OpenShift Dedicated 4

Serverless

Configuring OpenShift Serverless on OpenShift Dedicated
Configuring OpenShift Serverless on OpenShift Dedicated
Abstract

This document provides information about setting up and using OpenShift Serverless on OpenShift Dedicated.
Table of Contents

CHAPTER 1. RELEASE NOTES ................................................................. 11
1.1. ABOUT API VERSIONS .............................................................. 11
1.2. GENERALLY AVAILABLE AND TECHNOLOGY PREVIEW FEATURES .... 11
1.3. DEPRECATED AND REMOVED FEATURES .................................. 12
1.4. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.24.0 .... 12
1.4.1. New features ..................................................................... 12
1.4.2. Fixed issues ...................................................................... 13
1.4.3. Known issues .................................................................... 13
1.5. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.23.0 .... 13
1.5.1. New features ..................................................................... 13
1.5.2. Known issues .................................................................... 14
1.6. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.22.0 .... 14
1.6.1. New features ..................................................................... 15
1.6.2. Known issues .................................................................... 15
1.7. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.21.0 .... 15
1.7.1. New features ..................................................................... 15
1.7.2. Fixed issues ...................................................................... 16
1.7.3. Known issues .................................................................... 16
1.8. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.20.0 .... 17
1.8.1. New features ..................................................................... 17
1.8.2. Known issues .................................................................... 17

CHAPTER 2. DISCOVER ........................................................................ 19
2.1. ABOUT OPENSHIFT SERVERLESS .............................................. 19
2.1.1. Knative Serving .................................................................. 19
2.1.1.1. Knative Serving resources ........................................... 19
2.1.2. Knative Eventing ............................................................... 19
2.1.3. Supported configurations .................................................. 20
2.1.4. Additional resources .......................................................... 20
2.2. ABOUT OPENSHIFT SERVERLESS FUNCTIONS ....................... 20
2.2.1. Included runtimes ............................................................... 21
2.2.2. Next steps ...................................................................... 21
2.3. EVENT SOURCES .................................................................... 21
2.4. CHANNELS AND SUBSCRIPTIONS ......................................... 21
2.4.1. Channel implementation types ......................................... 22
2.4.2. Next steps ...................................................................... 23

CHAPTER 3. INSTALL .......................................................................... 24
3.1. INSTALLING THE OPENSHIFT SERVERLESS OPERATOR ............ 24
3.1.1. Defining cluster size requirements .................................... 24
3.1.2. Installing the OpenShift Serverless Operator ..................... 24
3.1.3. Additional resources .......................................................... 25
3.1.4. Next steps ...................................................................... 25
3.2. INSTALLING KNATIVE SERVING ............................................ 25
3.2.1. Installing Knative Serving by using the web console .......... 26
3.2.2. Installing Knative Serving by using YAML ......................... 28
3.2.3. Next steps ...................................................................... 29
3.3. INSTALLING KNATIVE EVENTING .......................................... 29
3.3.1. Installing Knative Eventing by using the web console ........ 30
3.3.2. Installing Knative Eventing by using YAML ....................... 32
3.3.3. Next steps ...................................................................... 33
CHAPTER 4. KNATIVE CLI

4.1. INSTALLING THE KNATIVE CLI

4.1.1. Installing the Knative CLI using the OpenShift Dedicated web console

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

4.1.3. Installing the Knative CLI for Linux

4.1.4. Installing the Knative CLI for macOS

4.1.5. Installing the Knative CLI for Windows

4.2. CONFIGURING THE KNATIVE CLI

4.3. KNATIVE SERVING CLI COMMANDS

4.3.1. kn service commands

4.3.1.1. Creating serverless applications by using the Knative CLI

4.3.1.2. Updating serverless applications by using the Knative CLI

4.3.1.3. Applying service declarations

4.3.1.4. Describing serverless applications by using the Knative CLI

4.3.2. About the Knative CLI offline mode

4.3.2.1. Creating a service using offline mode

4.3.3. kn container commands

4.3.3.1. Knative client multi-container support

4.3.4. kn domain commands

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

4.3.4.2. Managing custom domain mappings by using the Knative CLI

4.4. KNATIVE EVENTING CLI COMMANDS

4.4.1. kn source commands

4.4.1.1. Listing available event source types by using the Knative CLI

4.4.1.2. Knative CLI sink flag

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

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

4.4.1.5. Creating a ping source by using the Knative CLI

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

4.5. FUNCTIONS COMMANDS

4.5.1. Creating functions

4.5.2. Running a function locally

4.5.3. Building functions

4.5.3.1. Image container types

4.5.3.2. Image registry types

4.5.3.3. Push flag

4.5.3.4. Help command

4.5.4. Deploying functions

4.5.5. Listing existing functions

4.5.6. Describing a function

4.5.7. Invoking a deployed function with a test event

4.5.7.1. kn func invoke optional parameters

4.5.7.1.1. Main parameters
4.5.7.1.2. Example commands
4.5.7.1.2.1. Specifying the file with data
4.5.7.1.2.2. Specifying the function project
4.5.7.1.2.3. Specifying where the target function is deployed
4.5.8. Deleting a function

CHAPTER 5. DEVELOP ................................................................. 70
5.1. SERVERLESS APPLICATIONS ........................................... 70
  5.1.1. Creating serverless applications by using the Knative CLI 70
  5.1.2. Creating a service using offline mode 71
  5.1.3. Creating serverless applications using YAML 74
  5.1.4. Verifying your serverless application deployment 75
  5.1.5. Interacting with a serverless application using HTTP2 and gRPC 76
  5.1.6. Configuring init containers 77
  5.1.7. HTTPS redirection per service 78
  5.1.8. Additional resources 79
5.2. AUTOSCALING .............................................................. 79
  5.2.1. Scale bounds ......................................................... 79
    5.2.1.1. Minimum scale bounds 79
      5.2.1.1.1. Setting the min-scale annotation by using the Knative CLI 80
    5.2.1.2. Maximum scale bounds 80
      5.2.1.2.1. Setting the max-scale annotation by using the Knative CLI 81
  5.2.2. Concurrency ....................................................... 81
    5.2.2.1. Configuring a soft concurrency target 81
    5.2.2.2. Configuring a hard concurrency limit 82
    5.2.2.3. Concurrency target utilization 83
5.3. TRAFFIC MANAGEMENT .................................................. 83
  5.3.1. Traffic spec examples 84
  5.3.2. Knative CLI traffic management flags 85
    5.3.2.1. Multiple flags and order precedence 86
    5.3.2.2. Custom URLs for revisions 86
      5.3.2.2.1. Example: Assign a tag to a revision 87
      5.3.2.2.2. Example: Remove a tag from a revision 87
  5.3.3. Creating a traffic split by using the Knative CLI 87
  5.3.4. Managing traffic between revisions by using the OpenShift Dedicated web console 88
  5.3.5. Routing and managing traffic by using a blue-green deployment strategy 89
5.4. ROUTING ................................................................. 92
  5.4.1. Customizing labels and annotations for OpenShift Dedicated routes 92
  5.4.2. Configuring OpenShift Dedicated routes for Knative services 93
  5.4.3. Setting cluster availability to cluster local 95
5.5. EVENT SINKS ........................................................... 96
  5.5.1. Knative CLI sink flag 96
  5.5.2. Connect an event source to a sink using the Developer perspective 97
  5.5.3. Connecting a trigger to a sink 98
5.6. EVENT DELIVERY ........................................................ 98
  5.6.1. Event delivery behavior for Knative Eventing channels 98
    5.6.1.1. Event delivery behavior for Knative Kafka channels 98
    5.6.1.2. Delivery failure status codes 98
  5.6.2. Configurable event delivery parameters 99
  5.6.3. Configuring event delivery failure parameters using subscriptions 99
5.7. LISTING EVENT SOURCES AND EVENT SOURCE TYPES ...... 100
  5.7.1. Listing available event source types by using the Knative CLI 100
  5.7.2. Viewing available event source types within the Developer perspective 101
5.13.3.2. Creating a Kafka broker that uses an externally managed Kafka topic 159
5.13.4. Managing brokers
5.13.4.1. Listing existing brokers by using the Knative CLI 160
5.13.4.2. Describing an existing broker by using the Knative CLI 160
5.13.5. Additional resources 161
5.14. TRIGGERS
5.14.1. Creating a trigger by using the web console 162
5.14.2. Creating a trigger by using the Knative CLI 162
5.14.3. Listing triggers by using the Knative CLI 163
5.14.4. Describing a trigger by using the Knative CLI 163
5.14.5. Filtering events with triggers by using the Knative CLI 164
5.14.6. Updating a trigger by using the Knative CLI 165
5.14.7. Deleting a trigger by using the Knative CLI 165
5.15. USING KNATIVE KAFKA
5.15.1. Kafka event delivery and retries 166
5.15.2. Kafka source
5.15.2.1. Creating a Kafka event source by using the web console 167
5.15.2.2. Creating a Kafka event source by using the Knative CLI 168
5.15.2.2.1. Knative CLI sink flag 170
5.15.2.3. Creating a Kafka event source by using YAML 170
5.15.3. Kafka broker
5.15.3.1. Creating a Kafka broker by using YAML 172
5.15.3.2. Creating a Kafka broker that uses an externally managed Kafka topic 173
5.15.4. Creating a Kafka channel by using YAML 174
5.15.5. Kafka sink
5.15.5.1. Using a Kafka sink 175
5.15.6. Additional resources 176

CHAPTER 6. ADMINISTER ................................................................. 177
6.1. GLOBAL CONFIGURATION 177
6.1.1. Configuring the default channel implementation 177
6.1.2. Enabling scale-to-zero 178
6.1.3. Configuring the scale-to-zero grace period 179
6.1.4. Overriding system deployment configurations
6.1.4.1. Overriding Knative Serving system deployment configurations 179
6.1.4.2. Overriding Knative Eventing system deployment configurations 180
6.1.5. Configuring the EmptyDir extension 181
6.1.6. HTTPS redirection global settings 182
6.1.7. Setting the URL scheme for external routes 182
6.1.8. Setting the Kourier Gateway service type 183
6.1.9. Enabling PVC support 183
6.1.10. Enabling init containers 185
6.1.11. Tag-to-digest resolution
6.1.11.1. Configuring tag-to-digest resolution by using a secret 186
6.2. CONFIGURING KNATIVE KAFKA 187
6.2.1. Installing Knative Kafka 187
6.2.2. Security configuration for Knative Kafka
6.2.2.1. Configuring TLS authentication for Kafka brokers 190
6.2.2.2. Configuring SASL authentication for Kafka brokers 191
6.2.2.3. Configuring TLS authentication for Kafka channels 192
6.2.2.4. Configuring SASL authentication for Kafka channels 193
6.2.3. Additional resources 195
6.3. SERVERLESS COMPONENTS IN THE ADMINISTRATOR PERSPECTIVE 195
6.3.1. Creating serverless applications using the Administrator perspective 195
6.3.2. Mapping a custom domain to a service by using the Administrator perspective 196
6.3.3. Creating an event source by using the Administrator perspective 198
6.3.4. Creating a broker by using the Administrator perspective 198
6.3.5. Creating a trigger by using the Administrator perspective 199
6.3.6. Creating a channel by using the Administrator perspective 200
6.3.7. Creating a subscription by using the Administrator perspective 201
6.3.8. Additional resources 201

6.4. INTEGRATING SERVICE MESH WITH OPENSFiTH SERVERLESS 202
6.4.1. Prerequisites 202
6.4.2. Creating a certificate to encrypt incoming external traffic 202
6.4.3. Integrating Service Mesh with OpenShift Serverless 203
6.4.4. Enabling Knative Serving metrics when using Service Mesh with mTLS 207
6.4.5. Integrating Service Mesh with OpenShift Serverless when Kourier is enabled 208
6.4.6. Improving memory usage by using secret filtering for Service Mesh 210

6.5. SERVERLESS ADMINISTRATOR METRICS 211
6.5.1. Prerequisites 211
6.5.2. Controller metrics 212
6.5.3. Webhook metrics 213
6.5.4. Knative Eventing metrics 214
  6.5.4.1. Broker ingress metrics 214
  6.5.4.2. Broker filter metrics 215
  6.5.4.3. InMemoryChannel dispatcher metrics 215
  6.5.4.4. Event source metrics 216
6.5.5. Knative Serving metrics 217
  6.5.5.1. Activator metrics 217
  6.5.5.2. Autoscaler metrics 218
  6.5.5.3. Go runtime metrics 220

6.6. HIGH AVAILABILITY 223
6.6.1. Configuring high availability replicas for Knative Serving 224
6.6.2. Configuring high availability replicas for Knative Eventing 225
6.6.3. Configuring high availability replicas for Knative Kafka 226

CHAPTER 7. MONITOR ................................................................. 228
7.1. USING OPENSF'iTH LOGGIING WITH OPENSFiTH SERVERLESS 228
  7.1.1. About deploying the logging subsystem for Red Hat OpenShift 228
  7.1.2. About deploying and configuring the logging subsystem for Red Hat OpenShift 228
    7.1.2.1. Configuring and Tuning the logging subsystem 228
    7.1.2.2. Sample modified ClusterLogging custom resource 230
  7.1.3. Using OpenShift Logging to find logs for Knative Serving components 231
  7.1.4. Using OpenShift Logging to find logs for services deployed with Knative Serving 231
7.2. SERVERLESS DEVELOPER METRICS 232
  7.2.1. Knative service metrics exposed by default 232
  7.2.2. Knative service with custom application metrics 236
  7.2.3. Configuration for scraping custom metrics 237
  7.2.4. Examining metrics of a service 239
    7.2.4.1. Queue proxy metrics 240
    7.2.5. Examining metrics of a service in the dashboard 241

CHAPTER 8. TRACING REQUESTS .................................................. 243
8.1. USING JAEGER TO ENABLE DISTRIBUTED TRACING 243

CHAPTER 9. OPENSFiTH SERVERLESS SUPPORT .................................. 245
9.1. ABOUT THE RED HAT KNOWLEDGEBASE 245
9.2. SEARCHING THE RED HAT KNOWLEDGEBASE
9.3. SUBMITTING A SUPPORT CASE
9.4. GATHERING DIAGNOSTIC INFORMATION FOR SUPPORT
  9.4.1. About the must-gather tool
  9.4.2. About collecting OpenShift Serverless data

CHAPTER 10. SECURITY
  10.1. CONFIGURING JSON WEB TOKEN AUTHENTICATION FOR KNATIVE SERVICES
    10.1.1. Using JSON Web Token authentication with Service Mesh 2.x and OpenShift Serverless
    10.1.2. Using JSON Web Token authentication with Service Mesh 1.x and OpenShift Serverless
  10.2. CONFIGURING A CUSTOM DOMAIN FOR A KNATIVE SERVICE
    10.2.1. Creating a custom domain mapping
    10.2.2. Creating a custom domain mapping by using the Knative CLI
    10.2.3. Mapping a custom domain to a service by using the Developer perspective
    10.2.4. Securing a service with a custom domain by using a TLS certificate

CHAPTER 11. FUNCTIONS
  11.1. SETTING UP OPENSHIFT SERVERLESS FUNCTIONS
    11.1.1. Prerequisites
    11.1.2. Setting up podman
    11.1.3. Next steps
  11.2. GETTING STARTED WITH FUNCTIONS
    11.2.1. Prerequisites
    11.2.2. Creating functions
    11.2.3. Running a function locally
    11.2.4. Building functions
      11.2.4.1. Image container types
      11.2.4.2. Image registry types
      11.2.4.3. Push flag
      11.2.4.4. Help command
    11.2.5. Building and deploying functions on the cluster
    11.2.6. Deploying functions
    11.2.7. Invoking a deployed function with a test event
    11.2.8. Next steps
  11.3. DEVELOPING NODE.JS FUNCTIONS
    11.3.1. Prerequisites
    11.3.2. Node.js function template structure
    11.3.3. About invoking Node.js functions
      11.3.3.1. Node.js context objects
      11.3.3.1.1. Context object methods
      11.3.3.1.2. CloudEvent data
    11.3.4. Node.js function return values
      11.3.4.1. Returning headers
      11.3.4.2. Returning status codes
    11.3.5. Testing Node.js functions
    11.3.6. Next steps
  11.4. DEVELOPING TYPESCRIPT FUNCTIONS
    11.4.1. Prerequisites
    11.4.2. TypeScript function template structure
    11.4.3. About invoking TypeScript functions
      11.4.3.1. TypeScript context objects
      11.4.3.1.1. Context object methods
      11.4.3.1.2. Context types
11.10.1. Modifying function access to secrets and config maps interactively
11.10.2. Modifying function access to secrets and config maps interactively by using specialized commands
11.10.3. Adding function access to secrets and config maps manually
  11.10.3.1. Mounting a secret as a volume
  11.10.3.2. Mounting a config map as a volume
  11.10.3.3. Setting environment variable from a key value defined in a secret
  11.10.3.4. Setting environment variable from a key value defined in a config map
  11.10.3.5. Setting environment variables from all values defined in a secret
  11.10.3.6. Setting environment variables from all values defined in a config map

11.11. ADDING ANNOTATIONS TO FUNCTIONS
  11.11.1. Adding annotations to a function

11.12. FUNCTIONS DEVELOPMENT REFERENCE GUIDE
  11.12.1. Node.js context object reference
    11.12.1.1. log
    11.12.1.2. query
    11.12.1.3. body
    11.12.1.4. headers
    11.12.1.5. HTTP requests
  11.12.2. TypeScript context object reference
    11.12.2.1. log
    11.12.2.2. query
    11.12.2.3. body
    11.12.2.4. headers
    11.12.2.5. HTTP requests
CHAPTER 1. RELEASE NOTES

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

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

NOTE

OpenShift Serverless is based on the open source Knative project.

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

1.1. ABOUT API VERSIONS

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

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

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

1.2. GENERALLY AVAILABLE AND TECHNOLOGY PREVIEW FEATURES

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

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

Table 1.1. Generally Available and Technology Preview features tracker

<table>
<thead>
<tr>
<th>Feature</th>
<th>1.23</th>
<th>1.24</th>
</tr>
</thead>
<tbody>
<tr>
<td>kn func</td>
<td>TP</td>
<td>TP</td>
</tr>
<tr>
<td>kn func invoke</td>
<td>TP</td>
<td>TP</td>
</tr>
<tr>
<td>Service Mesh mTLS</td>
<td>GA</td>
<td>GA</td>
</tr>
<tr>
<td><code>emptyDir</code> volumes</td>
<td>GA</td>
<td>GA</td>
</tr>
</tbody>
</table>
1.3. DEPRECATED AND REMOVED FEATURES

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

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

Table 1.2. Deprecated and removed features tracker

<table>
<thead>
<tr>
<th>Feature</th>
<th>1.20</th>
<th>1.21</th>
<th>1.22</th>
<th>1.23</th>
<th>1.24</th>
</tr>
</thead>
<tbody>
<tr>
<td>KafkaBinding API</td>
<td>Deprecated</td>
<td>Deprecated</td>
<td>Removed</td>
<td>Removed</td>
<td>Removed</td>
</tr>
<tr>
<td>kn func emit (kn func invoke in 1.21+)</td>
<td>Deprecated</td>
<td>Removed</td>
<td>Removed</td>
<td>Removed</td>
<td>Removed</td>
</tr>
</tbody>
</table>

1.4. RELEASE NOTES FOR RED HAT OPENSOURCE SERVERLESS 1.24.0

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

1.4.1. New features

- OpenShift Serverless now uses Knative Serving 1.3.
- OpenShift Serverless now uses Knative Eventing 1.3.
- OpenShift Serverless now uses Kourier 1.3.
- OpenShift Serverless now uses Knative **kn** CLI 1.3.
- OpenShift Serverless now uses Knative **kafka** 1.3.
- The **kn func** CLI plug-in now uses **func** 0.24.
Init containers support for Knative services is now generally available (GA).

OpenShift Serverless logic is now available as a Developer Preview. It enables defining declarative workflow models for managing serverless applications.

### 1.4.2. Fixed issues

- Integrating OpenShift Serverless with Red Hat OpenShift Service Mesh causes the `net-istio-controller` pod to run out of memory on startup when too many secrets are present on the cluster.
  
  It is now possible to enable secret filtering, which causes `net-istio-controller` to consider only secrets with a `networking.internal.knative.dev/certificate-uid` label, thus reducing the amount of memory needed.

- The OpenShift Serverless Functions Technology Preview now uses Cloud Native Buildpacks by default to build container images.

### 1.4.3. Known issues

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

- In OpenShift Serverless 1.23, support for KafkaBindings and the `kafka-binding` webhook were removed. However, an existing `kafkabindings.webhook.kafka.sources.knative.dev MutatingWebhookConfiguration` might remain, pointing to the `kafka-source-webhook` service, which no longer exists.
  
  For certain specifications of KafkaBindings on the cluster, `kafkabindings.webhook.kafka.sources.knative.dev MutatingWebhookConfiguration` might be configured to pass any create and update events to various resources, such as Deployments, Knative Services, or Jobs, through the webhook, which would then fail.

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

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

### 1.5. RELEASE NOTES FOR RED HAT OPENSSHIFT SERVERLESS 1.23.0

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

### 1.5.1. New features

- OpenShift Serverless now uses Knative Serving 1.2.
- OpenShift Serverless now uses Knative Eventing 1.2.
- OpenShift Serverless now uses Kourier 1.2.
- OpenShift Serverless now uses Knative (kn) CLI 1.2.
- OpenShift Serverless now uses Knative Kafka 1.2.
The **kn func** CLI plug-in now uses **func** 0.24.

