁles.

Prerequisites

- You have Knative Serving and Eventing installed.
Procedure

1. To check that SinkBinding is set up correctly, create a Knative event display service, or event sink, that dumps incoming messages to its log.
   a. Copy the following sample YAML into a file named service.yaml:
      ```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:v0.13.2
      ```
   b. After you have created the service.yaml file, apply it by entering:
      ```bash
      $ oc apply --filename service.yaml
      ```

2. Create a SinkBinding that directs events to the service.
   a. Create a file named sinkbinding.yaml and copy the following sample code into it:
      ```yaml
      apiVersion: sources.knative.dev/v1alpha1
      kind: SinkBinding
      metadata:
        name: bind-heartbeat
      spec:
        subject:
          apiVersion: batch/v1
          kind: Job
        selector:
          matchLabels:
            app: heartbeat-cron
        sink:
          ref:
            apiVersion: serving.knative.dev/v1
            kind: Service
            name: event-display
      ```
   b. After you have created the sinkbinding.yaml file, apply it by entering:
      ```bash
      $ oc apply --filename sinkbinding.yaml
      ```

3. Create a CronJob.
   a. Create a file named heartbeats-cronjob.yaml and copy the following sample code into it:
apiVersion: batch/v1beta1
kind: CronJob
metadata:
  name: heartbeat-cron
spec:
  # Run every minute
  schedule: "* * * * *"
  jobTemplate:
    metadata:
      labels:
        app: heartbeat-cron
    spec:
      template:
        spec:
          restartPolicy: Never
          containers:
            - name: single-heartbeat
              image: quay.io/openshift-knative/knative-eventing-sources-heartbeats:v0.13.2
              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

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

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

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

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

The output should be similar to:

```
spec:
  sink:
    ref:
      apiVersion: serving.knative.dev/v1
      kind: Service
      name: event-display
      namespace: default
  subject:
    apiVersion: batch/v1
    kind: Job
    namespace: default
```
Verification steps

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

You can view the message dumper function logs by entering:

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

The logs should contain lines similar to the following:

```
☁ 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-a433-608fbd2596
contenttype: application/json
Extensions,
beats: true
heart: yes
the: 42
Data,
{
  "id": 1,
  "label": ""
}
```

7.6. USING TRIGGERS

All events which are sent to a channel or broker will be sent to all subscribers of that channel or broker by default.

Using triggers allows you to filter events from a channel or broker, so that subscribers will only receive a subset of events based on your defined criteria.

The Knative CLI provides a set of kn trigger commands that can be used to create and manage triggers.

Prerequisites

Before you can use triggers, you will need:

- Knative Eventing and kn installed.

- An available broker, either the default broker or one that you have created.

  You can create the default broker either by following the instructions on Using brokers with Knative Eventing, or by using the --inject-broker flag while creating a trigger. Use of this flag is described in the procedure below.
7.6.1. Creating a trigger using kn

Procedure

To create a trigger, enter the following command:

```
$ kn trigger create <TRIGGER-NAME> --broker <BROKER-NAME> --filter <KEY=VALUE> --sink <SINK>
```

To create a trigger and also create the default broker using broker injection, enter the following command:

```
$ kn trigger create <TRIGGER-NAME> --inject-broker --filter <KEY=VALUE> --sink <SINK>
```

Example trigger YAML:

```yaml
apiVersion: eventing.knative.dev/v1alpha1
kind: Trigger
metadata:
  name: trigger-example
spec:
  broker: default
  subscriber:
    ref:
      apiVersion: serving.knative.dev/v1
      kind: Service
      name: my-service
```

1. The name of the trigger.
2. The name of the broker where events will be filtered from. If the broker is not specified, the trigger will revert to using the default broker.
3. The name of the service that will consumer filtered events.

7.6.2. Listing triggers using kn

The `kn trigger list` command prints a list of available triggers.

Procedure

- To print a list of available triggers, enter the following command:

```
$ kn trigger list
```

Example output:

```
$ kn trigger list
NAME   BROKER     SINK           AGE   CONDITIONS  READY   REASON
email   default    svc:edisplay  4s    5 OK / 5     True
```

- An available event consumer, for example, a Knative service.
To print a list of triggers in JSON format, enter the following command:

```
$ kn trigger list -o json
```

7.6.3. Describing a trigger using `kn`

The `kn trigger describe` command prints information about a trigger.