It is now possible to use the **kafka.eventing.knative.dev/external.topic** annotation with the Kafka broker. This annotation makes it possible to use an existing externally managed topic instead of the broker creating its own internal topic.

The **kafka-ch-controller** and **kafka-webhook** Kafka components no longer exist. These components have been replaced by the **kafka-webhook-eventing** component.

The OpenShift Serverless Functions Technology Preview now uses Source-to-Image (S2I) by default to build container images.

### 1.5.2. Known issues

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

- If you delete a namespace that includes a Kafka broker, the namespace finalizer may fail to be removed if the broker’s **auth.secret.ref.name** secret is deleted before the broker.

- Running OpenShift Serverless with a large number of Knative services can cause Knative activator pods to run close to their default memory limits of 600MB. These pods might be restarted if memory consumption reaches this limit. Requests and limits for the activator deployment can be configured by modifying the **KnativeServing** custom resource:

```yaml
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
spec:
deployments:
- name: activator
  resources:
    - container: activator
      requests:
        cpu: 300m
        memory: 60Mi
      limits:
        cpu: 1000m
        memory: 1000Mi
```

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

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

### 1.6. RELEASE NOTES FOR RED HAT OPENSSHIFT SERVERLESS 1.22.0

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

- OpenShift Serverless now uses Knative Serving 1.1.
- OpenShift Serverless now uses Knative Eventing 1.1.
- OpenShift Serverless now uses Kourier 1.1.
- OpenShift Serverless now uses Knative (kn) CLI 1.1.
- OpenShift Serverless now uses Knative Kafka 1.1.
- The kn func CLI plug-in now uses func 0.23.
- Init containers support for Knative services is now available as a Technology Preview.
- Persistent volume claim (PVC) support for Knative services is now available as a Technology Preview.
- The knative-serving, knative-serving-ingress, knative-eventing and knative-kafka system namespaces now have the knative.openshift.io/part-of: "openshift-serverless" label by default.
- The Knative Eventing - Kafka Broker/Trigger dashboard has been added, which allows visualizing Kafka broker and trigger metrics in the web console.
- The Knative Eventing - KafkaSink dashboard has been added, which allows visualizing KafkaSink metrics in the web console.
- The Knative Eventing - Broker/Trigger dashboard is now called Knative Eventing - Channel-based Broker/Trigger.
- The knative.openshift.io/part-of: "openshift-serverless" label has substituted the knative.openshift.io/system-namespace label.
- Naming style in Knative Serving YAML configuration files changed from camel case (ExampleName) to hyphen style (example-name). Beginning with this release, use the hyphen style notation when creating or editing Knative Serving YAML configuration files.

1.6.2. Known issues

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

1.7. RELEASE NOTES FOR RED HAT OPENSHIFT SERVERLESS 1.21.0

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

1.7.1. New features

- OpenShift Serverless now uses Knative Serving 1.0
- OpenShift Serverless now uses Knative Eventing 1.0.
- OpenShift Serverless now uses Kourier 1.0.
OpenShift Serverless now uses Knative (kn) CLI 1.0.

OpenShift Serverless now uses Knative Kafka 1.0.

The kn func CLI plug-in now uses func 0.21.

The Kafka sink is now available as a Technology Preview.

The Knative open source project has begun to deprecate camel-cased configuration keys in favor of using kebab-cased keys consistently. As a result, the defaultExternalScheme key, previously mentioned in the OpenShift Serverless 1.18.0 release notes, is now deprecated and replaced by the default-external-scheme key. Usage instructions for the key remain the same.

1.7.2. Fixed issues

- In OpenShift Serverless 1.20.0, there was an event delivery issue affecting the use of kn event send to send events to a service. This issue is now fixed.

- In OpenShift Serverless 1.20.0 (func 0.20), TypeScript functions created with the http template failed to deploy on the cluster. This issue is now fixed.

- In OpenShift Serverless 1.20.0 (func 0.20), deploying a function using the gcr.io registry failed with an error. This issue is now fixed.

- In OpenShift Serverless 1.20.0 (func 0.20), creating a Springboot function project directory with the kn func create command and then running the kn func build command failed with an error message. This issue is now fixed.

- In OpenShift Serverless 1.19.0 (func 0.19), some runtimes were unable to build a function by using podman. This issue is now fixed.

1.7.3. Known issues

- Currently, the domain mapping controller cannot process the URI of a broker, which contains a path that is currently not supported.

This means that, if you want to use a DomainMapping custom resource (CR) to map a custom domain to a broker, you must configure the DomainMapping CR with the broker’s ingress service, and append the exact path of the broker to the custom domain:

**Example DomainMapping CR**

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

The URI for the broker is then `<domain-name>/<broker-namespace>/<broker-name>`. 
1.8. RELEASE NOTES FOR RED HAT OPENSSHIFT SERVERLESS 1.20.0

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

1.8.1. New features

- OpenShift Serverless now uses Knative Serving 0.26.
- OpenShift Serverless now uses Knative Eventing 0.26.
- OpenShift Serverless now uses Kourier 0.26.
- OpenShift Serverless now uses Knative (kn) CLI 0.26.
- OpenShift Serverless now uses Knative Kafka 0.26.
- The kn func CLI plug-in now uses func 0.20.
- The Kafka broker is now available as a Technology Preview.

**IMPORTANT**

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

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

1.8.2. Known issues

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

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

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

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

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

- The Kafka broker currently does not work on a cluster with Federal Information Processing Standards (FIPS) mode enabled.

- If you create a Springboot function project directory with the kn func create command, subsequent running of the kn func build command fails with this error message:
As a workaround, you can change the `builder` property to `gcr.io/paketo-buildpacks/builder:base` in the function configuration file `func.yaml`.

- Deploying a function using the `gcr.io` registry fails with this error message:
  
  ```shell
  Error: failed to get credentials: failed to verify credentials: status code: 404
  ```

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

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

  ```yaml
  buildEnvs: []
  ```

  with this:

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

- In `func` version 0.20, some runtimes might be unable to build a function by using podman. You might see an error message similar to the following:

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

  - The following workaround exists for this issue:

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

    ```shell
    Example service configuration
    ```

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

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

    ```shell
    $ systemctl --user daemon-reload
    $ systemctl restart --user podman.socket
    ```

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

    ```shell
    $ podman system service --time=0 tcp:127.0.0.1:5534 &
    export DOCKER_HOST=tcp://127.0.0.1:5534
    ```
2.1. ABOUT OPENSHIFT SERVERLESS

OpenShift Serverless provides Kubernetes native building blocks that enable developers to create and deploy serverless, event-driven applications on OpenShift Dedicated. OpenShift Serverless is based on the open source Knative project, which provides portability and consistency for hybrid and multi-cloud environments by enabling an enterprise-grade serverless platform.

2.1.1. Knative Serving

Knative Serving supports developers who want to create, deploy, and manage cloud-native applications. It provides a set of objects as Kubernetes custom resource definitions (CRDs) that define and control the behavior of serverless workloads on an OpenShift Dedicated cluster.

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

- Rapidly deploying serverless containers.
- Automatically scaling pods.

2.1.1.1. Knative Serving resources

Service

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

Revision

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

Route

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

Configuration

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

2.1.2. Knative Eventing

Knative Eventing on OpenShift Dedicated enables developers to use an event-driven architecture with serverless applications. An event-driven architecture is based on the concept of decoupled relationships between event producers and event consumers.

Event producers create events, and event sinks, or consumers, receive events. Knative Eventing uses standard HTTP POST requests to send and receive events between event producers and sinks. These events conform to the CloudEvents specifications, which enables creating, parsing, sending, and receiving events in any programming language.
Knative Eventing supports the following use cases:

**Publish an event without creating a consumer**
You can send events to a broker as an HTTP POST, and use binding to decouple the destination configuration from your application that produces events.

**Consume an event without creating a publisher**
You can use a trigger to consume events from a broker based on event attributes. The application receives events as an HTTP POST.

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

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

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

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

- Channels and subscriptions, or
- Brokers and Triggers.

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

#### 2.1.4. Additional resources
- [What is serverless?](#)

#### 2.2. ABOUT OPENSSHIFT SERVERLESS FUNCTIONS
OpenShift Serverless Functions enables developers to create and deploy stateless, event-driven functions as a Knative service on OpenShift Dedicated. The `kn func` CLI is provided as a plug-in for the Knative `kn` CLI. You can use the `kn func` CLI to create, build, and deploy the container image as a Knative service on the cluster.
2.2.1. Included runtimes

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

- Node.js
- Python
- Go
- Quarkus
- TypeScript

2.2.2. Next steps

- Getting started with functions.

2.3. EVENT SOURCES

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

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

Currently, OpenShift Serverless supports the following event source types:

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

**Ping source**
Produces events with a fixed payload on a specified cron schedule.

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

You can also create a custom event source.

2.4. CHANNELS AND SUBSCRIPTIONS
Channels are custom resources that define a single event-forwarding and persistence layer. After events have been sent to a channel from an event source or producer, these events can be sent to multiple Knative services or other sinks by using a subscription.

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

After you create a `Channel` object, a mutating admission webhook adds a set of `spec.channelTemplate` properties for the `Channel` object based on the default channel implementation. For example, for an `InMemoryChannel` default implementation, the `Channel` object looks as follows:

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

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

**NOTE**

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

When this mechanism is used with the preceding example, two objects are created: a generic backing channel and an `InMemoryChannel` channel. If you are using a different default channel implementation, the `InMemoryChannel` is replaced with one that is specific to your implementation. For example, with Knative Kafka, the `KafkaChannel` channel is created.

The backing channel acts as a proxy that copies its subscriptions to the user-created channel object, and sets the user-created channel object status to reflect the status of the backing channel.

### 2.4.1. Channel implementation types
InMemoryChannel and KafkaChannel channel implementations can be used with OpenShift Serverless for development use.

The following are limitations of InMemoryChannel type channels:

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

For more information about Kafka channels, see the Knative Kafka documentation.

2.4.2. Next steps

- Create a channel and a subscription that allows event sinks to subscribe to channels and receive events.
- If you are a cluster administrator, you can configure default settings for channels. See Configuring channel defaults.
CHAPTER 3. INSTALL

3.1. INSTALLING THE OPENSHIFT SERVERLESS OPERATOR

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

3.1.1. Defining cluster size requirements

To install and use OpenShift Serverless, the OpenShift Dedicated cluster must be sized correctly. The total size requirements to run OpenShift Serverless are dependent on the components that are installed and the applications that are deployed, and might vary depending on your deployment.

NOTE

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

By default, each pod requests approximately 400m of CPU, so the minimum requirements are based on this value. Lowering the actual CPU request of applications can increase the number of possible replicas.

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

3.1.2. Installing the OpenShift Serverless Operator

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

Prerequisites

- You have access to an OpenShift Dedicated account with cluster or dedicated administrator access.
- You have logged in to the OpenShift Dedicated web console.

Procedure

1. In the OpenShift Dedicated web console, navigate to the Operators → OperatorHub page.

2. Scroll, or type the keyword Serverless into the Filter by keyword box to find the OpenShift Serverless Operator.

3. Review the information about the Operator and click Install.

4. On the Install Operator page:
   - The Installation Mode is All namespaces on the cluster (default) This mode installs the Operator in the default openshift-serverless namespace to watch and be made available to all namespaces in the cluster.
b. The **Installed Namespace** is `openshift-serverless`.

c. Select the **stable** channel as the **Update Channel**. The **stable** channel will enable installation of the latest stable release of the OpenShift Serverless Operator.

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

5. Click **Install** to make the Operator available to the selected namespaces on this OpenShift Dedicated cluster.

6. From the **Catalog → Operator Management** page, you can monitor the OpenShift Serverless Operator subscription’s installation and upgrade progress.

   a. If you selected a **Manual** approval strategy, the subscription’s upgrade status will remain **Upgrading** until you review and approve its install plan. After approving on the **Install Plan** page, the subscription upgrade status moves to **Up to date**.

   b. If you selected an **Automatic** approval strategy, the upgrade status should resolve to **Up to date** without intervention.

**Verification**

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

If it does not:

1. Switch to the **Catalog → Operator Management** page and inspect the **Operator Subscriptions** and **Install Plans** tabs for any failure or errors under **Status**.

2. Check the logs in any pods in the `openshift-serverless` project on the **Workloads → Pods** page that are reporting issues to troubleshoot further.

**IMPORTANT**

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

### 3.1.3. Additional resources

- Configuring high availability replicas on OpenShift Serverless

### 3.1.4. Next steps

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

### 3.2. INSTALLING KNATIVE SERVING

Installing Knative Serving allows you to create Knative services and functions on your cluster. It also allows you to use additional functionality such as autoscaling and networking options for your applications.
After you install the OpenShift Serverless Operator, you can install Knative Serving by using the default settings, or configure more advanced settings in the **KnativeServing** custom resource (CR). For more information about configuration options for the **KnativeServing** CR, see [Global configuration](#).

**IMPORTANT**

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

### 3.2.1. Installing Knative Serving by using the web console

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

**Prerequisites**

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

**Procedure**

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

**NOTE**

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

**Verification**

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

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

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.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Status</th>
<th>Updated</th>
<th>Reason</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>DependenciesInstalled</td>
<td>True</td>
<td>3 minutes ago</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DeploymentsAvailable</td>
<td>True</td>
<td>3 minutes ago</td>
<td></td>
<td></td>
</tr>
<tr>
<td>InstallExceeded</td>
<td>True</td>
<td>3 minutes ago</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ready</td>
<td>True</td>
<td>3 minutes ago</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
It may take a few seconds for the Knative Serving resources to be created. You can check their status in the Resources tab.

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

3.2.2. Installing Knative Serving by using YAML

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

Prerequisites

- You have access to an OpenShift Dedicated account with cluster administrator or dedicated administrator access.
- You have installed the OpenShift Serverless Operator.
- Install the OpenShift CLI (oc).

Procedure

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

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

    $ oc apply -f serving.yaml
```

2. Apply the serving.yaml file:

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

Verification

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

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

Example output

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

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

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

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

   $ oc get pods -n knative-serving

Example output

<table>
<thead>
<tr>
<th>NAME</th>
<th>READY</th>
<th>STATUS</th>
<th>RESTARTS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>activator-67ddf8c9d7-p7rm5</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>4m</td>
</tr>
<tr>
<td>activator-67ddf8c9d7-q84fz</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>4m</td>
</tr>
<tr>
<td>autoscaler-5d87bc6dbf-6nqc6</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>3m59s</td>
</tr>
<tr>
<td>autoscaler-5d87bc6dbf-h64rl</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>3m59s</td>
</tr>
<tr>
<td>autoscaler-hpa-77f85f5cc4-lrts7</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>3m57s</td>
</tr>
<tr>
<td>autoscaler-hpa-77f85f5cc4-zx7hl</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>3m56s</td>
</tr>
<tr>
<td>controller-5fcf7cb8db-nlcl</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>3m50s</td>
</tr>
<tr>
<td>controller-5fcf7cb8db-rmv7r</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>3m18s</td>
</tr>
<tr>
<td>domain-mapping-86d84bb6b4-r746m</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>3m58s</td>
</tr>
<tr>
<td>domain-mapping-86d84bb6b4-v7nh8</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>3m58s</td>
</tr>
<tr>
<td>domainmapping-webhook-769d679d45-bkcnj</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>3m58s</td>
</tr>
<tr>
<td>domainmapping-webhook-769d679d45-ff68</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>3m58s</td>
</tr>
<tr>
<td>storage-version-migration-serving-serving-0.26.0--1-6qlkb</td>
<td>0/1</td>
<td>Completed</td>
<td>0</td>
<td>3m56s</td>
</tr>
<tr>
<td>webhook-5fb774f8d8-6bqrt</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>3m57s</td>
</tr>
<tr>
<td>webhook-5fb774f8d8-b8lf5</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>3m57s</td>
</tr>
</tbody>
</table>

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

   $ oc get pods -n knative-serving-ingress

Example output

<table>
<thead>
<tr>
<th>NAME</th>
<th>READY</th>
<th>STATUS</th>
<th>RESTARTS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>net-kourier-controller-7d4b6c5d95-62mkf</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>76s</td>
</tr>
<tr>
<td>net-kourier-controller-7d4b6c5d95-qmgm2</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>76s</td>
</tr>
<tr>
<td>3scale-kourier-gateway-6688b49568-987qz</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>75s</td>
</tr>
<tr>
<td>3scale-kourier-gateway-6688b49568-b5tnp</td>
<td>1/1</td>
<td>Running</td>
<td>0</td>
<td>75s</td>
</tr>
</tbody>
</table>

3.2.3. Next steps

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

3.3. INSTALLING KNATIVE EVENTING

To use event-driven architecture on your cluster, install Knative Eventing. You can create Knative components such as event sources, brokers, and channels and then use them to send events to applications or external systems.
After you install the OpenShift Serverless Operator, you can install Knative Eventing by using the default settings, or configure more advanced settings in the KnativeEventing custom resource (CR). For more information about configuration options for the KnativeEventing CR, see Global configuration.

**IMPORTANT**

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

### 3.3.1. Installing Knative Eventing by using the web console

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

**Prerequisites**

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

**Procedure**

1. In the Administrator perspective of the OpenShift Dedicated web console, navigate to Operators → Installed Operators.
2. Check that the Project dropdown at the top of the page is set to **Project: knative-eventing**.
3. Click Knative Eventing in the list of **Provided APIs** for the OpenShift Serverless Operator to go to the **Knative Eventing** tab.
4. Click **Create Knative Eventing**.
5. In the **Create Knative Eventing** page, you can choose to configure the KnativeEventing object by using either the default form provided, or by editing the YAML.
   - Using the form is recommended for simpler configurations that do not require full control of KnativeEventing object creation.
     Optional. If you are configuring the KnativeEventing object using the form, make any changes that you want to implement for your Knative Eventing deployment.
6. Click **Create**.
   - Editing the YAML is recommended for more complex configurations that require full control of KnativeEventing object creation. You can access the YAML by clicking the **edit YAML** link in the top right of the **Create Knative Eventing** page.
     Optional. If you are configuring the KnativeEventing object by editing the YAML, make any changes to the YAML that you want to implement for your Knative Eventing deployment.
7. Click **Create**.
8. After you have installed Knative Eventing, the KnativeEventing object is created, and you are automatically directed to the Knative Eventing tab. You will see the knative-eventing custom resource in the list of resources.

**Verification**

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

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

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

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

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

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

3.3.2. Installing Knative Eventing by using YAML

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

Prerequisites

- You have access to an OpenShift Dedicated account with cluster administrator or dedicated administrator access.
- You have installed the OpenShift Serverless Operator.
- Install the OpenShift CLI (oc).

Procedure

1. Create a file named eventing.yaml.

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

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

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

4. Apply the eventing.yaml file by entering:

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

Verification

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

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

   Example output
NOTE

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

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

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

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

   **Example output**

   ```
   NAME                                   READY   STATUS    RESTARTS   AGE
   broker-controller-58765d9d49-g9zp6     1/1     Running   0          7m21s
   eventing-controller-65fdd66b54-jw7bh   1/1     Running   0          7m31s
   eventing-webhook-57f745bd-kvhlz        1/1     Running   0          7m31s
   imc-controller-5b75d458fc-ptvm2        1/1     Running   0          7m19s
   imc-dispatcher-64f6d5fcb-kkc4c          1/1     Running   0          7m18s
   ```

3.3.3. Next steps

   - If you want to use Knative services you can [install Knative Serving](#).

3.4. REMOVING OPENSHEET SERVERLESS

If you need to remove OpenShift Serverless from your cluster, you can do so by manually removing the OpenShift Serverless Operator and other OpenShift Serverless components. Before you can remove the OpenShift Serverless Operator, you must remove Knative Serving and Knative Eventing.

3.4.1. Uninstalling Knative Serving

Before you can remove the OpenShift Serverless Operator, you must remove Knative Serving. To uninstall Knative Serving, you must remove the **KnativeServing** custom resource (CR) and delete the `knative-serving` namespace.

**Prerequisites**

- You have access to an OpenShift Dedicated account with cluster administrator or dedicated administrator access.

- Install the OpenShift CLI (`oc`).

**Procedure**

1. Delete the **KnativeServing** CR:

   ```
   $ oc delete knativeservings.operator.knative.dev knative-serving -n knative-serving
   ```
2. After the command has completed and all pods have been removed from the `knative-serving` namespace, delete the namespace:

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

### 3.4.2. Uninstalling Knative Eventing

Before you can remove the OpenShift Serverless Operator, you must remove Knative Eventing. To uninstall Knative Eventing, you must remove the **KnativeEventing** custom resource (CR) and delete the `knative-eventing` namespace.

**Prerequisites**

- You have access to an OpenShift Dedicated account with cluster administrator or dedicated administrator access.
- Install the OpenShift CLI (**oc**).

**Procedure**

1. Delete the **KnativeEventing** CR:

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

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

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

### 3.4.3. Removing the OpenShift Serverless Operator

After you have removed Knative Serving and Knative Eventing, you can remove the OpenShift Serverless Operator. You can do this by using the OpenShift Dedicated web console or the **oc** CLI.

#### 3.4.3.1. Deleting Operators from a cluster using the web console

Cluster administrators can delete installed Operators from a selected namespace by using the web console.

**Prerequisites**

- Access to an OpenShift Dedicated cluster web console using an account with

**Procedure**

1. Navigate to the **Operators → Installed Operators** page.

2. Scroll or enter a keyword into the **Filter by name** field to find the Operator that you want to remove. Then, click on it.

3. On the right side of the **Operator Details** page, select **Uninstall Operator** from the **Actions** list. An **Uninstall Operator?** dialog box is displayed.
4. Select **Uninstall** to remove the Operator, Operator deployments, and pods. Following this action, the Operator stops running and no longer receives updates.

**NOTE**

This action does not remove resources managed by the Operator, including custom resource definitions (CRDs) and custom resources (CRs). Dashboards and navigation items enabled by the web console and off-cluster resources that continue to run might need manual clean up. To remove these after uninstalling the Operator, you might need to manually delete the Operator CRDs.

### 3.4.3.2. Deleting Operators from a cluster using the CLI

Cluster administrators can delete installed Operators from a selected namespace by using the CLI.

**Prerequisites**

- Access to an OpenShift Dedicated cluster using an account with
- **oc** command installed on workstation.

**Procedure**

1. Check the current version of the subscribed Operator (for example, `jaeger`) in the **currentCSV** field:

   ```bash
   $ oc get subscription jaeger -n openshift-operators -o yaml | grep currentCSV
   ``

   **Example output**

   ```text
   currentCSV: jaeger-operator.v1.8.2
   ```

2. Delete the subscription (for example, `jaeger`):

   ```bash
   $ oc delete subscription jaeger -n openshift-operators
   
   Example output
   ```

   ```text
   subscription.operators.coreos.com "jaeger" deleted
   ```

3. Delete the CSV for the Operator in the target namespace using the **currentCSV** value from the previous step:

   ```bash
   $ oc delete clusterserviceversion jaeger-operator.v1.8.2 -n openshift-operators
   
   Example output
   ```

   ```text
   clusterserviceversion.operators.coreos.com "jaeger-operator.v1.8.2" deleted
   ```

### 3.4.3.3. Refreshing failing subscriptions

In Operator Lifecycle Manager (OLM), if you subscribe to an Operator that references images that are...
In Operator Lifecycle Manager (OLM), if you subscribe to an Operator that references images that are not accessible on your network, you can find jobs in the openshift-marketplace namespace that are failing with the following errors:

Example output

```
ImagePullBackOff for
Back-off pulling image "example.com/openshift4/ose-elasticsearch-operator-bundle@sha256:6d2587129c846ec28d384540322b40b05833e7e00b25cca584e004af9a1d292e"
```

Example output

```
rpc error: code = Unknown desc = error pinging docker registry example.com: Get "https://example.com/v2/": dial tcp: lookup example.com on 10.0.0.1:53: no such host
```

As a result, the subscription is stuck in this failing state and the Operator is unable to install or upgrade.

You can refresh a failing subscription by deleting the subscription, cluster service version (CSV), and other related objects. After recreating the subscription, OLM then reinstalls the correct version of the Operator.

Prerequisites

- You have a failing subscription that is unable to pull an inaccessible bundle image.
- You have confirmed that the correct bundle image is accessible.

Procedure

1. Get the names of the Subscription and ClusterServiceVersion objects from the namespace where the Operator is installed:

   ```
   $ oc get sub,csv -n <namespace>
   ```

   Example output

   ```
   NAME                                                       PACKAGE                  SOURCE             CHANNEL
   subscription.operators.coreos.com/elasticsearch-operator   elasticsearch-operator   redhat-operators   5.0

   NAME                                                                         DISPLAY                            VERSION
   REPLACES   PHASE
   clusterserviceversion.operators.coreos.com/elasticsearch-operator.5.0.0-65   OpenShift Elasticsearch Operator   5.0.0-65              Succeeded
   ```

2. Delete the subscription:

   ```
   $ oc delete subscription <subscription_name> -n <namespace>
   ```

3. Delete the cluster service version:

   ```
   $ oc delete csv <csv_name> -n <namespace>
   ```
4. Get the names of any failing jobs and related config maps in the `openshift-marketplace` namespace:

   ```bash
   $ oc get job,configmap -n openshift-marketplace
   
   Example output
   
<table>
<thead>
<tr>
<th>NAME</th>
<th>COMPLETIONS</th>
<th>DURATION</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>job.batch/1de9443b6324e629ddf31fed0a853a121275806170e34c926d69e53a7fcbccb</td>
<td>1/1</td>
<td>9m30s</td>
<td></td>
</tr>
</tbody>
</table>
   
<table>
<thead>
<tr>
<th>NAME</th>
<th>DATA</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>configmap/1de9443b6324e629ddf31fed0a853a121275806170e34c926d69e53a7fcbccb</td>
<td>3</td>
<td>9m30s</td>
</tr>
</tbody>
</table>
   
5. Delete the job:

   ```bash
   $ oc delete job <job_name> -n openshift-marketplace
   
   This ensures pods that try to pull the inaccessible image are not recreated.

6. Delete the config map:

   ```bash
   $ oc delete configmap <configmap_name> -n openshift-marketplace
   
   7. Reinstall the Operator using OperatorHub in the web console.

Verification

- Check that the Operator has been reinstalled successfully:

   ```bash
   $ oc get sub,csv,installplan -n <namespace>
   
3.4.4. Deleting OpenShift Serverless custom resource definitions

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

**IMPORTANT**

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

**Prerequisites**

- Install the OpenShift CLI (`oc`).
- You have access to an OpenShift Dedicated account with cluster administrator or dedicated administrator access.
- You have uninstalled Knative Serving and removed the OpenShift Serverless Operator.
Procedure

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

  $ oc get crd -oname | grep 'knative.dev' | xargs oc delete
CHAPTER 4. KNATIVE CLI

4.1. INSTALLING THE KNATIVE CLI

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

OpenShift Serverless cannot be installed using the Knative (kn) CLI. A cluster administrator must install the OpenShift Serverless Operator and set up the Knative components, as described in the Installing the OpenShift Serverless Operator documentation.

**IMPORTANT**

If you try to use an older version of the Knative (kn) CLI with a newer OpenShift Serverless release, the API is not found and an error occurs.

For example, if you use the 1.16.0 release of the Knative (kn) CLI, which uses version 0.22.0, with the 1.17.0 OpenShift Serverless release, which uses the 0.23.0 versions of the Knative Serving and Knative Eventing APIs, the CLI does not work because it continues to look for the outdated 0.22.0 API versions.

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

4.1.1. Installing the Knative CLI using the OpenShift Dedicated web console

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

**Prerequisites**

- You have logged in to the OpenShift Dedicated web console.
- The OpenShift Serverless Operator is installed on your OpenShift Dedicated cluster.

**IMPORTANT**

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

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

**Procedure**

1. Download the Knative (kn) CLI from the Command Line Tools page. You can access the Command Line Tools page by clicking the icon in the top right corner of the web console and selecting Command Line Tools in the list.

2. Unpack the archive:
3. Move the `kn` binary to a directory on your `PATH`.

4. To check your `PATH`, run:

   ```
   $ echo $PATH
   ```

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

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

**Prerequisites**

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

**Procedure**

1. Register with Red Hat Subscription Manager:
   ```
   # subscription-manager register
   ```

2. Pull the latest subscription data:
   ```
   # subscription-manager refresh
   ```

3. Attach the subscription to the registered system:
   ```
   # subscription-manager attach --pool=<pool_id>  
   ```

   ![Pool ID for an active OpenShift Dedicated subscription](image)

4. Enable the repositories required by the Knative (`kn`) CLI:
   - Linux (x86_64, amd64)
     ```
     # subscription-manager repos --enable="openshift-serverless-1-for-rhel-8-x86_64-rpms"
     ```
   - Linux on IBM Z and LinuxONE (s390x)
     ```
     # subscription-manager repos --enable="openshift-serverless-1-for-rhel-8-s390x-rpms"
     ```
   - Linux on IBM Power (ppc64le)
     ```
     # subscription-manager repos --enable="openshift-serverless-1-for-rhel-8-ppc64le-rpms"
     ```

5. Install the Knative (`kn`) CLI as an RPM by using a package manager:
4.1.3. Installing the Knative CLI for Linux

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

Prerequisites

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

**IMPORTANT**

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

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

Procedure

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

2. Unpack the archive:

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

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

4. To check your PATH, run:

   ```
   $ echo $PATH
   ```

4.1.4. Installing the Knative CLI for macOS

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

Procedure

1. Download the Knative (kn) CLI tar.gz archive.

2. Unpack and extract the archive.
3. Move the kn binary to a directory on your PATH.

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

   $ echo $PATH

4.1.5. Installing the Knative CLI for Windows

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

Procedure

1. Download the Knative (kn) CLI ZIP archive.

2. Extract the archive with a ZIP program.

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

4. To check your PATH, open the command prompt and run the command:

   C:\> path

4.2. CONFIGURING THE KNATIVE CLI

You can customize your Knative (kn) CLI setup by creating a config.yaml configuration file. You can provide this configuration by using the --config flag, otherwise the configuration is picked up from a default location. The default configuration location conforms to the XDG Base Directory Specification, and is different for UNIX systems and Windows systems.

For UNIX systems:

- If the XDG_CONFIG_HOME environment variable is set, the default configuration location that the Knative (kn) CLI looks for is $XDG_CONFIG_HOME/kn.

- If the XDG_CONFIG_HOME environment variable is not set, the Knative (kn) CLI looks for the configuration in the home directory of the user at $HOME/.config/kn/config.yaml.

For Windows systems, the default Knative (kn) CLI configuration location is %APPDATA%\kn.

Example configuration file

```yaml
plugins:
  path-lookup: true
  directory: ~/.config/kn/plugins
eventing:
  sink-mappings:
    - prefix: svc
      group: core
      version: v1
      resource: services
```
Specifies whether the Knative (kn) CLI should look for plug-ins in the PATH environment variable. This is a boolean configuration option. The default value is false.

Specifies the directory where the Knative (kn) CLI looks for plug-ins. The default path depends on the operating system, as described previously. This can be any directory that is visible to the user.

The sink-mappings spec defines the Kubernetes addressable resource that is used when you use the --sink flag with a Knative (kn) CLI command.

The prefix you want to use to describe your sink. svc for a service, channel, and broker are predefined prefixes for the Knative (kn) CLI.

The API group of the Kubernetes resource.

The version of the Kubernetes resource.

The plural name of the Kubernetes resource type. For example, services or brokers.

4.3. KNATIVE SERVING CLI COMMANDS

You can use the following Knative (kn) CLI commands to complete Knative Serving tasks on the cluster.

4.3.1. kn service commands

You can use the following commands to create and manage Knative services.

4.3.1.1. Creating serverless applications by using the Knative CLI

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

Prerequisites

- OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have installed the Knative (kn) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

Procedure

- Create a Knative service:

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

  Where:

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

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

Example output

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

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

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

4.3.1.2. Updating serverless applications by using the Knative CLI

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

Example commands

- Update a service by adding a new environment variable:

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

- Update a service by adding a new port:

  $ kn service update <service_name> --port 80

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

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

- Assign the `latest` tag to a revision:

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

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

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

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

  $ kn service update <service_name> --tag <revision_name>=test --traffic test=10,@latest=90
4.3.1.3. Applying service declarations

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

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

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

Example commands

- Create a service:
  
  ```
  $ kn service apply <service_name> --image <image>
  ```

- Add an environment variable to a service:
  
  ```
  $ kn service apply <service_name> --image <image> --env <key>=<value>
  ```

- Read the service declaration from a JSON or YAML file:
  
  ```
  $ kn service apply <service_name> -f <filename>
  ```

4.3.1.4. Describing serverless applications by using the Knative CLI

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

Example commands

- Describe a service:
  
  ```
  $ kn service describe --verbose <service_name>
  ```

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

Example output without `--verbose` flag

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

Revisions:
100%  @latest (hello-00001) [1] (2m)

Image:  docker.io/openshift/hello-openshift (pinned to aaea76)
```

Conditions:

```
OK TYPE   AGE REASON
```
Describe a service in YAML format:

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

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

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

• Describe a service in YAML format:

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

• Describe a service in JSON format:

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

• Print the service URL only:

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

### 4.3.2. About the Knative CLI offline mode

When you execute `kn service` commands, the changes immediately propagate to the cluster. However, as an alternative, you can execute `kn service` commands in offline mode. When you create a service in offline mode, no changes happen on the cluster, and instead the service descriptor file is created on your local machine.
The offline mode of the Knative CLI is a Technology Preview feature only. Technology Preview features are not supported with Red Hat production service level agreements (SLAs) and might not be functionally complete. Red Hat does not recommend using them in production. These features provide early access to upcoming product features, enabling customers to test functionality and provide feedback during the development process.

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

After the descriptor file is created, you can manually modify it and track it in a version control system. You can also propagate changes to the cluster by using the `kn service create -f`, `kn service apply -f`, or `oc apply -f` commands on the descriptor files.

The offline mode has several uses:

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

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

**4.3.2.1. Creating a service using offline mode**

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

**Prerequisites**

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

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

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

   **Example output**

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

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

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

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

2. Examine the created directory structure:

   ```
   $ tree ./
   ```

   **Example output**

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

   2 directories, 1 file

   - The current `./` directory specified with `--target` contains the new `test/` directory that is named after the specified namespace.

   - The `test/` directory contains the `ksvc` directory, named after the resource type.

   - The `ksvc` directory contains the descriptor file `event-display.yaml`, named according to the specified service name.

3. Examine the generated service descriptor file:

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

   **Example output**
4. List information about the new service:

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

**Example output**

<table>
<thead>
<tr>
<th>Name:</th>
<th>event-display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Namespace:</td>
<td>test</td>
</tr>
<tr>
<td>Age:</td>
<td></td>
</tr>
<tr>
<td>URL:</td>
<td></td>
</tr>
</tbody>
</table>

**Conditions:**

<table>
<thead>
<tr>
<th>OK TYPE</th>
<th>AGE</th>
<th>REASON</th>
</tr>
</thead>
</table>

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

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

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

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

**Example output**

Creating service 'event-display' in namespace 'test'.
4.3.3. kn container commands

You can use the following commands to create and manage multiple containers in a Knative service spec.

4.3.3.1. Knative client multi-container support

You can use the `kn container add` command to print YAML container spec to standard output. This command is useful for multi-container use cases because it can be used along with other standard `kn` flags to create definitions.

The `kn container add` command accepts all container-related flags that are supported for use with the `kn service create` command. The `kn container add` command can also be chained by using UNIX pipes (`|`) to create multiple container definitions at once.

Example commands

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

  ```bash
  $ kn container add <container_name> --image <image_uri>
  
  Example command
  
  $ kn container add sidecar --image docker.io/example/sidecar
  
  Example output
  
  containers:
  - image: docker.io/example/sidecar
    name: sidecar
    resources: {}
  
  - Chain two `kn container add` commands together, and then pass them to a `kn service create` command to create a Knative service with two containers:

  ```bash
  $ kn container add <first_container_name> --image <image_uri> | \
  kn container add <second_container_name> --image <image_uri> | \
  kn service create <service_name> --image <image_uri> --extra-containers -
  
  --extra-containers - specifies a special case where `kn` reads the pipe input instead of a YAML file.
Example command

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

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

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

Example command

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

### 4.3.4. kn domain commands

You can use the following commands to create and manage domain mappings.

#### 4.3.4.1. Creating a custom domain mapping by using the Knative CLI

You can customize the domain for your Knative service by mapping a custom domain name that you own to a Knative service. You can use the Knative (`kn`) CLI to create a DomainMapping custom resource (CR) that maps to an Addressable target CR, such as a Knative service or a Knative route.

**Prerequisites**

- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have created a Knative service or route, and control a custom domain that you want to map to that CR.

**NOTE**

Your custom domain must point to the DNS of the OpenShift Dedicated cluster.

- You have installed the Knative (`kn`) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

**Procedure**

- Map a domain to a CR in the current namespace:

```bash
$ kn domain create <domain_mapping_name> --ref <target_name>
```

**Example command**

```bash
$ kn domain create example-domain-map --ref example-service
```
The --ref flag specifies an Addressable target CR for domain mapping.

If a prefix is not provided when using the --ref flag, it is assumed that the target is a Knative service in the current namespace.

- Map a domain to a Knative service in a specified namespace:

  $ kn domain create <domain_mapping_name> --ref <ksvc:service_name:service_namespace>

  **Example command**

  $ kn domain create example-domain-map --ref ksvc:example-service:example-namespace

- Map a domain to a Knative route:

  $ kn domain create <domain_mapping_name> --ref <kroute:route_name>

  **Example command**

  $ kn domain create example-domain-map --ref kroute:example-route

### 4.3.4.2. Managing custom domain mappings by using the Knative CLI

After you have created a **DomainMapping** custom resource (CR), you can list existing CRs, view information about an existing CR, update CRs, or delete CRs by using the Knative (kn) CLI.

**Prerequisites**

- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have created at least one **DomainMapping** CR.
- You have installed the Knative (kn) CLI tool.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

**Procedure**

- List existing **DomainMapping** CRs:

  $ kn domain list -n <domain_mapping_namespace>

- View details of an existing **DomainMapping** CR:

  $ kn domain describe <domain_mapping_name>

- Update a **DomainMapping** CR to point to a new target:

  $ kn domain update --ref <target>
4.4.1. kn source commands

You can use the following commands to list, create, and manage Knative event sources.

4.4.1.1. Listing available event source types by using the Knative CLI

Using the Knative (kn) CLI provides a streamlined and intuitive user interface to view available event source types on your cluster. You can list event source types that can be created and used on your cluster by using the `kn source list-types` CLI command.

Prerequisites

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

Procedure

1. List the available event source types in the terminal:

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

   **Example output**

<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>

4.4.1.2. Knative CLI sink flag

When you create an event source by using the Knative (kn) CLI, you can specify a sink where events are sent to from that resource by using the `--sink` flag. The sink can be any addressable or callable resource that can receive incoming events from other resources.

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

**Example command using the sink flag**
4.4.1.3. Creating and managing container sources by using the Knative CLI

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

Create a container source

```
$ kn source container create <container_source_name> --image <image_uri> --sink <sink>
```

Delete a container source

```
$ kn source container delete <container_source_name>
```

Describe a container source

```
$ kn source container describe <container_source_name>
```

List existing container sources

```
$ kn source container list
```

List existing container sources in YAML format

```
$ kn source container list -o yaml
```

Update a container source

This command updates the image URI for an existing container source:

```
$ kn source container update <container_source_name> --image <image_uri>
```

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

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

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on the cluster.
You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

You have installed the OpenShift (oc) CLI.

You have installed the Knative (kn) CLI.

PROCEDURE

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

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

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

---

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

---

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

1 Change this namespace to the namespace that you have selected for installing the event source.
2. Apply the YAML file:

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

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

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

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

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

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

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

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

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

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

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

**Example output**

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

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

1. Get the pods:

$ oc get pods

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

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

Example output

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

Deleting the API server source

1. Delete the trigger:

$ kn trigger delete <trigger_name>

2. Delete the event source:

$ kn source apiserver delete <source_name>

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

   $ oc delete -f authentication.yaml

4.4.1.5. Creating a ping source by using the Knative CLI

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

**Prerequisites**

- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on the cluster.
- You have installed the Knative (kn) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- Optional: If you want to use the verification steps for this procedure, install the OpenShift (oc) CLI.

**Procedure**

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

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

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

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

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

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

**Example output**

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

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

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

1. Watch for new pods created:

   ```
   $ watch oc get pods
   ```

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

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

Example output

```
<cloudevents.Event
Validation: valid
Context Attributes,
  specversion: 1.0
  type: dev.knative.sources.ping
  source: /apis/v1/namespaces/default/pingsources/test-ping-source
  id: 99e4f4f6-08ff-4bff-acf1-47f61ded68c9
  time: 2020-04-07T16:16:00.000601161Z
  datacontenttype: application/json
Data,
  {
    "message": "Hello world!"
  }
```

Deleting the ping source

- Delete the ping source:

  ```
  $ kn delete pingsources.sources.knative.dev <ping_source_name>
  ```
4.4.1.6. Creating a Kafka event source by using the Knative CLI

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

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, Knative Serving, and the **KnativeKafka** custom resource (CR) are installed on your cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have access to a Red Hat AMQ Streams (Kafka) cluster that produces the Kafka messages you want to import.
- You have installed the Knative (kn) CLI.
- Optional: You have installed the OpenShift (oc) CLI if you want to use the verification steps in this procedure.

Procedure

1. To verify that the Kafka event source is working, create a Knative service that dumps incoming events into the service logs:

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

2. Create a **KafkaSource** CR:

   ```bash
   $ kn source kafka create <kafka_source_name>
   --servers <cluster_kafka_bootstrap>.kafka.svc:9092
   --topics <topic_name> --consumergroup my-consumer-group
   --sink event-display
   ```

   **NOTE**

   Replace the placeholder values in this command with values for your source name, bootstrap servers, and topics.

   The `--servers`, `--topics`, and `--consumergroup` options specify the connection parameters to the Kafka cluster. The `--consumergroup` option is optional.

3. Optional: View details about the **KafkaSource** CR you created:

   ```bash
   $ kn source kafka describe <kafka_source_name>
   ```

Example output

<table>
<thead>
<tr>
<th>Name:</th>
<th>example-kafka-source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Namespace:</td>
<td>kafka</td>
</tr>
<tr>
<td>Age:</td>
<td>1h</td>
</tr>
</tbody>
</table>
Verification steps

1. Trigger the Kafka instance to send a message to the topic:

   $ oc -n kafka run kafka-producer \
     -ti --image=quay.io/strimzi/kafka:latest-kafka-2.7.0 --rm=true \n     --restart=Never -- bin/kafka-console-producer.sh \n     --broker-list <cluster_kafka_bootstrap>:9092 --topic my-topic

   Enter the message in the prompt. This command assumes that:

   - The Kafka cluster is installed in the **kafka** namespace.
   - The **KafkaSource** object has been configured to use the **my-topic** topic.

2. Verify that the message arrived by viewing the logs:

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

**Example output**