**Procedure**

To print information about a trigger, enter the following command:

```
$ kn trigger describe <TRIGGER-NAME>
```

Example output:

```
$ kn trigger describe ping
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
```

7.6.4. Deleting a trigger using `kn`

**Procedure**

To delete a trigger, enter the following command:

```
$ kn trigger delete <TRIGGER-NAME>
```

7.6.5. Updating a trigger using `kn`

You can use the `kn trigger update` command with certain flags to quickly update attributes of a trigger.
Procedure

To update a trigger, enter the following command:

$ kn trigger update NAME --filter KEY=VALUE --sink SINK [flags]

You can update a trigger to filter exact event attributes that match incoming events, such as `type=knative.dev.event`. For example:

$ kn trigger update mytrigger --filter type=knative.dev.event

You can also remove a filter attribute from a trigger. For example, you can remove the filter attribute with key `type`:

$ kn trigger update mytrigger --filter type-

The following example shows how to update the sink of a trigger to `svc:new-service`:

$ kn trigger update mytrigger --sink svc:new-service

7.6.6. Filtering events using triggers

In the following trigger example, only events with attribute `type: dev.knative.samples.helloworld` will reach the event consumer.

$ kn trigger create foo --broker default --filter type=dev.knative.samples.helloworld --sink svc:mysvc

You can also filter events using multiple attributes. The following example shows how to filter events using the type, source, and extension attributes.

$ kn trigger create foo --broker default --sink svc:mysvc
   --filter type=dev.knative.samples.helloworld
   --filter source=dev.knative.samples/helloworldsource
   --filter myextension=my-extension-value

7.7. USING BROKERS WITH KNATIVE EVENTING

Knative Eventing uses the `default` broker unless otherwise specified.

If you have cluster administrator permissions, you can create the `default` broker automatically using namespace annotation.

All other users must create a broker using the manual process as described in this guide.

7.7.1. Creating a broker manually

To create a broker, you must create a `ServiceAccount` for each namespace and give that `ServiceAccount` the required RBAC permissions.

Prerequisites

- Knative Eventing installed, which includes the `ClusterRole`. 

Procedure

1. Create the **ServiceAccount** objects:

   ```
   $ oc -n default create serviceaccount eventing-broker-ingress
   $ oc -n default create serviceaccount eventing-broker-filter
   ```

2. Give those objects RBAC permissions:

   ```
   $ oc -n default create rolebinding eventing-broker-ingress \
   --clusterrole=eventing-broker-ingress \
   --serviceaccount=default:eventing-broker-ingress
   $ oc -n default create rolebinding eventing-broker-filter \
   --clusterrole=eventing-broker-filter \
   --serviceaccount=default:eventing-broker-filter
   ```

3. Create the broker:

   ```
   cat << EOF | oc apply -f -
   apiVersion: eventing.knative.dev/v1beta1
   kind: Broker
   metadata:
     namespace: default
     name: default
   EOF
   ```

   This example uses the name **default**, but you can replace this with any other valid name.

---

### 7.7.2. Creating a broker automatically using namespace annotation

If you have cluster administrator permissions, you can create a broker automatically by annotating a namespace.

**Prerequisites**

- Knative Eventing installed.
- Cluster administrator permissions for OpenShift Container Platform.

**Procedure**

1. Annotate your namespace by entering the following commands:

   ```
   $ oc label namespace default knative-eventing-injection=enabled
   $ oc -n default get broker default
   ```

   Replace **default** with the desired namespace.

   The line shown in this example will automatically create a broker named **default** in the **default** namespace.
NOTE

Brokers created due to annotation will not be removed if you remove the annotation. You must manually delete them.

7.7.3. Deleting a broker that was created using namespace annotation

1. Delete the injected broker from the selected namespace (in this example, the default namespace):

   $ oc -n default delete broker default

7.8. USING CHANNELS

It is possible to sink events from an event source to a Knative Eventing channel. Channels are Custom Resources (CRs) that define a single event-forwarding and persistence layer. After events have been sent to a channel, these events can be sent to multiple Knative services by using a subscription.