```plaintext
    cloudevents.Event
    Validation: valid
    Context Attributes,
      specversion: 1.0
      type: dev.knative.kafka.event
      source: /apis/v1/namespaces/default/kafkasources/example-kafka-source#example-topic
      subject: partition:46#0
    id: partition:46/offset:0
    time: 2021-03-10T11:21:49.4Z
    Extensions,
      traceparent: 00-161ff3815727d8755848ec01c866d1cd-7ff3916c44334678-00
    Data,
      Hello!
```

## 4.5. FUNCTIONS COMMANDS

### 4.5.1. Creating functions
Before you can build and deploy a function, you must create it by using the Knative (kn) CLI. You can specify the path, runtime, template, and image registry as flags on the command line, or use the -c flag to start the interactive experience in the terminal.

**Prerequisites**

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

**Procedure**

- Create a function project:

  ```bash
  $ kn func create -r <repository> -l <runtime> -t <template> <path>
  ```

  - Accepted runtime values include node, go, python, quarkus, and typescript.
  - Accepted template values include http and events.

  **Example command**

  ```bash
  $ kn func create -l typescript -t events examplefunc
  ```

  **Example output**

  Project path: /home/user/demo/examplefunc
  Function name: examplefunc
  Runtime: typescript
  Template: events
  Writing events to /home/user/demo/examplefunc

  Alternatively, you can specify a repository that contains a custom template.

  **Example command**

  ```bash
  $ kn func create -r https://github.com/boson-project/templates/ -l node -t hello-world examplefunc
  ```

  **Example output**

  Project path: /home/user/demo/examplefunc
  Function name: examplefunc
  Runtime: node
  Template: hello-world
  Writing events to /home/user/demo/examplefunc

**4.5.2. Running a function locally**

You can use the kn func run command to run a function locally in the current directory or in the directory specified by the --path flag. If the function that you are running has never previously been built, or if the project files have been modified since the last time it was built, the kn func run command builds the function before running it by default.
Example command to run a function in the current directory

$ kn func run

Example command to run a function in a directory specified as a path

$ kn func run --path=<directory_path>

You can also force a rebuild of an existing image before running the function, even if there have been no changes to the project files, by using the `--build` flag:

Example run command using the build flag

$ kn func run --build

If you set the `build` flag as false, this disables building of the image, and runs the function using the previously built image:

Example run command using the build flag

$ kn func run --build=false

You can use the help command to learn more about `kn func run` command options:

Build help command

$ kn func help run

4.5.3. Building functions

Before you can run a function, you must build the function project. If you are using the `kn func run` command, the function is built automatically. However, you can use the `kn func build` command to build a function without running it, which can be useful for advanced users or debugging scenarios.

The `kn func build` command creates an OCI container image that can be run locally on your computer or on an OpenShift Dedicated cluster. This command uses the function project name and the image registry name to construct a fully qualified image name for your function.

4.5.3.1. Image container types

By default, `kn func build` creates a container image by using Red Hat Source-to-Image (S2I) technology.

Example build command using Red Hat Source-to-Image (S2I)

$ kn func build

You can use CNCF Cloud Native Buildpacks technology instead, by adding the `--builder` flag to the command and specifying the `pack` strategy:

Example build command using CNCF Cloud Native Buildpacks
4.5.3.2. Image registry types

The OpenShift Container Registry is used by default as the image registry for storing function images.

Example build command using OpenShift Container Registry

```bash
$ kn func build
```

Example output

Building function image
Function image has been built, image: registry.redhat.io/example/example-function:latest

You can override using OpenShift Container Registry as the default image registry by using the `--registry` flag:

Example build command overriding OpenShift Container Registry to use quay.io

```bash
$ kn func build --registry quay.io/username
```

Example output

Building function image
Function image has been built, image: quay.io/username/example-function:latest

4.5.3.3. Push flag

You can add the `--push` flag to a `kn func build` command to automatically push the function image after it is successfully built:

Example build command using OpenShift Container Registry

```bash
$ kn func build --push
```

4.5.3.4. Help command

You can use the help command to learn more about `kn func build` command options:

Build help command

```bash
$ kn func help build
```

4.5.4. Deploying functions

You can deploy a function to your cluster as a Knative service by using the `kn func deploy` command. If the targeted function is already deployed, it is updated with a new container image that is pushed to a container image registry, and the Knative service is updated.
Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (kn) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You must have already created and initialized the function that you want to deploy.

Procedure

- Deploy a function:

  ```
  $ kn func deploy [-n <namespace> -p <path> -i <image>]
  ```

  **Example output**

  Function deployed at: http://func.example.com

  - If no `namespace` is specified, the function is deployed in the current namespace.
  - The function is deployed from the current directory, unless a `path` is specified.
  - The Knative service name is derived from the project name, and cannot be changed using this command.

4.5.5. Listing existing functions

You can list existing functions by using `kn func list`. If you want to list functions that have been deployed as Knative services, you can also use `kn service list`.

Procedure

- List existing functions:

  ```
  $ kn func list [-n <namespace> -p <path>]
  ```

  **Example output**

<table>
<thead>
<tr>
<th>NAME</th>
<th>NAMESPACE</th>
<th>RUNTIME</th>
<th>URL</th>
<th>LATEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>example-function</td>
<td>default</td>
<td>node</td>
<td><a href="http://example-function.default.apps.ci-ln-g9f36hb-d5d6b.origin-ci-int-aws.dev.rhcloud.com">http://example-function.default.apps.ci-ln-g9f36hb-d5d6b.origin-ci-int-aws.dev.rhcloud.com</a></td>
<td>True</td>
</tr>
</tbody>
</table>

- List functions deployed as Knative services:

  ```
  $ kn service list -n <namespace>
  ```

  **Example output**

<table>
<thead>
<tr>
<th>NAME</th>
<th>URL</th>
<th>LATEST</th>
</tr>
</thead>
</table>
4.5.6. Describing a function

The `kn func info` command prints information about a deployed function, such as the function name, image, namespace, Knative service information, route information, and event subscriptions.

**Procedure**

- Describe a function:

  ```
  $ kn func info [-f <format> -n <namespace> -p <path>]
  
  Example command
  
  $ kn func info -p function/example-function
  ```

  **Example output**

  ```
  Function name: example-function
  Function is built in image: docker.io/user/example-function:latest
  Function is deployed as Knative Service: example-function
  Function is deployed in namespace: default
  Routes: http://example-function.default.apps.ci-ln-g9f36hb-d5d6b.origin-ci-int-aws.dev.rhcloud.com
  ```

4.5.7. Invoking a deployed function with a test event

You can use the `kn func invoke` CLI command to send a test request to invoke a function either locally or on your OpenShift Dedicated cluster. This command can be used to test that a function is working and able to receive events correctly.

**Example command**

```
$ kn func invoke
```

The `kn func invoke` command executes on the local directory by default, and assumes that this directory is a function project.

4.5.7.1. `kn func invoke` optional parameters

You can specify optional parameters for the request by using the following `kn func invoke` CLI command flags.
### Flags and Description

<table>
<thead>
<tr>
<th>Flags</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>-t, --target</code></td>
<td>Specifies the target instance of the invoked function, for example, <code>local</code> or <code>remote</code> or <code>https://staging.example.com/</code>. The default target is <code>local</code>.</td>
</tr>
<tr>
<td><code>-f, --format</code></td>
<td>Specifies the format of the message, for example, <code>cloudevent</code> or <code>http</code>.</td>
</tr>
<tr>
<td><code>--id</code></td>
<td>Specifies a unique string identifier for the request.</td>
</tr>
<tr>
<td><code>--namespace</code></td>
<td>Specifies the namespace on the cluster.</td>
</tr>
<tr>
<td><code>--source</code></td>
<td>Specifies sender name for the request. This corresponds to the CloudEvent <code>source</code> attribute.</td>
</tr>
<tr>
<td><code>--type</code></td>
<td>Specifies the type of request, for example, <code>boson.fn</code>. This corresponds to the CloudEvent <code>type</code> attribute.</td>
</tr>
<tr>
<td><code>--data</code></td>
<td>Specifies content for the request. For CloudEvent requests, this is the CloudEvent <code>data</code> attribute.</td>
</tr>
<tr>
<td><code>--file</code></td>
<td>Specifies path to a local file containing data to be sent.</td>
</tr>
<tr>
<td><code>--content-type</code></td>
<td>Specifies the MIME content type for the request.</td>
</tr>
<tr>
<td><code>-p, --path</code></td>
<td>Specifies path to the project directory.</td>
</tr>
<tr>
<td><code>-c, --confirm</code></td>
<td>Enables prompting to interactively confirm all options.</td>
</tr>
<tr>
<td><code>-v, --verbose</code></td>
<td>Enables printing verbose output.</td>
</tr>
<tr>
<td><code>-h, --help</code></td>
<td>Prints information on usage of <code>kn func invoke</code>.</td>
</tr>
</tbody>
</table>

### 4.5.7.1.1. Main parameters

The following parameters define the main properties of the `kn func invoke` command:

**Event target (`-t, --target`)**

The target instance of the invoked function. Accepts the `local` value for a locally deployed function, the `remote` value for a remotely deployed function, or a URL for a function deployed to an arbitrary endpoint. If a target is not specified, it defaults to `local`.

**Event message format (`-f, --format`)**

The message format for the event, such as `http` or `cloudevent`. This defaults to the format of the template that was used when creating the function.

**Event type (`--type`)**

The type of event that is sent. You can find information about the `type` parameter that is set in the documentation for each event producer. For example, the API server source might set the `type` parameter of produced events as `dev.knative.apiserver.resource.update`.

---

CHAPTER 4. KNATIVE CLI

67
Event source (--source)
The unique event source that produced the event. This might be a URI for the event source, for example https://10.96.0.1/, or the name of the event source.

Event ID (--id)
A random, unique ID that is created by the event producer.

Event data (--data)
Allows you to specify a data value for the event sent by the `kn func invoke` command. For example, you can specify a --data value such as "Hello World" so that the event contains this data string. By default, no data is included in the events created by `kn func invoke`.

NOTE
Functions that have been deployed to a cluster can respond to events from an existing event source that provides values for properties such as source and type. These events often have a data value in JSON format, which captures the domain specific context of the event. By using the CLI flags noted in this document, developers can simulate those events for local testing.

You can also send event data using the --file flag to provide a local file containing data for the event. In this case, specify the content type using --content-type.

Data content type (--content-type)
If you are using the --data flag to add data for events, you can use the --content-type flag to specify what type of data is carried by the event. In the previous example, the data is plain text, so you might specify `kn func invoke --data "Hello world!" --content-type "text/plain"`.

4.5.7.1.2. Example commands
This is the general invocation of the `kn func invoke` command:

```bash
$ kn func invoke --type <event_type> --source <event_source> --data <event_data> --content-type <content_type> --id <event_ID> --format <format> --namespace <namespace>
```

For example, to send a "Hello world!" event, you can run:

```bash
$ kn func invoke --type ping --source example-ping --data "Hello world!" --content-type "text/plain" --id example-ID --format http --namespace my-ns
```

4.5.7.1.2.1. Specifying the file with data
To specify the file on disk that contains the event data, use the --file and --content-type flags:

```bash
$ kn func invoke --file <path> --content-type <content-type>
```

For example, to send JSON data stored in the `test.json` file, use this command:

```bash
$ kn func invoke --file ./test.json --content-type application/json
```

4.5.7.1.2.2. Specifying the function project
You can specify a path to the function project by using the \texttt{--path} flag:

\begin{verbatim}
$ kn func invoke --path <path_to_function>
\end{verbatim}

For example, to use the function project located in the ./example/example-function directory, use this command:

\begin{verbatim}
$ kn func invoke --path ./example/example-function
\end{verbatim}

\subsection*{4.5.7.1.2.3. Specifying where the target function is deployed}

By default, \texttt{kn func invoke} targets the local deployment of the function:

\begin{verbatim}
$ kn func invoke
\end{verbatim}

To use a different deployment, use the \texttt{--target} flag:

\begin{verbatim}
$ kn func invoke --target <target>
\end{verbatim}

For example, to use the function deployed on the cluster, use the \texttt{--target remote} flag:

\begin{verbatim}
$ kn func invoke --target remote
\end{verbatim}

To use the function deployed at an arbitrary URL, use the \texttt{--target <URL>} flag:

\begin{verbatim}
$ kn func invoke --target "https://my-event-broker.example.com"
\end{verbatim}

You can explicitly target the local deployment. In this case, if the function is not running locally, the command fails:

\begin{verbatim}
$ kn func invoke --target local
\end{verbatim}

\subsection*{4.5.8. Deleting a function}

You can delete a function from your cluster by using the \texttt{kn func delete} command.

\textbf{Procedure}

- Delete a function:

  \begin{verbatim}
  $ kn func delete [function_name] -n <namespace> -p <path>
  \end{verbatim}

  - If the name or path of the function to delete is not specified, the current directory is searched for a \texttt{func.yaml} file that is used to determine the function to delete.

  - If the namespace is not specified, it defaults to the \texttt{namespace} value in the \texttt{func.yaml} file.
CHAPTER 5. DEVELOP

5.1. SERVERLESS APPLICATIONS

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

**Example Knative Service object YAML file**

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

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

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

- Create a Knative service from the OpenShift Dedicated web console.
- Create a Knative service by using the Knative (**kn**) CLI.
- Create and apply a Knative **Service** object as a YAML file, by using the **oc** CLI.

5.1.1. Creating serverless applications by using the Knative CLI

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

**Prerequisites**

- OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have installed the Knative (**kn**) CLI.
You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

Procedure

- Create a Knative service:

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

  Where:

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

  **Example command**

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

  **Example output**

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

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

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

5.1.2. Creating a service using offline mode

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

**IMPORTANT**

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

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

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

You have installed the Knative (kn) CLI.

Procedure

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

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

   **Example output**

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

   - The **--target ./** flag enables offline mode and specifies ./ as the directory for storing the new directory tree.
   - If you do not specify an existing directory, but use a filename, such as **--target my-service.yaml**, then no directory tree is created. Instead, only the service descriptor file **my-service.yaml** is created in the current directory.
   - The filename can have the .yaml, .yml, or .json extension. Choosing .json creates the service descriptor file in the JSON format.
   - The **--namespace test** option places the new service in the test namespace.
   - If you do not use **--namespace**, and you are logged in to an OpenShift Dedicated cluster, the descriptor file is created in the current namespace. Otherwise, the descriptor file is created in the default namespace.

2. Examine the created directory structure:

   ```
   $ tree ./
   ```

   **Example output**

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

   2 directories, 1 file

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

3. Examine the generated service descriptor file:
4. List information about the new service:

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

Example output

<table>
<thead>
<tr>
<th>Name</th>
<th>event-display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Namespace</td>
<td>test</td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>URL</td>
<td></td>
</tr>
</tbody>
</table>

Revisions:

Conditions:

<table>
<thead>
<tr>
<th>OK</th>
<th>TYPE</th>
<th>AGE</th>
<th>REASON</th>
</tr>
</thead>
</table>

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

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

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

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

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

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

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

5.1.3. Creating serverless applications using YAML

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

After the service is created and the application is deployed, Knative creates an immutable revision for this version of the application. Knative also performs network programming to create a route, ingress, service, and load balancer for your application and automatically scales your pods up and down based on traffic.

Prerequisites

- OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- Install the OpenShift CLI (`oc`).

Procedure

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

```yaml
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: event-delivery
  namespace: default
spec:
template:
  spec:
    containers:
    - image: quay.io/openshift-knative/knative-eventing-sources-event-display:latest
      env:
      - name: RESPONSE
        value: "Hello Serverless!"
```
2. Navigate to the directory where the YAML file is contained, and deploy the application by applying the YAML file:

   $ oc apply -f <filename>

5.1.4. Verifying your serverless application deployment

To verify that your serverless application has been deployed successfully, you must get the application URL created by Knative, and then send a request to that URL and observe the output. OpenShift Serverless supports the use of both HTTP and HTTPS URLs, however the output from `oc get ksvc` always prints URLs using the `http://` format.

Prerequisites

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

Prerequisites

- Install the OpenShift CLI (`oc`).

Procedure

1. Find the application URL:

   $ oc get ksvc <service_name>

   **Example output**

<table>
<thead>
<tr>
<th>NAME</th>
<th>URL</th>
<th>LATESTCREATED</th>
<th>LATESTREADY</th>
</tr>
</thead>
<tbody>
<tr>
<td>event-delivery</td>
<td><a href="http://event-delivery-default.example.com">http://event-delivery-default.example.com</a></td>
<td>event-delivery-4wsd2</td>
<td>event-delivery-4wsd2</td>
</tr>
</tbody>
</table>

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

   **Example HTTP request**

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

   **Example HTTPS request**

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

   **Example output**

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

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

**Example output**

```
Hello Serverless!
```

**IMPORTANT**

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

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

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

**Example output**

```
Hello Serverless!
```

### 5.1.5. Interacting with a serverless application using HTTP2 and gRPC

OpenShift Serverless supports only insecure or edge-terminated routes. Insecure or edge-terminated routes do not support HTTP2 on OpenShift Dedicated. These routes also do not support gRPC because gRPC is transported by HTTP2. If you use these protocols in your application, you must call the application using the ingress gateway directly. To do this you must find the ingress gateway’s public address and the application’s specific host.

**IMPORTANT**

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

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

**Prerequisites**

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

**Procedure**

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

2. Find the ingress gateway’s public address:

   ```
   $ oc -n knative-serving-ingress get svc kourier
   
   **Example output**
   
<table>
<thead>
<tr>
<th>NAME</th>
<th>TYPE</th>
<th>CLUSTER-IP</th>
<th>EXTERNAL-IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>kourier</td>
<td>LoadBalancer</td>
<td>172.30.51.103</td>
<td>a83e86291bcdd11e993af02b7a65e514-33544245.us-east-1.elb.amazonaws.com:80/TCP,443:31390/TCP</td>
</tr>
</tbody>
</table>
   
   The public address is surfaced in the **EXTERNAL-IP** field, and in this case is **a83e86291bcdd11e993af02b7a65e514-33544245.us-east-1.elb.amazonaws.com**.

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

   ```
   $ curl -H "Host: hello-default.example.com" a83e86291bcdd11e993af02b7a65e514-33544245.us-east-1.elb.amazonaws.com
   
   **Example output**
   
   Hello Serverless!
   
   You can also make a gRPC request by setting the authority to the application’s host, while directing the request against the ingress gateway directly:

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

   **NOTE**

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

**5.1.6. Configuring init containers**

Init containers are specialized containers that are run before application containers in a pod. They are generally used to implement initialization logic for an application, which may include running setup scripts or downloading required configurations.
**NOTE**

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

Multiple init containers are supported in a single Knative service spec. Knative provides a default, configurable naming template if a template name is not provided. The init containers template can be set by adding an appropriate value in a Knative **Service** object spec.

**Prerequisites**

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

- Before you can use init containers for Knative services, an administrator must add the `kubernetes.podspec-init-containers` flag to the **KnativeServing** custom resource (CR). See the OpenShift Serverless "Global configuration" documentation for more information.

**Procedure**

- Add the `initContainers` spec to a Knative **Service** object:

  **Example service spec**

  ```yaml
  apiVersion: serving.knative.dev/v1
  kind: Service
  ...  
  spec:
    template:
      spec:
        initContainers:
          - imagePullPolicy: IfNotPresent 1
            image: <image_uri> 2
            volumeMounts: 3
              - name: data
                mountPath: /data
          ...
  ```

  1 The **image pull policy** when the image is downloaded.
  2 The URI for the init container image.
  3 The location where volumes are mounted within the container file system.

**5.1.7. HTTPS redirection per service**

You can enable or disable HTTPS redirection for a service by configuring the `networking.knative.dev/http-option` annotation. The following example shows how you can use this annotation in a Knative **Service** YAML object:

```yaml
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: example
```
5.1.8. Additional resources

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

5.2. AUTOSCALING

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

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

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

NOTE

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

5.2.1. Scale bounds

Scale bounds determine the minimum and maximum numbers of replicas that can serve an application at any given time. You can set scale bounds for an application to help prevent cold starts or control computing costs.

5.2.1.1. Minimum scale bounds

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

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

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

Example service spec with min-scale annotation

```yaml
apiVersion: serving.knative.dev/v1
```
5.2.1.1. Setting the min-scale annotation by using the Knative CLI

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

Prerequisites

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

Procedure

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

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

5.2.1.2. Maximum scale bounds

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

Example service spec with max-scale annotation

```yaml
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: example-service
  namespace: default
spec:
  template:
    metadata:
      annotations:
        autoscaling.knative.dev/max-scale: "10"
...
5.2.1.2.1. Setting the max-scale annotation by using the Knative CLI

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

Prerequisites

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

Procedure

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

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

Example command

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

5.2.2. Concurrency

Concurrency determines the number of simultaneous requests that can be processed by each replica of an application at any given time. Concurrency can be configured as a soft limit or a hard limit:

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

IMPORTANT

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

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

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

5.2.2.1. Configuring a soft concurrency target

A soft limit is a targeted requests limit, rather than a strictly enforced bound. For example, if there is a sudden burst of traffic, the soft limit target can be exceeded. You can specify a soft concurrency target for your Knative service by setting the autoscaling.knative.dev/target annotation in the spec, or by
using the **kn service** command with the correct flags.

**Procedure**

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

  **Example service spec**

  ```yaml
  apiVersion: serving.knative.dev/v1
  kind: Service
  metadata:
    name: example-service
    namespace: default
  spec:
    template:
      metadata:
        annotations:
          autoscaling.knative.dev/target: "200"
  
  $ kn service create <service_name> --image <image_uri> --concurrency-target <integer>
  
  **Example command to create a service with a concurrency target of 50 requests**

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

  
  
  
  
  
  5.2.2.2. Configuring a hard concurrency limit

A hard concurrency limit is a strictly enforced upper bound requests limit. If concurrency reaches the hard limit, surplus requests are buffered and must wait until there is enough free capacity to execute the requests. You can specify a hard concurrency limit for your Knative service by modifying the **containerConcurrency** spec, or by using the **kn service** command with the correct flags.

**Procedure**

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

  **Example service spec**

  ```yaml
  apiVersion: serving.knative.dev/v1
  kind: Service
  metadata:
    name: example-service
    namespace: default
  spec:
    template:
      spec:
        containerConcurrency: 50
  ```
The default value is 0, which means that there is no limit on the number of simultaneous requests that are permitted to flow into one replica of the service at a time.

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

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

  ```
  $ kn service create <service_name> --image <image_uri> --concurrency-limit <integer>
  
  Example command to create a service with a concurrency limit of 50 requests
  ```

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

5.2.2.3. Concurrency target utilization

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

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

**Example service configured using the target-utilization-percentage annotation**

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

5.3. TRAFFIC MANAGEMENT

In a Knative application, traffic can be managed by creating a traffic split. A traffic split is configured as part of a route, which is managed by a Knative service.
Configuring a route allows requests to be sent to different revisions of a service. This routing is determined by the `traffic` spec of the `Service` object.

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

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

The `traffic` spec can be modified by:

- Editing the YAML of a `Service` object directly.
- Using the Knative (kn) CLI `--traffic` flag.
- Using the OpenShift Dedicated web console.

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

### 5.3.1. Traffic spec examples

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

```yaml
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: example-service
  namespace: default
spec:
  ...
  traffic:
```
The following example shows a traffic spec where 100% of traffic is routed to the revision tagged as current, and the name of that revision is specified as example-service. The revision tagged as latest is kept available, even though no traffic is routed to it:

```
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: example-service
  namespace: default
spec:
...
  traffic:
  - tag: current
    revisionName: example-service
    percent: 100
  - tag: latest
    latestRevision: true
    percent: 0
```

The following example shows how the list of revisions in the traffic spec can be extended so that traffic is split between multiple revisions. This example sends 50% of traffic to the revision tagged as current, and 50% of traffic to the revision tagged as candidate. The revision tagged as latest is kept available, even though no traffic is routed to it:

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

### 5.3.2. Knative CLI traffic management flags

The Knative (kn) CLI supports traffic operations on the traffic block of a service as part of the kn service update command.
The following table displays a summary of traffic splitting flags, value formats, and the operation the flag performs. The **Repetition** column denotes whether repeating the particular value of flag is allowed in a **kn service update** command.

<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>

### 5.3.2.1. Multiple flags and order precedence

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

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

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

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

### 5.3.2.2. Custom URLs for revisions

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

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

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

5.3.2.2.1. Example: Assign a tag to a revision

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

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

5.3.2.2.2. Example: Remove a tag from a revision

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

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

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

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

5.3.3. Creating a traffic split by using the Knative CLI

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

Prerequisites

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

Procedure

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

  **Example command**

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

  Where:

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

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

  **Example command**

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

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

  **Example command**

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

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

### 5.3.4. Managing traffic between revisions by using the OpenShift Dedicated web console

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

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

**Prerequisites**

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

**Procedure**

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

1. Click the Knative service to see its overview in the side panel.

2. Click the **Resources** tab, to see a list of **Revisions** and **Routes** for the service.
Figure 5.1. Serverless application

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

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

5. In the Resources tab, click Set Traffic Distribution to see the traffic distribution dialog box:
   a. Add the split traffic percentage portion for the two revisions in the Splits field.
   b. Add tags to create custom URLs for the two revisions.
   c. Click Save to see two nodes representing the two revisions in the Topology view.

Figure 5.2. Serverless application revisions

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

Prerequisites

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

Procedure

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

   ```
   $ oc get ksvc <service_name> -o=jsonpath='{.status.latestCreatedRevisionName}'
   
   Example command
   $ oc get ksvc example-service -o=jsonpath='{.status.latestCreatedRevisionName}'
   
   Example output
   $ example-service-00001
   
   3. Add the following YAML to the service `spec` to send inbound traffic to the revision:

   ```yaml
   ...
   spec:
     traffic:
     - revisionName: <first_revision_name>
       percent: 100  # All traffic goes to this revision
   ...
   
   4. Verify that you can view your app at the URL output you get from running the following command:

   ```
   $ oc get ksvc <service_name>
   
   5. Deploy a second revision of your app by modifying at least one field in the `template` spec of the service and redeploying it. For example, you can modify the `image` of the service, or an `env` environment variable. You can redeploy the service by applying the service YAML file, or by using the `kn service update` command if you have installed the Knative ( `kn`) CLI.

   6. Find the name of the second, latest revision that was created when you redeployed the service, by running the command:

   ```
   $ oc get ksvc <service_name> -o=jsonpath='{.status.latestCreatedRevisionName}'
   
   At this point, both the first and second revisions of the service are deployed and running.
7. Update your existing service to create a new, test endpoint for the second revision, while still sending all other traffic to the first revision:

Example of updated service spec with test endpoint

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

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

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

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

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

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

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

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

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

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

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

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

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

5.4. ROUTING

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

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

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

5.4.1. Customizing labels and annotations for OpenShift Dedicated routes

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

Prerequisites

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

Procedure

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

   - To create a service by using YAML:

     Example service created by using YAML

     ```yaml
     apiVersion: serving.knative.dev/v1
     kind: Service
     metadata:
       name: <service_name>
     labels:
       <label_name>: <label_value>
     annotations:
       <annotation_name>: <annotation_value>
     ```
• To create a service by using the Knative (kn) CLI, enter:

**Example service created by using a kn command**

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

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

**Example command for verification**

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

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

### 5.4.2. Configuring OpenShift Dedicated routes for Knative services

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

**NOTE**

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

**Prerequisites**

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

**Procedure**

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

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

a. Create a Knative Service resource:

```
Example resource

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

b. Apply the Service resource:

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

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

```
Example kn command

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

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

```
Example command

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

You will see the following output:

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

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

```
apiVersion: route.openshift.io/v1
```
kind: Route
metadata:
  annotations:
    haproxy.router.openshift.io/timeout: 600s
name: <route_name>
namespace: knative-serving-ingress
spec:
  host: <service_host>
  port:
    targetPort: http2
to:
  kind: Service
  name: kourier
  weight: 100
tls:
  insecureEdgeTerminationPolicy: Allow
termination: edge
  key: |
    -----BEGIN PRIVATE KEY-----
    [...]
    -----END PRIVATE KEY-----
  certificate: |
    -----BEGIN CERTIFICATE-----
    [...]
    -----END CERTIFICATE-----
  caCertificate: |
    -----BEGIN CERTIFICATE-----
    [...]
    -----END CERTIFICATE-----
  wildcardPolicy: None

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

4. Apply the Route resource:

    $ oc apply -f <filename>

5.4.3. Setting cluster availability to cluster local

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

Publicly accessible URLs are accessible from outside of the cluster. However, developers may need to
build back-end services that are only be accessible from inside the cluster, known as private services. Developers can label individual services in the cluster with the `networking.knative.dev/visibility=cluster-local` label to make them private.

**IMPORTANT**

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

**Prerequisites**

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

**Procedure**

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

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

**Verification**

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

  ```
  $ oc get ksvc
  ```

**Example output**

<table>
<thead>
<tr>
<th>NAME</th>
<th>URL</th>
<th>LATESTCREATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>hello</td>
<td><a href="http://hello.default.svc.cluster.local">http://hello.default.svc.cluster.local</a></td>
<td>hello-tx2g7</td>
</tr>
</tbody>
</table>

**5.5. EVENT SINKS**

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

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

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

**5.5.1. Knative CLI sink flag**
When you create an event source by using the Knative (`kn`) CLI, you can specify a sink where events are sent to from that resource by using the `--sink` flag. The sink can be any addressable or callable resource that can receive incoming events from other resources.

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

**Example command using the sink flag**

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

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

**TIP**

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

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

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

**Prerequisites**

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

**Procedure**

1. Create an event source of any type, by navigating to `+Add → Event Source` and selecting the event source type that you want to create.

2. In the Sink section of the Create Event Source form view, select your sink in the Resource list.

3. Click Create.

**Verification**

You can verify that the event source was created and is connected to the sink by viewing the Topology page.
1. In the Developer perspective, navigate to Topology.

2. View the event source and click the connected sink to see the sink details in the right panel.

## 5.5.3. Connecting a trigger to a sink

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

**Example of a Trigger object connected to a Kafka sink**

```yaml
apiVersion: eventing.knative.dev/v1
kind: Trigger
metadata:
  name: <trigger_name>  # 1
spec:
  ...  
    subscriber:
      ref:
        apiVersion: eventing.knative.dev/v1alpha1
        kind: KafkaSink
        name: <kafka_sink_name>  # 2
```

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

## 5.6. EVENT DELIVERY

You can configure event delivery parameters for Knative Eventing that are applied in cases where an event fails to be delivered by a subscription or trigger to a subscriber. Event delivery parameters are configured individually per subscriber.

### 5.6.1. Event delivery behavior for Knative Eventing channels

Different Knative Eventing channel types have their own behavior patterns that are followed for event delivery. Developers can set event delivery parameters in the subscription configuration to ensure that any events that fail to be delivered from channels to an event sink are retried. You must also configure a dead letter sink for subscriptions if you want to provide a sink where events that are not eventually delivered can be stored, otherwise undelivered events are dropped.

#### 5.6.1.1. Event delivery behavior for Knative Kafka channels

If an event is successfully delivered to a Kafka channel or broker receiver, the receiver responds with a 202 status code, which means that the event has been safely stored inside a Kafka topic and is not lost. If the receiver responds with any other status code, the event is not safely stored, and steps must be taken by the user to resolve this issue.

#### 5.6.1.2. Delivery failure status codes

The channel or broker receiver can respond with the following status codes if an event fails to be delivered:
500
This is a generic status code which means that the event was not delivered successfully.

404
This status code means that the channel or broker the event is being delivered to does not exist, or that the Host header is incorrect.

400
This status code means that the event being sent to the receiver is invalid.

5.6.2. Configurable event delivery parameters

Knative Eventing provides configuration parameters that can be used to control what happens to events in cases where events fail to be delivered. For example, you can configure Knative to retry sending events that failed to be consumed, or forward these events to a dead letter sink.

The following parameters can be configured for event delivery:

Dead letter sink
You can configure the deadLetterSink delivery parameter so that if an event fails to be delivered it is sent to the specified event sink.

Retries
You can set a minimum number of times that the delivery must be retried before the event is sent to the dead letter sink, by configuring the retry delivery parameter with an integer value.

Back off delay
You can set the backoffDelay delivery parameter to specify the time delay before an event delivery retry is attempted after a failure. The duration of the backoffDelay parameter is specified using the ISO 8601 format.

Back off policy
The backoffPolicy delivery parameter can be used to specify the retry back off policy. The policy can be specified as either linear or exponential. When using the linear back off policy, the back off delay is the time interval specified between retries. When using the exponential backoff policy, the back off delay is equal to backoffDelay*2^<numberOfRetries>.

5.6.3. Configuring event delivery failure parameters using subscriptions

After you have created a channel and an event sink, you can create a subscription to enable event delivery. You can configure event delivery parameters for individual subscriptions by modifying the delivery settings for a Subscription object. Knative Eventing provides configuration parameters for subscriptions that you can use to control what happens to events in cases where events fail to be delivered.

Example Subscription object

```
apiVersion: messaging.knative.dev/v1
kind: Subscription
metadata:
  name: <subscription_name>
  namespace: <subscription_namespace>
spec:
  delivery:
    deadLetterSink: 1
    ref:
```
Configuration settings to enable using a dead letter sink. This tells the subscription what happens to events that cannot be delivered to the subscriber.

When this is configured, events that fail to be delivered are sent to the dead letter sink destination. The destination can be a Knative service or a URI.

You can set the `backoffDelay` delivery parameter to specify the time delay before an event delivery retry is attempted after a failure. The duration of the `backoffDelay` parameter is specified using the ISO 8601 format. For example, `PT1S` specifies a 1 second delay.

The `backoffPolicy` delivery parameter can be used to specify the retry back off policy. The policy can be specified as either linear or exponential. When using the linear back off policy, the back off delay is the time interval specified between retries. When using the exponential back off policy, the back off delay is equal to `backoffDelay*2^{numberOfRetries}`.

The number of times that event delivery is retried before the event is sent to the dead letter sink.

### 5.7. LISTING EVENT SOURCES AND EVENT SOURCE TYPES

It is possible to view a list of all event sources or event source types that exist or are available for use on your OpenShift Dedicated cluster. You can use the Knative (kn) CLI or the Developer perspective in the OpenShift Dedicated web console to list available event sources or event source types.

#### 5.7.1. Listing available event source types by using the Knative CLI

Using the Knative (kn) CLI provides a streamlined and intuitive user interface to view available event source types on your cluster. You can list event source types that can be created and used on your cluster by using the `kn source list-types` CLI command.

**Prerequisites**

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

**Procedure**

1. List the available event source types in the terminal:

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

**Example output**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>API Server Source</td>
<td>apiserversources.sources.knative.dev</td>
<td>Watch and send Kubernetes API events to a sink</td>
</tr>
</tbody>
</table>
5.7.2. Viewing available event source types within the Developer perspective

It is possible to view a list of all available event source types on your cluster. Using the OpenShift Dedicated web console provides a streamlined and intuitive user interface to view available event source types.

Prerequisites

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

Procedure

1. Access the Developer perspective.
2. Click +Add.
3. Click Event Source.
4. View the available event source types.

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 ksvc:eshow2</td>
<td>True</td>
<td></td>
</tr>
<tr>
<td>b1</td>
<td>SinkBinding</td>
<td>sinkbindings.sources.knative.dev ksvc:eshow3</td>
<td>False</td>
<td></td>
</tr>
<tr>
<td>p1</td>
<td>PingSource</td>
<td>pingsources.sources.knative.dev ksvc:eshow1</td>
<td>True</td>
<td></td>
</tr>
</tbody>
</table>

5.7.3. Listing available event sources by using the Knative CLI

Using the Knative (kn) CLI provides a streamlined and intuitive user interface to view existing event sources on your cluster. You can list existing event sources by using the kn source list command.

Prerequisites

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

Procedure

1. List the existing event sources in the terminal:

```
$ kn source list
```

Example output

<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 ksvc:eshow2</td>
<td>True</td>
<td></td>
</tr>
<tr>
<td>b1</td>
<td>SinkBinding</td>
<td>sinkbindings.sources.knative.dev ksvc:eshow3</td>
<td>False</td>
<td></td>
</tr>
<tr>
<td>p1</td>
<td>PingSource</td>
<td>pingsources.sources.knative.dev ksvc:eshow1</td>
<td>True</td>
<td></td>
</tr>
</tbody>
</table>
2. Optional: You can list event sources of a specific type only, by using the `--type` flag:

```bash
$ kn source list --type <event_source_type>
```

**Example command**

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

**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>ksvc:eshow1</td>
<td>True</td>
</tr>
</tbody>
</table>

### 5.8. CREATING AN API SERVER SOURCE

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

#### 5.8.1. Creating an API server source by using the web console

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

**Prerequisites**

- You have logged in to the OpenShift Dedicated web console.
- The OpenShift Serverless Operator and Knative Eventing are installed on the cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have installed the OpenShift (`oc`) CLI.

**PROCEDURE**

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

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

   ```yaml
   apiVersion: v1
   kind: ServiceAccount
   metadata:
     name: events-sa
   namespace: default
   ---
   apiVersion: rbac.authorization.k8s.io/v1
   ```
2. **Apply the YAML file:**

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

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

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

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

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

   **NOTE**

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

   a. Enter `v1` as the **APIVERSION** and `Event` as the **KIND.**
b. Select the **Service Account Name** for the service account that you created.

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

7. Click **Create**.

**Verification**

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

![Topology view of API server source](image)

**NOTE**

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

**Deleting the API server source**

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

2. Right-click the API server source and select **Delete ApiServerSource**.
5.8.2. Creating an API server source by using the Knative CLI

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

**Prerequisites**

- The OpenShift Serverless Operator and Knative Eventing are installed on the cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have installed the OpenShift (`oc`) CLI.
- You have installed the Knative (`kn`) CLI.

**PROCEDURE**

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

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

```yaml
apiVersion: v1
kind: ServiceAccount
metadata:
  name: events-sa
namespace: default
```
1. Change this namespace to the namespace that you have selected for installing the event source.

2. Apply the YAML file:

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

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

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

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

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

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

   ```bash
   $ kn trigger create <trigger_name> --sink ksvc:<service_name>
   ```
6. Create events by launching a pod in the default namespace:

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

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

   $ kn sourceapiserver describe <source_name>

**Example output**

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

**Verification**

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

1. Get the pods:

   $ oc get pods

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

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

**Example output**

```
> cloudevents.Event
Validation: valid
Context Attributes,
specversion: 1.0
type: dev.knative.apiserver.resource.update
```
Deleting the API server source

1. Delete the trigger:

   $ kn trigger delete <trigger_name>

2. Delete the event source:

   $ kn source apiserver delete <source_name>

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

   $ oc delete -f authentication.yaml

5.8.2.1. Knative CLI sink flag

When you create an event source by using the Knative (kn) CLI, you can specify a sink where events are sent to from that resource by using the 

   --sink

flag. The sink can be any addressable or callable resource that can receive incoming events from other resources.

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

**Example command using the sink flag**

```
$ kn source binding create bind-heartbeat \
   --namespace sinkbinding-example \
   --subject "Job:batch/v1:app=heartbeat-cron" \
   --sink http://event-display.svc.cluster.local \
   --ce-override "sink=bound"
```
svc in `http://event-display.svc.cluster.local` determines that the sink is a Knative service. Other default sink prefixes include `channel`, and `broker`.

### 5.8.3. Creating an API server source by using YAML files

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

**Prerequisites**

- The OpenShift Serverless Operator and Knative Eventing are installed on the cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have created the `default` broker in the same namespace as the one defined in the API server source YAML file.
- Install the OpenShift (`oc`) CLI.

**PROCEDURE**

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

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

```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

---
"
1. Change this namespace to the namespace that you have selected for installing the event source.

2. Apply the YAML file:

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

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

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

4. Apply the `ApiServerSource` YAML file:

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

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

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

   $ oc apply -f <filename>

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

   ```yaml
   apiVersion: eventing.knative.dev/v1
   kind: Trigger
   metadata:
     name: event-display-trigger
     namespace: default
   spec:
     broker: default
     subscriber:
       ref:
         apiVersion: serving.knative.dev/v1
         kind: Service
         name: event-display
   
   $ oc apply -f <filename>
   
8. Apply the Trigger YAML file:

   $ oc apply -f <filename>

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

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

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

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

Example output

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

1. Get the pods by entering the following command:

   ```
   $ oc get pods
   ```

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

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

Example output

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

1. Delete the trigger:

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

2. Delete the event source:

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

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

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

5.9. CREATING A PING SOURCE

A ping source is an event source that can be used to periodically send ping events with a constant payload to an event consumer. A ping source can be used to schedule sending events, similar to a timer.

5.9.1. Creating a ping source by using the web console

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

Prerequisites

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

Procedure

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

      ```yaml
      apiVersion: serving.knative.dev/v1
      kind: Service
      ```
2. Create a ping source in the same namespace as the service created in the previous step, or any other sink that you want to send events to.

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

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

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

   **NOTE**

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

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

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

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

   g. Click **Create.**

**Verification**

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

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

2. View the ping source and sink.
Deleting the ping source

1. Navigate to the Topology view.

2. Right-click the API server source and select Delete Ping Source

5.9.2. Creating a ping source by using the Knative CLI

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

Prerequisites

- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on the cluster.
- You have installed the Knative (kn) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- Optional: If you want to use the verification steps for this procedure, install the OpenShift (oc) CLI.

Procedure

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

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

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

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

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

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

Example output

<table>
<thead>
<tr>
<th>Name:</th>
<th>test-ping-source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Namespace:</td>
<td>default</td>
</tr>
<tr>
<td>Annotations:</td>
<td>sources.knative.dev/creator=developer, sources.knative.dev/lastModifier=developer</td>
</tr>
<tr>
<td>Age:</td>
<td>15s</td>
</tr>
<tr>
<td>Schedule:</td>
<td>*/2 * * * *</td>
</tr>
</tbody>
</table>
Verification

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

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

1. Watch for new pods created:

   ```
   $ watch oc get pods
   ```

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

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

Example output

```
☁ cloudevents.Event
Validation: valid
Context Attributes,
   specversion: 1.0
   type: dev.knative.sources.ping
   source: /apis/v1/namespaces/default/pingsources/test-ping-source
   id: 99e4f4f6-08ff-4bff-acf1-47f61ded68c9
   time: 2020-04-07T16:16:00.000601161Z
   datacontenttype: application/json
Data,
   {
     "message": "Hello world!"
   }
```

Deleting the ping source

- Delete the ping source:

  ```
  $ kn delete pingsources.sources.knative.dev <ping_source_name>
  ```
5.9.2.1. Knative CLI sink flag

When you create an event source by using the Knative (kn) CLI, you can specify a sink where events are sent to from that resource by using the `--sink` flag. The sink can be any addressable or callable resource that can receive incoming events from other resources.