The default configuration for channel instances is defined in the default-ch-webhook ConfigMap. However, developers can still create their own channels directly by instantiating a supported channel object.

7.8.1. Supported channel types

Currently, OpenShift Serverless only supports the use of InMemoryChannel channels as part of the Knative Eventing Technology Preview.

The following are limitations of InMemoryChannel channels:

- No event persistence is available. If a Pod goes down, events on that Pod will be lost.
- InMemoryChannel channels do not implement event ordering, so two events that are received in the channel at the same time may be delivered to a subscriber in any order.
- If a subscriber rejects an event, there are no redelivery attempts. Instead, the rejected event is sent to a dead letter sink if this sink exists, or is otherwise dropped.

7.8.2. Creating a channel with cluster default configuration

To create a channel using the cluster default configuration set by the cluster administrator, you must create a generic Channel custom object.

Example Channel object

```yaml
apiVersion: messaging.knative.dev/v1beta1
kind: Channel
metadata:
  name: example-channel
namespace: default
```

When the above Channel object is created, a mutating admission webhook adds a set of spec.channelTemplate properties for the Channel object based on the default channel implementation chosen by the cluster administrator.
Example Channel object with spec.channelTemplate properties

```yaml
apiVersion: messaging.knative.dev/v1beta1
kind: Channel
metadata:
  name: example-channel
  namespace: default
spec:
  channelTemplate:
    apiVersion: messaging.knative.dev/v1beta1
    kind: InMemoryChannel

The channel controller will then create the backing channel instance based on that spec.channelTemplate configuration. 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, two objects are created, a generic channel, and an InMemoryChannel channel.

The generic channel acts as a proxy that copies its subscriptions to the InMemoryChannel, and sets its status to reflect the status of the backing InMemoryChannel channel.

Because the channel in this example is created in the default namespace, the channel uses the cluster default, which is InMemoryChannel.
CHAPTER 8. HIGH AVAILABILITY IN OPENSHIFT SERVERLESS

Active/passive high availability (HA) is a standard feature of Kubernetes APIs that helps to ensure that APIs stay operational if a disruption occurs. In an HA deployment, if an active controller crashes or is deleted, another controller is available to take over processing of the APIs that were being serviced by the controller that is now unavailable.

Active/passive HA in OpenShift Serverless is available through leader election, which is enabled by default after the Knative Serving control plane is installed.

When using a leader election HA pattern, instances of controllers are already scheduled and running inside the cluster before they are required. These controller instances compete to use a shared resource, known as the leader election lock. The instance of the controller that has access to the leader election lock resource at any given time is referred to as the leader.

8.1. CONFIGURING HIGH-AVAILABILITY OPENSHIFT SERVERLESS COMPONENTS

This guide provides information about which components of OpenShift Serverless are configured as high availability (HA) by default, and how you can modify HA settings.

HA functionality is available by default on OpenShift Serverless for the **autoscaler-hpa**, **controller**, **activator**, **kourier-control**, and **kourier-gateway** components. These components are configured with two replicas by default.

8.1.1. Disabling high availability

You can disable HA for Knative Serving components by changing the configuration of the **KnativeServing.spec.highAvailability** field.

**IMPORTANT**

Do not modify any YAML contained inside the **config** field. Some of the configuration values in this field are injected by the OpenShift Serverless Operator, and modifying them will cause your deployment to become unsupported.

**Prerequisites**

- An OpenShift Container Platform account with cluster administrator access.
- Installed the OpenShift Serverless Operator and Knative Serving.

**Procedure**

1. In the OpenShift Container Platform web console, navigate to the **Catalog → OperatorHub → Installed Operators** page.
2. Select the **OpenShift Serverless Operator**.
3. Click **Knative Serving** in the list of **Provided APIs** for the OpenShift Serverless Operator to go to the **Knative Serving** tab.
4. Click on **knative-serving** in the **Knative Serving** tab.

5. Click on **YAML** in the **knative-serving** page.

6. In the **spec** section of the YAML, update the **high-availability.replicas** field to 1:

```
high-availability:
  replicas: 1
```
CHAPTER 9. USING METERING WITH OPENSHIFT SERVERLESS

As a cluster administrator, you can use metering to analyze what is happening in your OpenShift Serverless cluster.

For more information about metering on OpenShift Container Platform, see About metering.

9.1. INSTALLING METERING

For information about installing metering on OpenShift Container Platform, see Installing Metering.

9.2. DATASOURCES FOR KNATIVE SERVING METERING

The following ReportDataSources are examples of how Knative Serving can be used with OpenShift Container Platform metering.

9.2.1. Datasource for CPU usage in Knative Serving

This datasource provides the accumulated CPU seconds used per Knative service over the report time period.

YAML file

```yaml
apiVersion: metering.openshift.io/v1
kind: ReportDataSource
metadata:
  name: knative-service-cpu-usage
spec:
prometheusMetricsImporter:
  query: |
    sum
      by(namespace,
          label_serving_knative_dev_service,
          label_serving_knative_dev_revision)
    
    label_replace(rate(container_cpu_usage_seconds_total{container!="POD",container!="",pod!=""}[1m]), "pod", "$1", "pod", "(.*)")
      
      on(pod, namespace)
      group_left(label_serving_knative_dev_service, label_serving_knative_dev_revision)
      kube_pod_labels{label_serving_knative_dev_service!=""}

      )
```

9.2.2. Datasource for memory usage in Knative Serving

This datasource provides the average memory consumption per Knative service over the report time period.

YAML file

```yaml

```
9.2.3. Applying Datasources for Knative Serving metering

You can apply the `ReportDataSources` by using the following command:

```
$ oc apply -f <datasource-name>.yaml
```

Example

```
$ oc apply -f knative-service-memory-usage.yaml
```

9.3. QUERIES FOR KNATIVE SERVING METERING

The following `ReportQuery` resources reference the example `DataSources` provided.

9.3.1. Query for CPU usage in Knative Serving

YAML file

```yaml
apiVersion: metering.openshift.io/v1
kind: ReportQuery
metadata:
  name: knative-service-cpu-usage
spec:
  inputs:
  - name: ReportingStart
type: time
  - name: ReportingEnd
type: time
  - default: knative-service-cpu-usage
    name: KnativeServiceCpuUsageDataSource
type: ReportDataSource
columns:
```
9.3.2. Query for memory usage in Knative Serving

YAML file

```yaml
apiVersion: metering.openshift.io/v1
kind: ReportQuery
metadata:
  name: knative-service-memory-usage
spec:
  inputs:
    - name: ReportingStart
type: time
    - name: ReportingEnd
type: time
    - default: knative-service-memory-usage
      name: KnativeServiceMemoryUsageDataSource
type: ReportDataSource
```
9.3.3. Applying Queries for Knative Serving metering

You can apply the `ReportQuery` by using the following command:

```
$ oc apply -f <query-name>.yaml
```

Example

```
$ oc apply -f knative-service-memory-usage.yaml
```

9.4. METERING REPORTS FOR KNATIVE SERVING

You can run metering reports against Knative Serving by creating `Report` resources. Before you run a report, you must modify the input parameter within the `Report` resource to specify the start and end dates of the reporting period.
YAML file

```yaml
apiVersion: metering.openshift.io/v1
kind: Report
metadata:
  name: knative-service-cpu-usage
spec:
  reportingStart: '2019-06-01T00:00:00Z'
  query: knative-service-cpu-usage
  runImmediately: true
```

1. Start date of the report, in ISO 8601 format.
2. End date of the report, in ISO 8601 format.

9.4.1. Running a metering report

Once you have provided the input parameters, you can run the report using the command:

```
$ oc apply -f <report-name>.yml
```

You can then check the report as shown in the following example:

```
$ kubectl get report
```

<table>
<thead>
<tr>
<th>NAME</th>
<th>QUERY</th>
<th>SCHEDULE</th>
<th>RUNNING</th>
<th>FAILED</th>
<th>LAST REPORT</th>
</tr>
</thead>
</table>