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

Example command using the sink flag

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

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

5.9.3. Creating a ping source by using YAML

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

Example PingSource object

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

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

Prerequisites

- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on the cluster.
- Install the OpenShift (oc) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

Procedure

1. To verify that the ping source is working, create a simple Knative service that dumps incoming messages to the service's logs.
   a. Create a service YAML file:
      ```yaml
      apiVersion: serving.knative.dev/v1
      kind: Service
      metadata:
        name: event-display
      spec:
        template:
          spec:
            containers:
              - image: quay.io/openshift-knative/knative-eventing-sources-event-display:latest
      
      $ oc apply -f <filename>
      
      Example output
      
      apiVersion: serving.knative.dev/v1
      kind: Service
      metadata:
        name: event-display
      spec:
        template:
          spec:
            containers:
              - image: quay.io/openshift-knative/knative-eventing-sources-event-display:latest
      
   b. Create the service:
      
      $ oc apply -f <filename>

2. For each set of ping events that you want to request, create a ping source in the same namespace as the event consumer.
   a. Create a YAML file for the ping source:
      ```yaml
      apiVersion: sources.knative.dev/v1
      kind: PingSource
      metadata:
        name: test-ping-source
      spec:
        schedule: "*/2 * * * *"
        data: '{"message": "Hello world!"}"
        sink:
          ref:
            apiVersion: serving.knative.dev/v1
            kind: Service
            name: event-display
      
      $ oc apply -f <filename>

   b. Create the ping source:
      
      $ oc apply -f <filename>

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

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

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

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

1. Watch for new pods created:
   
   ```
   $ watch oc get pods
   ```

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

**Example output**

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

- Delete the ping source:

  ```
  $ oc delete -f <filename>
  
  Example command
  
  $ oc delete -f ping-source.yaml
  ```

5.10. CUSTOM EVENT SOURCES

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

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

5.10.1. Sink binding

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

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

**K_SINK**

The URL of the resolved sink.

**K_CE_OVERRIDES**

A JSON object that specifies overrides to the outbound event.

5.10.1.1. Creating a sink binding by using YAML

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

Prerequisites

- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on the cluster.
- Install the OpenShift (oc) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
Procedure

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

   a. Create a service YAML file:

      Example service YAML file

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

   b. Create the service:

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

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

   a. Create a sink binding YAML file:

      Example service YAML file

      ```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. Create the sink binding:

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

   1 In this example, any Job with the label **app: heartbeat-cron** will be bound to the event sink.
3. Create a **CronJob** object.

   a. Create a cron job YAML file:

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

   IMPORTANT
   To use sink binding, you must manually add a
   `bindings.knative.dev/include=true` label to your Knative resources.
   
   For example, to add this label to a **CronJob** resource, add the following lines to the **Job** resource YAML definition:

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

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

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

**Example output**

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

**Verification**

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

1. Enter the command:

```
$ oc get pods
```

2. Enter the command:

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

**Example output**

```
> cloudevents.Event
Validation: valid
Context Attributes,
  specversion: 1.0
  type: dev.knative.eventing.samples.heartbeat
  source: https://knative.dev/eventing-contrib/cmd/heartbeats/#event-test/mypod
  id: 2b72d7bf-c38f-4a98-a433-608fbcdd2596
  contenttype: application/json
Extensions,
  beats: true
  heart: yes
the: 42
Data,
  {
```
5.10.1.2. Creating a sink binding by using the Knative CLI

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

**Prerequisites**

- The OpenShift Serverless Operator, Knative Serving and Knative Eventing are installed on the cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- Install the Knative (kn) CLI.
- Install the OpenShift (oc) CLI.

**NOTE**

The following procedure requires you to create YAML files.

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

**Procedure**

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

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

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

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

3. Create a **CronJob** object.

   a. Create a cron job YAML file:

   **Example cron job YAML file**

   ```yaml
   apiVersion: batch/v1
   kind: CronJob
   metadata:
     name: heartbeat-cron
   spec:
     # Run every minute
   ```
IMPORTANT

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

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

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

b. Create the cron job:

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

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

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

Example output

```
Name: bind-heartbeat
```
Verification

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

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

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

Example output

```yaml
<table>
<thead>
<tr>
<th>cloudevents.Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Validation: valid</td>
</tr>
</tbody>
</table>

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,

```json
{
  "id": 1,
  "label": ""
}
```
The following example creates a sink binding that uses a service, `http://event-display.svc.cluster.local`, as the sink:

**Example command using the sink flag**

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

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

### 5.10.1.3. Creating a sink binding by using the web console

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

**Prerequisites**

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

**Procedure**

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

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

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

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

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

c. Click **Create**.

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

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

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

c. Select **Sink Binding** and then click **Create Event Source** The Create Event Source page is displayed.
NOTE
You can configure the Sink Binding settings by using the Form view or YAML view and can switch between the views. The data is persisted when switching between the views.

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

e. In the Kind field enter `Job`.

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

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

g. In the Match labels section:

i. Enter `app` in the Name field.

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

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

h. Click Create.

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

1. In the Developer perspective, navigate to Topology.

2. View the sink binding, sink, and heartbeats cron job.
3. Observe that successful jobs are being registered by the cron job once the sink binding is added. This means that the sink binding is successfully reconfiguring the jobs created by the cron job.

4. Browse the logs of the **event-display** service pod to see events produced by the heartbeats cron job.

### 5.10.1.4. Sink binding reference

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

**SinkBinding** objects support the following parameters:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Required or optional</th>
</tr>
</thead>
<tbody>
<tr>
<td>apiVersion</td>
<td>Specifies the API version, for example <strong>sources.knative.dev/v1</strong>.</td>
<td>Required</td>
</tr>
<tr>
<td>kind</td>
<td>Identifies this resource object as a <strong>SinkBinding</strong> object.</td>
<td>Required</td>
</tr>
<tr>
<td>metadata</td>
<td>Specifies metadata that uniquely identifies the <strong>SinkBinding</strong> object. For example, a <strong>name</strong>.</td>
<td>Required</td>
</tr>
<tr>
<td>spec</td>
<td>Specifies the configuration information for this <strong>SinkBinding</strong> object.</td>
<td>Required</td>
</tr>
<tr>
<td>spec.sink</td>
<td>A reference to an object that resolves to a URI to use as the sink.</td>
<td>Required</td>
</tr>
</tbody>
</table>
**spec.subject**  
References the resources for which the runtime contract is augmented by binding implementations.  
Required

**spec.ceOverrides**  
Defines overrides to control the output format and modifications to the event sent to the sink.  
Optional

### 5.10.1.4.1. Subject parameter

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

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

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Required or optional</th>
</tr>
</thead>
<tbody>
<tr>
<td>apiVersion</td>
<td>API version of the referent.</td>
<td>Required</td>
</tr>
<tr>
<td>kind</td>
<td>Kind of the referent.</td>
<td>Required</td>
</tr>
<tr>
<td>namespace</td>
<td>Namespace of the referent. If omitted, this defaults to the namespace of the object.</td>
<td>Optional</td>
</tr>
<tr>
<td>name</td>
<td>Name of the referent.</td>
<td>Do not use if you configure selector.</td>
</tr>
<tr>
<td>selector</td>
<td>Selector of the referents.</td>
<td>Do not use if you configure name.</td>
</tr>
<tr>
<td>selector.matchExpressions</td>
<td>A list of label selector requirements.</td>
<td>Only use one of either matchExpressions or matchLabels.</td>
</tr>
<tr>
<td>selector.matchExpressions.key</td>
<td>The label key that the selector applies to.</td>
<td>Required if using matchExpressions.</td>
</tr>
<tr>
<td>selector.matchExpressions.operator</td>
<td>Represents a key’s relationship to a set of values. Valid operators are In, NotIn, Exists and DoesNotExist.</td>
<td>Required if using matchExpressions.</td>
</tr>
<tr>
<td>Field</td>
<td>Description</td>
<td>Required or optional</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>selector.matchExpressions.values</td>
<td>An array of string values. If the operator parameter value is <strong>In</strong> or <strong>NotIn</strong>, the values array must be non-empty. If the operator parameter value is <strong>Exists</strong> or <strong>DoesNotExist</strong>, the values array must be empty. This array is replaced during a strategic merge patch.</td>
<td>Required if using matchExpressions.</td>
</tr>
<tr>
<td>selector.matchLabels</td>
<td>A map of key-value pairs. Each key-value pair in the matchLabels map is equivalent to an element of matchExpressions, where the key field is matchLabels.&lt;key&gt;, the operator is In, and the values array contains only matchLabels.&lt;value&gt;.</td>
<td>Only use one of either matchExpressions or matchLabels.</td>
</tr>
</tbody>
</table>

**Subject parameter examples**

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

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

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

```yaml
apiVersion: sources.knative.dev/v1
kind: SinkBinding
metadata:
  name: bind-heartbeat
spec:
  subject:
    apiVersion: batch/v1
    kind: Job
    namespace: default
    selector:
```
Given the following YAML, any Pod object with the label `working=example` or `working=sample` in the default namespace is selected:

```yaml
matchLabels:
  working: example
...
```

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

A `ceOverrides` definition supports the following fields:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Required or optional</th>
</tr>
</thead>
<tbody>
<tr>
<td>extensions</td>
<td>Specifies which attributes are added or overridden on the outbound event. Each <code>extensions</code> key-value pair is set independently on the event as an attribute extension.</td>
<td>Optional</td>
</tr>
</tbody>
</table>

**NOTE**

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

**CloudEvent Overrides example**

```yaml
apiVersion: sources.knative.dev/v1
kind: SinkBinding
metadata:

spec:
  subject:
    apiVersion: v1
    kind: Pod
    namespace: default
    selector:
      - matchExpression:
          key: working
          operator: In
          values:
            - example
            - sample

...
name: bind-heartbeat
spec:
  ...  
ceOverrides:
  extensions:
    extra: this is an extra attribute
    additional: 42

This sets the `K_CE_OVERRIDES` environment variable on the subject.

Example output

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

5.10.1.4.3. The include label

To use a sink binding, you need to assign the `bindings.knative.dev/include: "true"` label to either the resource or the namespace that the resource is included in. If the resource definition does not include the label, a cluster administrator can attach it to the namespace by running:

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

5.10.2. Container source

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

5.10.2.1. Guidelines for creating a container image

Two environment variables are injected by the container source controller: `K_SINK` and `K_CE_OVERRIDES`. These variables are resolved from the `sink` and `ceOverrides` spec, respectively. Events are sent to the sink URI specified in the `K_SINK` environment variable. The message must be sent as a `POST` using the `CloudEvent` HTTP format.

Example container images

The following is an example of a heartbeats container image:

```go
package main

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

  duckv1 "knative.dev/pkg/apis/duck/v1"
  cloudevents "github.com/cloudevents/sdk-go/v2"
```
type Heartbeat struct {
    Sequence int `json:"id"`
    Label    string `json:"label"
}

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

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

type envConfig struct {  
    // Sink URL where to send heartbeat cloud events  
    Sink string `envconfig:"K_SINK"`
    
    // CEOverrides are the CloudEvents overrides to be applied to the outbound event.  
    //CEOversides string `envconfig:"K_CE_OVERRIDES"
    
    // Name of this pod.  
    Name string `envconfig:"POD_NAME" required:"true"
    
    // Namespace this pod exists in.  
    Namespace string `envconfig:"POD_NAMESPACE" required:"true"
    
    // Whether to run continuously or exit.  
    OneShot bool `envconfig:"ONE_SHOT" default:"false"
}

cfunc main() {  
    flag.Parse()
    
    var env envConfig  
    if err := envconfig.Process("", &env); err != nil {  
        log.Printf("[ERROR] Failed to process env var: %s", err)  
        os.Exit(1)
    }
    
    if env.Sink != 
"" {  
        sink = env.Sink
    }
    
    var ceOverrides *duckv1.CloudEventOverrides
}
if len(env.CEOverrides) > 0 {
    overrides := duckv1.CloudEventOverrides{}
    err := json.Unmarshal([]byte(env.CEOverrides), &overrides)
    if err != nil {
        log.Printf("[ERROR] Unparseable CloudEvents overrides %s: %v", env.CEOverrides, err)
        os.Exit(1)
    }
    ceOverrides = &overrides
}

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

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

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

if eventSource == "" {
    log.Printf("Heartbeats Source: %s", eventSource)
}

if len(label) > 0 && label[0] == '"' {
    label, _ = strconv.Unquote(label)
}

hb := &Heartbeat{
    Sequence: 0,
    Label:    label,
}
ticker := time.NewTicker(period)
for {
    hb.Sequence++

    event := cloudevents.NewEvent("1.0")
    event.SetType(eventType)
    event.SetSource(eventSource)
    event.SetExtension("the", 42)
    event.SetExtension("heart", "yes")
    event.SetExtension("beats", true)

    if ceOverrides != nil && ceOverrides.Extensions != nil {
        for n, v := range ceOverrides.Extensions {
            event.SetExtension(n, v)
        }
    }
}
The following is an example of a container source that references the previous heartbeats container image:

```yaml
apiVersion: sources.knative.dev/v1
kind: ContainerSource
metadata:
  name: test-heartbeats
spec:
  template:
    spec:
      containers:
        # This corresponds to a heartbeats image URI that you have built and published
        - image: gcr.io/knative-releases/knative.dev/eventing/cmd/heartbeats
          name: heartbeats
          args:
            - --period=1
          env:
            - name: POD_NAME
              value: "example-pod"
            - name: POD_NAMESPACE
              value: "event-test"
      sink:
        ref:
          apiVersion: serving.knative.dev/v1
          kind: Service
          name: example-service
```

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

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

Create a container source
Delete a container source

$ kn source container delete <container_source_name>

Describe a container source

$ kn source container describe <container_source_name>

List existing container sources

$ kn source container list

List existing container sources in YAML format

$ kn source container list -o yaml

Update a container source

This command updates the image URI for an existing container source:

$ kn source container update <container_source_name> --image <image_uri>

5.10.2.3. Creating a container source by using the web console

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

Prerequisites

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

Procedure

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

2. Select **Container Source** and then click **Create Event Source**. The **Create Event Source** page is displayed.

3. Configure the **Container Source** settings by using the **Form view** or **YAML view**.
NOTE

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

a. In the Image field, enter the URI of the image that you want to run in the container created by the container source.

b. In the Name field, enter the name of the image.

c. Optional: In the Arguments field, enter any arguments to be passed to the container.

d. Optional: In the Environment variables field, add any environment variables to set in the container.

e. In the Sink section, add a sink where events from the container source are routed to. If you are using the Form view, you can choose from the following options:

i. Select Resource to use a channel, broker, or service as a sink for the event source.

ii. Select URI to specify where the events from the container source are routed to.

4. After you have finished configuring the container source, click Create.

5.10.2.4. Container source reference

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

ContainerSource objects support the following fields:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Required or optional</th>
</tr>
</thead>
<tbody>
<tr>
<td>apiVersion</td>
<td>Specifies the API version, for example sources.knative.dev/v1.</td>
<td>Required</td>
</tr>
<tr>
<td>kind</td>
<td>Identifies this resource object as a ContainerSource object.</td>
<td>Required</td>
</tr>
<tr>
<td>metadata</td>
<td>Specifies metadata that uniquely identifies the ContainerSource object. For example, a name.</td>
<td>Required</td>
</tr>
<tr>
<td>spec</td>
<td>Specifies the configuration information for this ContainerSource object.</td>
<td>Required</td>
</tr>
<tr>
<td>spec.sink</td>
<td>A reference to an object that resolves to a URI to use as the sink.</td>
<td>Required</td>
</tr>
</tbody>
</table>
A template spec for the ContainerSource object.

Required

spec.ceOverrides

 Defines overrides to control the output format and modifications to the event sent to the sink.

Optional

### Field Description

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Required or optional</th>
</tr>
</thead>
<tbody>
<tr>
<td>spec.template</td>
<td>A template spec for the ContainerSource object.</td>
<td>Required</td>
</tr>
<tr>
<td>spec.ceOverrides</td>
<td>Defines overrides to control the output format and modifications to the event sent to the sink.</td>
<td>Optional</td>
</tr>
</tbody>
</table>

### Template parameter example

```
apiVersion: sources.knative.dev/v1
kind: ContainerSource
metadata:
  name: test-heartbeats
spec:
  template:
    spec:
      containers:
        - image: quay.io/openshift-knative/heartbeats:latest
          name: heartbeats
          args:
            - --period=1
          env:
            - name: POD_NAME
              value: "mypod"
            - name: POD_NAMESPACE
              value: "event-test"
```

### 5.10.2.4.1. CloudEvent overrides

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

A `ceOverrides` definition supports the following fields:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Required or optional</th>
</tr>
</thead>
<tbody>
<tr>
<td>extensions</td>
<td>Specifies which attributes are added or overridden on the outbound event. Each extensions key-value pair is set independently on the event as an attribute extension.</td>
<td>Optional</td>
</tr>
</tbody>
</table>

**NOTE**

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

```yaml
apiVersion: sources.knative.dev/v1
kind: ContainerSource
metadata:
  name: test-heartbeats
spec:
  ...
  ceOverrides:
    extensions:
      extra: this is an extra attribute
      additional: 42
```

This sets the `K_CE_OVERRIDES` environment variable on the **subject**.

**Example output**

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

### 5.11. CREATING CHANNELS

Channels are custom resources that define a single event-forwarding and persistence layer. After events have been sent to a channel from an event source or producer, these events can be sent to multiple Knative services or other sinks by using a subscription.

---

#### 5.11.1. Creating a channel by using the web console

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

**Prerequisites**

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

You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

**Procedure**

1. In the **Developer** perspective, navigate to **+Add → Channel**.
2. Select the type of **Channel** object that you want to create in the **Type** list.
3. Click **Create**.

**Verification**

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

5.11.2. Creating a channel by using the Knative CLI

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

**Prerequisites**

- The OpenShift Serverless Operator and Knative Eventing are installed on the cluster.
- You have installed the Knative (kn) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

**Procedure**

- Create a channel:

  ```bash
  $ kn channel create <channel_name> --type <channel_type>
  
  The channel type is optional, but where specified, must be given in the format **Group:Version:Kind**. For example, you can create an **InMemoryChannel** object:

  ```bash
  $ kn channel create mychannel --type messaging.knative.dev:v1:InMemoryChannel
  ```

  **Example output**
Verification

- To confirm that the channel now exists, list the existing channels and inspect the output:

  $ kn channel list

**Example output**

```
kn channel list
NAME        TYPE              URL                                                      AGE   READY   REASON
mychannel   InMemoryChannel   http://mychannel-kn-channel.default.svc.cluster.local   93s   True
```

Deleting a channel

- Delete a channel:

  $ kn channel delete <channel_name>

5.11.3. Creating a default implementation channel by using YAML

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

**Prerequisites**

- The OpenShift Serverless Operator and Knative Eventing are installed on the cluster.
- Install the OpenShift (oc) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

**Procedure**

1. Create a `Channel` object as a YAML file:

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

2. Apply the YAML file:

   `$ oc apply -f <filename>`

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

**Prerequisites**

- The OpenShift Serverless Operator, Knative Eventing, and the `KnativeKafka` custom resource are installed on your OpenShift Dedicated cluster.
- Install the OpenShift (`oc`) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

**Procedure**

1. Create a `KafkaChannel` object as a YAML file:

   ```yaml
   apiVersion: messaging.knative.dev/v1beta1
   kind: KafkaChannel
   metadata:
     name: example-channel
     namespace: default
   spec:
     numPartitions: 3
     replicationFactor: 1
   ```

   **IMPORTANT**

   Only the `v1beta1` version of the API for `KafkaChannel` objects on OpenShift Serverless is supported. Do not use the `v1alpha1` version of this API, as this version is now deprecated.

2. Apply the `KafkaChannel` YAML file:

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

5.11.5. **Next steps**

- After you have created a channel, create a subscription that allows event sinks to subscribe to channels and receive events.

5.12. **CREATING AND MANAGING SUBSCRIPTIONS**

After you have created a channel and an event sink, you can create a subscription to enable event delivery. Subscriptions are created by configuring a `Subscription` object, which specifies the channel and the sink (also known as a subscriber) to deliver events to. You can also specify some sink-specific options, such as how to handle failures.

5.12.1. **Creating a subscription by using the web console**
After you have created a channel and an event sink, you can create a subscription to enable event delivery. Using the OpenShift Dedicated web console provides a streamlined and intuitive user interface to create a subscription.

**Prerequisites**

- The OpenShift Serverless Operator, Knative Serving, and Knative Eventing are installed on your OpenShift Dedicated cluster.
- You have logged in to the web console.
- You have created an event sink, such as a Knative service, and a channel.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

**Procedure**

1. In the Developer perspective, navigate to the Topology page.
2. Create a subscription using one of the following methods:
   a. Hover over the channel that you want to create a subscription for, and drag the arrow. The Add Subscription option is displayed.
      i. Select your sink in the Subscriber list.
      ii. Click Add.
   b. If the service is available in the Topology view under the same namespace or project as the channel, click on the channel that you want to create a subscription for, and drag the arrow directly to a service to immediately create a subscription from the channel to that service.

**Verification**

- After the subscription has been created, you can see it represented as a line that connects the channel to the service in the Topology view:
5.12.2. Creating a subscription by using YAML

After you have created a channel and an event sink, you can create a subscription to enable event delivery. Creating Knative resources by using YAML files uses a declarative API, which enables you to describe subscriptions declaratively and in a reproducible manner. To create a subscription by using YAML, you must create a YAML file that defines a Subscription object, then apply it by using the `oc apply` command.

**Prerequisites**

- The OpenShift Serverless Operator and Knative Eventing are installed on the cluster.
- Install the OpenShift (oc) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

**Procedure**

- Create a Subscription object:
  
  - Create a YAML file and copy the following sample code into it:

```yaml
apiVersion: messaging.knative.dev/v1beta1
kind: Subscription
metadata:
  name: my-subscription
  namespace: default
spec:
  channel:
    apiVersion: messaging.knative.dev/v1beta1
    kind: Channel
    name: example-channel
  delivery:
    deadLetterSink:
      ref:
        apiVersion: serving.knative.dev/v1
        kind: Service
        name: error-handler
```


1 Name of the subscription.

2 Configuration settings for the channel that the subscription connects to.

3 Configuration settings for event delivery. This tells the subscription what happens to events that cannot be delivered to the subscriber. When this is configured, events that failed to be consumed are sent to the **deadLetterSink**. The event is dropped, no re-delivery of the event is attempted, and an error is logged in the system. The **deadLetterSink** value must be a **Destination**.

4 Configuration settings for the subscriber. This is the event sink that events are delivered to from the channel.

- Apply the YAML file:

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

### 5.12.3. Creating a subscription by using the Knative CLI

After you have created a channel and an event sink, you can create a subscription to enable event delivery. Using the Knative (**kn**) CLI to create subscriptions provides a more streamlined and intuitive user interface than modifying YAML files directly. You can use the **kn subscription create** command with the appropriate flags to create a subscription.

**Prerequisites**

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

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

- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

**Procedure**

- Create a subscription to connect a sink to a channel:

  ```
  $ kn subscription create <subscription_name> \
  --channel <group:version:kind>:<channel_name> \
  --sink <sink_prefix>:<sink_name> \
  --sink-dead-letter <sink_prefix>:<sink_name>
  ```

  - **--channel** specifies the source for cloud events that should be processed. You must provide the channel name. If you are not using the default **InMemoryChannel** channel that is backed by the **Channel** custom resource, you must prefix the channel name with the **<group:version:kind>** for the specified channel type. For example, this will be
messaging.knative.dev:v1beta1:KafkaChannel for a Kafka backed channel.

--sink specifies the target destination to which the event should be delivered. By default, the <sink_name> is interpreted as a Knative service of this name, in the same namespace as the subscription. You can specify the type of the sink by using one of the following prefixes:

ksvc
A Knative service.
channel
A channel that should be used as destination. Only default channel types can be referenced here.
broker
An Eventing broker.

Optional: --sink-dead-letter is an optional flag that can be used to specify a sink which events should be sent to in cases where events fail to be delivered. For more information, see the OpenShift Serverless Event delivery documentation.

Example command

$ kn subscription create mysubscription --channel mychannel --sink ksvc:event-display

Example output

Subscription 'mysubscription' created in namespace 'default'.

Verification

- To confirm that the channel is connected to the event sink, or subscriber, by a subscription, list the existing subscriptions and inspect the output:

  $ kn subscription list

  Example output

  NAME       CHANNEL           SUBSCRIBER           REPLY   DEAD LETTER SINK
  READY     REASON
  mysubscription Channel:mychannel ksvc:event-display  True

Deleting a subscription

- Delete a subscription:

  $ kn subscription delete <subscription_name>

5.12.4. Describing subscriptions by using the Knative CLI

You can use the kn subscription describe command to print information about a subscription in the terminal by using the Knative (kn) CLI. Using the Knative CLI to describe subscriptions provides a more streamlined and intuitive user interface than viewing YAML files directly.
Prerequisites

- You have installed the Knative (kn) CLI.
- You have created a subscription in your cluster.

Procedure

- Describe a subscription:

  ```
  $ kn subscription describe <subscription_name>
  ```

Example output

- Name: my-subscription
- Namespace: default
- Annotations: messaging.knative.dev/creator=openshift-user,
  messaging.knative.dev/lastModifier=min ...
- Age: 43s
- Channel: Channel:my-channel (messaging.knative.dev/v1)
- Subscriber:
  - URI: http://edisplay.default.example.com
  - Reply:
    - Name: default
    - Resource: Broker (eventing.knative.dev/v1)
  - DeadLetterSink:
    - Name: my-sink
    - Resource: Service (serving.knative.dev/v1)
- Conditions:

<table>
<thead>
<tr>
<th>OK TYPE</th>
<th>AGE</th>
<th>REASON</th>
</tr>
</thead>
<tbody>
<tr>
<td>++ Ready</td>
<td>43s</td>
<td></td>
</tr>
<tr>
<td>++ AddedToChannel</td>
<td>43s</td>
<td></td>
</tr>
<tr>
<td>++ ChannelReady</td>
<td>43s</td>
<td></td>
</tr>
<tr>
<td>++ ReferencesResolved</td>
<td>43s</td>
<td></td>
</tr>
</tbody>
</table>

5.12.5. Listing subscriptions by using the Knative CLI

You can use the **kn subscription list** command to list existing subscriptions on your cluster by using the Knative (kn) CLI. Using the Knative CLI to list subscriptions provides a streamlined and intuitive user interface.

Prerequisites

- You have installed the Knative (kn) CLI.

Procedure

- List subscriptions on your cluster:

  ```
  $ kn subscription list
  ```

Example output

-
5.12.6. Updating subscriptions by using the Knative CLI

You can use the `kn subscription update` command as well as the appropriate flags to update a subscription from the terminal by using the Knative (kn) CLI. Using the Knative CLI to update subscriptions provides a more streamlined and intuitive user interface than updating YAML files directly.

**Prerequisites**

- You have installed the Knative (kn) CLI.
- You have created a subscription.

**Procedure**

- Update a subscription:

  ```
  $ kn subscription update <subscription_name> \ 
  --sink <sink_prefix>:<sink_name> \  
  --sink-dead-letter <sink_prefix>:<sink_name>
  ```

  **1** 
  - `--sink` specifies the updated target destination to which the event should be delivered. You can specify the type of the sink by using one of the following prefixes:
    - `ksvc` A Knative service.
    - `channel` A channel that should be used as destination. Only default channel types can be referenced here.
    - `broker` An Eventing broker.

  **2**
  - Optional: `--sink-dead-letter` is an optional flag that can be used to specify a sink which events should be sent to in cases where events fail to be delivered. For more information, see the OpenShift Serverless *Event delivery* documentation.

  **Example command**

  ```
  $ kn subscription update mysubscription --sink ksvc:event-display
  ```

5.12.7. Configuring event delivery failure parameters using subscriptions

After you have created a channel and an event sink, you can create a subscription to enable event delivery. You can configure event delivery parameters for individual subscriptions by modifying the delivery settings for a Subscription object. Knative Eventing provides configuration parameters for subscriptions that you can use to control what happens to events in cases where events fail to be delivered.

**Example Subscription object**

```
Configuration settings to enable using a dead letter sink. This tells the subscription what happens to events that cannot be delivered to the subscriber.

When this is configured, events that fail to be delivered are sent to the dead letter sink destination. The destination can be a Knative service or a URI.

You can set the `backoffDelay` delivery parameter to specify the time delay before an event delivery retry is attempted after a failure. The duration of the `backoffDelay` parameter is specified using the ISO 8601 format. For example, `PT1S` specifies a 1 second delay.

The `backoffPolicy` delivery parameter can be used to specify the retry back off policy. The policy can be specified as either linear or exponential. When using the linear back off policy, the back off delay is the time interval specified between retries. When using the exponential back off policy, the back off delay is equal to `backoffDelay*2^<numberOfRetries>`.

The number of times that event delivery is retried before the event is sent to the dead letter sink.

5.13. BROKERS

Brokers can be used in combination with triggers to deliver events from an event source to an event sink. Events are sent from an event source to a broker as an HTTP POST request. After events have entered the broker, they can be filtered by CloudEvent attributes using triggers, and sent as an HTTP POST request to an event sink.
5.13.1. Broker types

There are multiple broker implementations available for use with OpenShift Serverless, each of which have different event delivery guarantees and use different underlying technologies. You can choose the broker implementation when creating a broker by specifying a broker class, otherwise the default broker class is used. The default broker class can be configured by cluster administrators.

5.13.1.1. Channel-based broker

The channel-based broker implementation internally uses channels for event delivery. Channel-based brokers provide different event delivery guarantees based on the channel implementation a broker instance uses, for example:

- A broker using the `InMemoryChannel` implementation is useful for development and testing purposes, but does not provide adequate event delivery guarantees for production environments.

- A broker using the `KafkaChannel` implementation provides the event delivery guarantees required for a production environment.

5.13.1.2. Kafka broker

The Kafka broker is a broker implementation that uses Kafka internally to provide at-least once delivery guarantees. It supports multiple Kafka versions, and has a native integration with Kafka for storing and routing events.

**IMPORTANT**

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

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

5.13.2. Creating a broker that uses default settings

OpenShift Serverless provides a default Knative broker that you can create by using the Knative (`kn`) CLI. You can also create the default broker by adding the `eventing.knative.dev/injection: enabled` annotation to a trigger, or by adding the `eventing.knative.dev/injection=enabled` label to a namespace.

5.13.2.1. Creating a broker by using the Knative CLI

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

**Prerequisites**

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Dedicated cluster.
You have installed the Knative (kn) CLI.

You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

Procedure

- Create the default broker:

  $ kn broker create default

Verification

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

  $ kn broker list

Example output

<table>
<thead>
<tr>
<th>NAME</th>
<th>URL</th>
<th>AGE</th>
<th>CONDITIONS</th>
<th>READY</th>
</tr>
</thead>
<tbody>
<tr>
<td>default</td>
<td><a href="http://broker-ingress.knative-eventing.svc.cluster.local/test/default">http://broker-ingress.knative-eventing.svc.cluster.local/test/default</a></td>
<td>45s</td>
<td>5 OK / 5 True</td>
<td></td>
</tr>
</tbody>
</table>

2. Optional: If you are using the OpenShift Dedicated web console, you can navigate to the Topology view in the Developer perspective, and observe that the broker exists:

5.13.2.2. Creating a broker by annotating a trigger

Brokers can be used in combination with triggers to deliver events from an event source to an event sink. You can create a broker by adding the `eventing.knative.dev/injection: enabled` annotation to a Trigger object.

**IMPORTANT**

If you create a broker by using the `eventing.knative.dev/injection: enabled` annotation, you cannot delete this broker without cluster administrator permissions. If you delete the broker without having a cluster administrator remove this annotation first, the broker is created again after deletion.
Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Dedicated cluster.
- Install the OpenShift (oc) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

Procedure

1. Create a Trigger object as a YAML file that has the `eventing.knative.dev/injection: enabled` annotation:

   ```yaml
   apiVersion: eventing.knative.dev/v1
   kind: Trigger
   metadata:
     annotations:
       eventing.knative.dev/injection: enabled
   name: <trigger_name>
   spec:
     broker: default
     subscriber:
       ref:
         apiVersion: serving.knative.dev/v1
         kind: Service
         name: <service_name>
   ```

   1 Specify details about the event sink, or subscriber, that the trigger sends events to.

2. Apply the Trigger YAML file:

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

Verification

You can verify that the broker has been created successfully by using the oc CLI, or by observing it in the Topology view in the web console.

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

   ```bash
   $ oc -n <namespace> get broker default
   ```

Example output

<table>
<thead>
<tr>
<th>NAME</th>
<th>READY</th>
<th>REASON</th>
<th>URL</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>default</td>
<td>True</td>
<td></td>
<td><a href="http://broker-ingress.knative-eventing.svc.cluster.local/test/default">http://broker-ingress.knative-eventing.svc.cluster.local/test/default</a></td>
<td>3m56s</td>
</tr>
</tbody>
</table>

2. Optional: If you are using the OpenShift Dedicated web console, you can navigate to the Topology view in the Developer perspective, and observe that the broker exists:
5.13.2.3. Creating a broker by labeling a namespace

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

**NOTE**

Brokers created using this method are not removed if you remove the label. You must manually delete them.

**Prerequisites**

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Dedicated cluster.
- Install the OpenShift (`oc`) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have cluster or dedicated administrator permissions.

**Procedure**

- Label a namespace with `eventing.knative.dev/injection=enabled`:

  ```bash
  $ oc label namespace <namespace> eventing.knative.dev/injection=enabled
  
  $ oc -n <namespace> get broker <broker_name>
  
  $ oc -n default get broker default
  ```

**Verification**

You can verify that the broker has been created successfully by using the `oc` CLI, or by observing it in the Topology view in the web console.

1. Use the `oc` command to get the broker:

   ```bash
   $ oc -n <namespace> get broker <broker_name>
   ```

   **Example command**

   ```bash
   $ oc -n default get broker default
   ```
2. Optional: If you are using the OpenShift Dedicated web console, you can navigate to the Topology view in the Developer perspective, and observe that the broker exists:

```
NAME    READY     REASON    URL                                                                 AGE
default True                http://broker-ingress.knative-eventing.svc.cluster.local/test/default
  3m56s
```

5.13.2.4. Deleting a broker that was created by injection

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

**Prerequisites**

- Install the OpenShift (oc) CLI.

**Procedure**

1. Remove the `eventing.knative.dev/injection=enabled` label from the namespace:

   ```
   $ oc label namespace <namespace> eventing.knative.dev/injection=
   
   Removing the annotation prevents Knative from recreating the broker after you delete it.
   
2. Delete the broker from the selected namespace:

   ```
   $ oc -n <namespace> delete broker <broker_name>
   ```

**Verification**

- Use the `oc` command to get the broker:

  ```
  $ oc -n <namespace> get broker <broker_name>
  ```

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

Prerequisites

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

Procedure

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

Verification

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

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

```
$ oc -n default get broker default

Example output

No resources found.
Error from server (NotFound): brokers.eventing.knative.dev "default" not found
```

## 5.13.2.5. Creating a broker by using the web console
5.13.3. Kafka broker

The Knative Kafka broker is an Apache Kafka native implementation of the Knative broker API. It has a better integration with Kafka for the broker and trigger model over other broker types and reduces network hops.

**IMPORTANT**

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

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

If a cluster administrator has configured your OpenShift Serverless deployment to use Kafka as the default broker type, creating a broker by using the default settings creates a Kafka-based Broker object. If your OpenShift Serverless deployment is not configured to use Kafka broker as the default broker type, you can use one of the following procedures to create a Kafka-based broker.

**IMPORTANT**

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

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

5.13.3.1. Creating a Kafka broker by using YAML

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

**Prerequisites**

- The OpenShift Serverless Operator, Knative Eventing, and the `KnativeKafka` custom resource are installed on your OpenShift Dedicated cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have installed the OpenShift (`oc`) CLI.

**Procedure**

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

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

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

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

2. Apply the Kafka-based broker YAML file:

$ oc apply -f <filename>

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

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

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, and the KnativeKafka custom resource are installed on your OpenShift Dedicated cluster.
- You have access to a Kafka instance such as Red Hat AMQ Streams, and have created a Kafka topic.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have installed the OpenShift (oc) CLI.

Procedure

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

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

1. The broker class. If not specified, brokers use the default class as configured by cluster administrators. To use the Kafka broker, this value must be Kafka.
2. The name of the Kafka topic that you want to use.

2. Apply the Kafka-based broker YAML file:

   $ oc apply -f <filename>

5.13.4. Managing brokers

The Knative (kn) CLI provides commands that can be used to list, describe, update, and delete brokers.

5.13.4.1. Listing existing brokers by using the Knative CLI

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

Prerequisites

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

- You have installed the Knative (kn) CLI.

Procedure

- List all existing brokers:

  $ kn broker list

Example output

<table>
<thead>
<tr>
<th>NAME</th>
<th>URL</th>
<th>AGE</th>
<th>CONDITIONS</th>
<th>READY</th>
</tr>
</thead>
<tbody>
<tr>
<td>default</td>
<td><a href="http://broker-ingress.knative-eventing.svc.cluster.local/test/default">http://broker-ingress.knative-eventing.svc.cluster.local/test/default</a></td>
<td>45s</td>
<td>5 OK / 5</td>
<td>True</td>
</tr>
</tbody>
</table>

5.13.4.2. Describing an existing broker by using the Knative CLI

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

Prerequisites

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

- You have installed the Knative (kn) CLI.

Procedure

- Describe an existing broker:
Example command using default broker

$ kn broker describe <broker_name>

Example output

Name:         default
Namespace:    default
Annotations:  eventing.knative.dev/broker.class=MTChannelBasedBroker,
              eventing.knative.dev/create ...
Age:          22s
Address:
URL:    http://broker-ingress.knative-eventing.svc.cluster.local/default/default

Conditions:
OK TYPE                   AGE REASON
++ Ready                  22s
++ Addressable            22s
++ FilterReady            22s
++ IngressReady           22s
++ TriggerChannelReady    22s

5.13.5. Additional resources

- Triggers
- Event sources
- Event delivery
- Kafka broker

5.14. TRIGGERS

Brokers can be used in combination with triggers to deliver events from an event source to an event sink. Events are sent from an event source to a broker as an HTTP `POST` request. After events have entered the broker, they can be filtered by CloudEvent attributes using triggers, and sent as an HTTP `POST` request to an event sink.
5.14.1. Creating a trigger by using the web console

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

Prerequisites

- The OpenShift Serverless Operator, Knative Serving, and Knative Eventing are installed on your OpenShift Dedicated cluster.
- You have logged in to the web console.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have created a broker and a Knative service or other event sink to connect to the trigger.

Procedure

1. In the Developer perspective, navigate to the Topology page.
2. Hover over the broker that you want to create a trigger for, and drag the arrow. The Add Trigger option is displayed.
3. Click Add Trigger.
4. Select your sink in the Subscriber list.
5. Click Add.

Verification

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

Deleting a trigger

1. In the Developer perspective, navigate to the Topology page.
2. Click on the trigger that you want to delete.
3. In the Actions context menu, select Delete Trigger.

5.14.2. Creating a trigger by using the Knative CLI

Using the Knative (kn) CLI to create triggers provides a more streamlined and intuitive user interface over modifying YAML files directly. You can use the kn trigger create command to create a trigger.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Dedicated cluster.
- You have installed the Knative (kn) CLI.
• You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

Procedure

• Create a trigger:

```
$ kn trigger create <trigger_name> --broker <broker_name> --filter <key=value> --sink <sink_name>
```

Alternatively, you can create a trigger and simultaneously create the *default* broker using broker injection:

```
$ kn trigger create <trigger_name> --inject-broker --filter <key=value> --sink <sink_name>
```

By default, triggers forward all events sent to a broker to sinks that are subscribed to that broker. Using the `--filter` attribute for triggers allows you to filter events from a broker, so that subscribers will only receive a subset of events based on your defined criteria.

5.14.3. Listing triggers by using the Knative CLI

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

Prerequisites

• The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Dedicated cluster.

• You have installed the Knative (`kn`) CLI.

Procedure

1. Print a list of available triggers:

```
$ kn trigger list
```

Example output

```
NAME    BROKER    SINK           AGE   CONDITIONS   READY   REASON
email   default   ksvc:edisplay   4s    5 OK / 5     True
ping    default   ksvc:edisplay   32s   5 OK / 5     True
```

2. Optional: Print a list of triggers in JSON format:

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

5.14.4. Describing a trigger by using the Knative CLI

Using the Knative (`kn`) CLI to describe triggers provides a streamlined and intuitive user interface. You can use the `kn trigger describe` command to print information about existing triggers in your cluster by using the Knative CLI.
Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Dedicated cluster.
- You have installed the Knative (kn) CLI.
- You have created a trigger.

Procedure

- Enter the command:

  `$ kn trigger describe <trigger_name>`

Example output

<table>
<thead>
<tr>
<th>Name</th>
<th>ping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Namespace</td>
<td>default</td>
</tr>
<tr>
<td>Labels</td>
<td>eventing.knative.dev/broker=default</td>
</tr>
<tr>
<td>Annotations</td>
<td>eventing.knative.dev/creator=kube:admin, eventing.knative.dev/lastModifier=kube:admin</td>
</tr>
<tr>
<td>Age</td>
<td>2m</td>
</tr>
<tr>
<td>Broker</td>
<td>default</td>
</tr>
<tr>
<td>Filter</td>
<td>type: dev.knative.event</td>
</tr>
<tr>
<td>Sink</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>edisplay</td>
</tr>
<tr>
<td>Namespace</td>
<td>default</td>
</tr>
<tr>
<td>Resource</td>
<td>Service (serving.knative.dev/v1)</td>
</tr>
</tbody>
</table>

Conditions:

<table>
<thead>
<tr>
<th>OK TYPE</th>
<th>AGE</th>
<th>REASON</th>
</tr>
</thead>
<tbody>
<tr>
<td>++ Ready</td>
<td>2m</td>
<td></td>
</tr>
<tr>
<td>++ BrokerReady</td>
<td>2m</td>
<td></td>
</tr>
<tr>
<td>++ DependencyReady</td>
<td>2m</td>
<td></td>
</tr>
<tr>
<td>++ Subscribed</td>
<td>2m</td>
<td></td>
</tr>
<tr>
<td>++ SubscriberResolved</td>
<td>2m</td>
<td></td>
</tr>
</tbody>
</table>

5.14.5. Filtering events with triggers by using the Knative CLI

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

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

```
$ kn trigger create <trigger_name> --broker <broker_name> --filter type=dev.knative.samples.helloworld --sink ksvc:<service_name>
```

You can also filter events by using multiple attributes. The following example shows how to filter events using the type, source, and extension attributes:
5.14.6. Updating a trigger by using the Knative CLI

Using the Knative (kn) CLI to update triggers provides a streamlined and intuitive user interface. You can use the `kn trigger update` command with certain flags to update attributes for a trigger.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Dedicated cluster.
- You have installed the Knative (kn) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

Procedure

- Update a trigger:

  ```
  $ kn trigger update <trigger_name> --filter <key=value> --sink <sink_name> [flags]
  ```

  - You can update a trigger to filter exact event attributes that match incoming events. For example, using the `type` attribute:

    ```
    $ kn trigger update <trigger_name> --filter type=knative.dev.event
    ```

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

    ```
    $ kn trigger update <trigger_name> --filter type=
    ```

  - You can use the `--sink` parameter to change the event sink of a trigger:

    ```
    $ kn trigger update <trigger_name> --sink ksvc:my-event-sink
    ```

5.14.7. Deleting a trigger by using the Knative CLI

Using the Knative (kn) CLI to delete a trigger provides a streamlined and intuitive user interface. You can use the `kn trigger delete` command to delete a trigger.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Dedicated cluster.
- You have installed the Knative (kn) CLI.

```
• You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

Procedure

• Delete a trigger:

  $ kn trigger delete <trigger_name>

Verification

1. List existing triggers:

  $ kn trigger list

2. Verify that the trigger no longer exists:

Example output

No triggers found.

5.15. USING KNATIVE KAFKA

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

Knative Kafka functionality is available in an OpenShift Serverless installation if a cluster administrator has installed the KnativeKafka custom resource.

Knative Kafka provides additional options, such as:

• Kafka source

• Kafka channel

• Kafka broker (Technology Preview)

• Kafka sink (Technology Preview)

5.15.1. Kafka event delivery and retries

Using Kafka components in an event-driven architecture provides "at least once" event delivery. This means that operations are retried until a return code value is received. This makes applications more resilient to lost events; however, it might result in duplicate events being sent.

For the Kafka event source, there is a fixed number of retries for event delivery by default. For Kafka channels, retries are only performed if they are configured in the Kafka channel Delivery spec.

See the Event delivery documentation for more information about delivery guarantees.

5.15.2. Kafka source

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

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

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

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, and the KnativeKafka custom resource are installed on your cluster.
- You have logged in to the web console.
- You have access to a Red Hat AMQ Streams (Kafka) cluster that produces the Kafka messages you want to import.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

Procedure

1. In the Developer perspective, navigate to the +Add page and select Event Source.
2. In the Event Sources page, select Kafka Source in the Type section.
3. Configure the Kafka Source settings:
   a. Add a comma-separated list of Bootstrap Servers.
   b. Add a comma-separated list of Topics.
   c. Add a Consumer Group.
   d. Select the Service Account Name for the service account that you created.
   e. Select the Sink for the event source. A Sink can be either a Resource, such as a channel, broker, or service, or a URI.
   f. Enter a Name for the Kafka event source.
4. Click Create.

Verification

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

1. In the Developer perspective, navigate to Topology.
2. View the Kafka event source and sink.
5.15.2.2. Creating a Kafka event source by using the Knative CLI

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

**Prerequisites**

- The OpenShift Serverless Operator, Knative Eventing, Knative Serving, and the `KnativeKafka` custom resource (CR) are installed on your cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have access to a Red Hat AMQ Streams (Kafka) cluster that produces the Kafka messages you want to import.
- You have installed the Knative (kn) CLI.
- Optional: You have installed the OpenShift (oc) CLI if you want to use the verification steps in this procedure.

**Procedure**

1. To verify that the Kafka event source is working, create a Knative service that dumps incoming events into the service logs:

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

2. Create a `KafkaSource` CR:

   ```bash
   $ kn source kafka create <kafka_source_name> \
   --servers <cluster_kafka_bootstrap>.kafka.svc:9092 \
   --topics <topic_name> --consumergroup my-consumer-group \
   --sink event-display
   ```
NOTE

Replace the placeholder values in this command with values for your source name, bootstrap servers, and topics.

The \texttt{--servers}, \texttt{--topics}, and \texttt{--consumergroup} options specify the connection parameters to the Kafka cluster. The \texttt{--consumergroup} option is optional.

3. Optional: View details about the \texttt{KafkaSource} CR you created:

```bash
$ kn source kafka describe <kafka_source_name>
```

Example output

```
Name:              example-kafka-source
Namespace:         kafka
Age:               1h
BootstrapServers:  example-cluster-kafka-bootstrap.kafka.svc:9092
Topics:            example-topic
ConsumerGroup:     example-consumer-group

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

Conditions:
OK TYPE            AGE REASON
++ Ready            1h
++ Deployed         1h
++ SinkProvided     1h
```

Verification steps

1. Trigger the Kafka instance to send a message to the topic:

```bash
$ oc -n kafka run kafka-producer \
   -ti --image=quay.io/strimzi/kafka:latest-kafka-2.7.0 --rm=true \
   --restart=Never -- bin/kafka-console-producer.sh \ 
   --broker-list <cluster_kafka_bootstrap>:9092 --topic my-topic
```

Enter the message in the prompt. This command assumes that:

- The Kafka cluster is installed in the \texttt{kafka} namespace.
- The \texttt{KafkaSource} object has been configured to use the \texttt{my-topic} topic.

2. Verify that the message arrived by viewing the logs:

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

Example output

```
! cloudevents.Event
```
5.15.2.2.1. Knative CLI sink flag

When you create an event source by using the Knative (kn) CLI, you can specify a sink where events are sent to from that resource by using the `--sink` flag. The sink can be any addressable or callable resource that can receive incoming events from other resources.

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

**Example command using the sink flag**

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

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

5.15.2.3. Creating a Kafka event source by using YAML

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

**Prerequisites**

- The OpenShift Serverless Operator, Knative Eventing, and the `KnativeKafka` custom resource are installed on your cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have access to a Red Hat AMQ Streams (Kafka) cluster that produces the Kafka messages you want to import.
- Install the OpenShift CLI (`oc`).
Procedure

1. Create a **KafkaSource** object as a YAML file:

```yaml
apiVersion: sources.knative.dev/v1beta1
kind: KafkaSource
metadata:
  name: <source_name>
spec:
  consumerGroup: <group_name>  # 1
  bootstrapServers:
    - <list_of_bootstrap_servers>
  topics:
    - <list_of_topics>  # 2
  sink:
    - <list_of_sinks>  # 3
```

1. A consumer group is a group of consumers that use the same group ID, and consume data from a topic.

2. A topic provides a destination for the storage of data. Each topic is split into one or more partitions.

3. A sink specifies where events are sent to from a source.

**IMPORTANT**

Only the **v1beta1** version of the API for **KafkaSource** objects on OpenShift Serverless is supported. Do not use the **v1alpha1** version of this API, as this version is now deprecated.

Example KafkaSource object

```yaml
apiVersion: sources.knative.dev/v1beta1
kind: KafkaSource
metadata:
  name: kafka-source
spec:
  consumerGroup: knative-group
  bootstrapServers:
    - my-cluster-kafka-bootstrap.kafka:9092
  topics:
    - knative-demo-topic
  sink:
    ref:
      apiVersion: serving.knative.dev/v1
      kind: Service
      name: event-display
```

2. Apply the **KafkaSource** YAML file:

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

- Verify that the Kafka event source was created by entering the following command:

  $ oc get pods

 Example output

  NAME                                      READY STATUS    RESTARTS AGE
  kafkasource-kafka-source-5ca0248f-...   1/1   Running   0   13m

 5.15.3. Kafka broker

The Knative Kafka broker is an Apache Kafka native implementation of the Knative broker API. It has a better integration with Kafka for the broker and trigger model over other broker types and reduces network hops.

 IMPORTANT

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

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

If a cluster administrator has configured your OpenShift Serverless deployment to use Kafka as the default broker type, creating a broker by using the default settings creates a Kafka-based Broker object. If your OpenShift Serverless deployment is not configured to use Kafka broker as the default broker type, you can use one of the following procedures to create a Kafka-based broker.

 IMPORTANT

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

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

 5.15.3.1. Creating a Kafka broker by using YAML

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

 Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, and the KnativeKafka custom resource are installed on your OpenShift Dedicated cluster.
You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

You have installed the OpenShift (oc) CLI.

Procedure

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

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

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

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

2. Apply the Kafka-based broker YAML file:

   `$ oc apply -f <filename>`

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

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

Prerequisites

- The OpenShift Serverless Operator, Knative Eventing, and the KnativeKafka custom resource are installed on your OpenShift Dedicated cluster.

- You have access to a Kafka instance such as Red Hat AMQ Streams, and have created a Kafka topic.

- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

- You have installed the OpenShift (oc) CLI.

Procedure

1. Create a Kafka-based broker as a YAML file:
apiVersion: eventing.knative.dev/v1
kind: Broker
metadata:
  annotations:
    eventing.knative.dev/broker.class: Kafka
    kafka.eventing.knative.dev/external.topic: <topic_name>
...

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

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

2. Apply the Kafka-based broker YAML file:

   $ oc apply -f <filename>

5.15.4. Creating a Kafka channel by using YAML

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

**Prerequisites**

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

**Procedure**

1. Create a **KafkaChannel** object as a YAML file:

   ```yaml
   apiVersion: messaging.knative.dev/v1beta1
   kind: KafkaChannel
   metadata:
     name: example-channel
     namespace: default
   spec:
     numPartitions: 3
     replicationFactor: 1
   
   IMPORTANT
   
   Only the v1beta1 version of the API for **KafkaChannel** objects on OpenShift Serverless is supported. Do not use the v1alpha1 version of this API, as this version is now deprecated.
   ```
2. Apply the KafkaChannel YAML file:

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

### 5.15.5. Kafka sink

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

**IMPORTANT**

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

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

#### 5.15.5.1. Using a Kafka sink

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

**Prerequisites**

- The OpenShift Serverless Operator, Knative Eventing, and the KnativeKafka custom resource (CR) are installed on your cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have access to a Red Hat AMQ Streams (Kafka) cluster that produces the Kafka messages you want to import.
- Install the OpenShift (oc) CLI.

**Procedure**

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

```
Kafka sink YAML

apiVersion: eventing.knative.dev/v1alpha1
kind: KafkaSink
metadata:
  name: <sink-name>
namespace: <namespace>
spec:
```
To create the Kafka sink, apply the **KafkaSink** YAML file:

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

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

**Example of a Kafka sink connected to an API server source**

```yaml
apiVersion: sources.knative.dev/v1alpha2
kind: ApiServerSource
metadata:
  name: <source-name>  
  namespace: <namespace>  
spec:
  serviceAccountName: <service-account-name>  
  mode: Resource
  resources:
    - apiVersion: v1
      kind: Event
    sink:
      ref:
        apiVersion: eventing.knative.dev/v1alpha1
        kind: KafkaSink
        name: <sink-name>
```

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

### 5.15.6. Additional resources

- Red Hat AMQ Streams documentation
- Red Hat AMQ Streams TLS and SASL on Kafka documentation
- Event delivery
- Knative Kafka cluster administrator documentation
6.1. GLOBAL CONFIGURATION

The OpenShift Serverless Operator manages the global configuration of a Knative installation, including propagating values from the KnativeServing and KnativeEventing custom resources to system config maps. Any updates to config maps which are applied manually are overwritten by the Operator. However, modifying the Knative custom resources allows you to set values for these config maps.

Knative has multiple config maps that are named with the prefix config-. All Knative config maps are created in the same namespace as the custom resource that they apply to. For example, if the KnativeServing custom resource is created in the knative-serving namespace, all Knative Serving config maps are also created in this namespace.

The spec.config in the Knative custom resources have one <name> entry for each config map, named config-<name>, with a value which is be used for the config map data.

6.1.1. Configuring the default channel implementation

The default-ch-webhook config map can be used to specify the default channel implementation of Knative Eventing. The default channel implementation can be specified for the entire cluster, as well as for one or more namespaces. Currently the InMemoryChannel and KafkaChannel channel types are supported.

Prerequisites

- You have cluster or dedicated administrator permissions on OpenShift Dedicated.
- You have installed the OpenShift Serverless Operator and Knative Eventing on your cluster.
- If you want to use Kafka channels as the default channel implementation, you must also install the KnativeKafka CR on your cluster.

Procedure

- Modify the KnativeEventing custom resource to add configuration details for the default-ch-webhook config map:

```yaml
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeEventing
metadata:
  name: knative-eventing
  namespace: knative-serving
spec:
  config:
  default-ch-webhook:
  default-ch-config:
    clusterDefault:
      apiVersion: messaging.knative.dev/v1
      kind: InMemoryChannel
      spec:
        delivery:
          backoffDelay: PT0.5S
          backoffPolicy: exponential
```
In `spec.config`, you can specify the config maps that you want to add modified configurations for.

The `default-ch-webhook` config map can be used to specify the default channel implementation for the cluster or for one or more namespaces.

The cluster-wide default channel type configuration. In this example, the default channel implementation for the cluster is `InMemoryChannel`.

The namespace-scoped default channel type configuration. In this example, the default channel implementation for the `my-namespace` namespace is `KafkaChannel`.

**IMPORTANT**

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

### 6.1.2. Enabling scale-to-zero

Knative Serving provides automatic scaling, or autoscaling, for applications to match incoming demand. You can use the `enable-scale-to-zero` spec to enable or disable scale-to-zero globally for applications on the cluster.

**Prerequisites**

- You have installed OpenShift Serverless Operator and Knative Serving on your cluster.
- You have cluster or dedicated administrator permissions.
- You are using the default Knative Pod Autoscaler. The scale to zero feature is not available if you are using the Kubernetes Horizontal Pod Autoscaler.

**Procedure**

- Modify the `enable-scale-to-zero` spec in the `KnativeServing` custom resource (CR):

**Example KnativeServing CR**

```yaml
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
spec:
  config:
    autoscaler:
      enable-scale-to-zero: "false"
```

```bash
retry: 5
namespaceDefaults:
  my-namespace:
    apiVersion: messaging.knative.dev/v1beta1
    kind: KafkaChannel
    spec:
      numPartitions: 1
      replicationFactor: 1
```
The enable-scale-to-zero spec can be either "true" or "false". If set to true, scale-to-zero is enabled. If set to false, applications are scaled down to the configured minimum scale bound. The default value is "true".

6.1.3. Configuring the scale-to-zero grace period

Knative Serving provides automatic scaling down to zero pods for applications. You can use the scale-to-zero-grace-period spec to define an upper bound time limit that Knative waits for scale-to-zero machinery to be in place before the last replica of an application is removed.

Prerequisites

- You have installed OpenShift Serverless Operator and Knative Serving on your cluster.
- You have cluster or dedicated administrator permissions.
- You are using the default Knative Pod Autoscaler. The scale-to-zero feature is not available if you are using the Kubernetes Horizontal Pod Autoscaler.

Procedure

- Modify the scale-to-zero-grace-period spec in the KnativeServing custom resource (CR):

Example KnativeServing CR

```yaml
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
spec:
  config:
    autoscaler:
      scale-to-zero-grace-period: "30s"
```

The grace period time in seconds. The default value is 30 seconds.

6.1.4. Overriding system deployment configurations

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

6.1.4.1. Overriding Knative Serving system deployment configurations

You can override the default configurations for some specific deployments by modifying the deployments spec in the KnativeServing custom resource (CR). Currently, overriding default configuration settings is supported for the resources, replicas, labels, annotations, and nodeSelector fields.

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

- The deployment has specified CPU and memory resource limits.
The deployment has 3 replicas.

- The **example-label**: label label is added.

- The **example-annotation**: annotation annotation is added.

- The **nodeSelector** field is set to select nodes with the **disktype**: hdd label.

**NOTE**

The KnativeServing CR label and annotation settings override the deployment’s labels and annotations for both the deployment itself and the resulting pods.

**KnativeServing CR example**

```yaml
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: ks
  namespace: knative-serving
spec:
  high-availability:
    replicas: 2
  deployments:
    - name: webhook
      resources:
        - container: webhook
          requests:
            cpu: 300m
            memory: 60Mi
          limits:
            cpu: 1000m
            memory: 1000Mi
      replicas: 3
      labels:
        example-label: label
      annotations:
        example-annotation: annotation
      nodeSelector:
        disktype: hdd
```

### 6.1.4.2. Overriding Knative Eventing system deployment configurations

You can override the default configurations for some specific deployments by modifying the **deployments** spec in the KnativeEventing custom resource (CR). Currently, overriding default configuration settings is supported for the **eventing-controller**, **eventing-webhook**, and **imc-controller** fields.

**IMPORTANT**

The **replicas** spec cannot override the number of replicas for deployments that use the Horizontal Pod Autoscaler (HPA), and does not work for the **eventing-webhook** deployment.
In the following example, a KnativeEventing CR overrides the eventing-controller deployment so that:

- The deployment has specified CPU and memory resource limits.
- The deployment has 3 replicas.
- The example-label: label label is added.
- The example-annotation: annotation annotation is added.
- The nodeSelector field is set to select nodes with the disktype: hdd label.

KnativeEventing CR example

```yaml
apiVersion: operator.knative.dev/v1beta1
kind: KnativeEventing
metadata:
  name: knative-eventing
  namespace: knative-eventing
spec:
deployments:
- name: eventing-controller
  resources:
    container: eventing-controller
    requests:
      cpu: 300m
      memory: 100Mi
    limits:
      cpu: 1000m
      memory: 250Mi
  replicas: 3
  labels:
    example-label: label
  annotations:
    example-annotation: annotation
  nodeSelector:
    disktype: hdd
```

NOTE

The KnativeEventing CR label and annotation settings override the deployment’s labels and annotations for both the deployment itself and the resulting pods.

6.1.5. Configuring the EmptyDir extension

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

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

Example KnativeServing CR
6.1.6. HTTPS redirection global settings

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

Example KnativeServing CR that enables HTTPS redirection

```yaml
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
spec:
  config:
    network:
      httpProtocol: "redirected"
```

6.1.7. Setting the URL scheme for external routes

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

Default spec

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

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

HTTP override spec

```yaml
... spec:
  config:
    network:
      default-external-scheme: "http"
...```
6.1.8. Setting the Kourier Gateway service type

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

Default spec

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

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

LoadBalancer override spec

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

6.1.9. Enabling PVC support

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

**IMPORTANT**

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

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

Procedure

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

   **Enabling PVCs with write access**

   ```yaml
   ... 
   spec: 
     config: 
       features: 
   ```
The `kubernetes.podspec-persistent-volume-claim` extension controls whether persistent volumes (PVs) can be used with Knative Serving.

- The `kubernetes.podspec-persistent-volume-write` extension controls whether PVs are available to Knative Serving with the write access.

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

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

**PersistentVolumeClaim configuration**

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

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

**Knative service PVC configuration**

```yaml
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  namespace: my-ns
...
spec:
template:
  spec:
    containers:
      ...
      volumeMounts: 1
        - mountPath: /data
          name: mydata
          readOnly: false
          volumes:
            - name: mydata
```

...
Volume mount specification.
Persistent volume claim specification.
Flag that enables read-only access.

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

6.1.10. Enabling init containers

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

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

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

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

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

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

Example KnativeServing CR

```yaml
apiVersion: operator.knative.dev/v1alpha1
```
6.1.11. Tag-to-digest resolution

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

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

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

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

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

Prerequisites

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

Procedure

1. Create a secret:

   Example command

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

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

   Example KnativeServing CR

   ```
   apiVersion: operator.knative.dev/v1alpha1
   kind: KnativeServing
   metadata:
   ```
6.2. CONFIGURING KNATIVE KAFKA

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

In addition to the Knative Eventing components that are provided as part of a core OpenShift Serverless installation, cluster or dedicated administrators can install the KnativeKafka custom resource (CR).

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

- Kafka source
- Kafka channel
- Kafka broker (Technology Preview)
- Kafka sink (Technology Preview)

6.2.1. Installing Knative Kafka

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

Prerequisites

- You have installed the OpenShift Serverless Operator and Knative Eventing on your cluster.
- You have access to a Red Hat AMQ Streams cluster.
- Install the OpenShift CLI (oc) if you want to use the verification steps.
- You have cluster or dedicated administrator permissions on OpenShift Dedicated.
- You are logged in to the OpenShift Dedicated web console.

Procedure

1. In the Administrator perspective, navigate to Operators → Installed Operators.
2. Check that the Project dropdown at the top of the page is set to Project: knative-eventing.
3. In the list of Provided APIs for the OpenShift Serverless Operator, find the Knative Kafka box and click Create Instance.
4. Configure the KnativeKafka object in the Create Knative Kafka page.
IMPORTANT

To use the Kafka channel, source, broker, or sink on your cluster, you must toggle the enabled switch for the options you want to use to true. These switches are set to false by default. Additionally, to use the Kafka channel, broker, or sink you must specify the bootstrap servers.

Example KnativeKafka custom resource

```yaml
apiVersion: operator.serverless.openshift.io/v1alpha1
kind: KnativeKafka
metadata:
  name: knative-kafka
  namespace: knative-eventing
spec:
  channel:
    enabled: true
    bootstrapServers: <bootstrap_servers>
  source:
    enabled: true
  broker:
    enabled: true
    defaultConfig:
      bootstrapServers: <bootstrap_servers>
      numPartitions: <num_partitions>
      replicationFactor: <replication_factor>
  sink:
    enabled: true
```

1. Enables developers to use the KafkaChannel channel type in the cluster.
2. A comma-separated list of bootstrap servers from your AMQ Streams cluster.
3. Enables developers to use the KafkaSource event source type in the cluster.
4. Enables developers to use the Knative Kafka broker implementation in the cluster.
5. A comma-separated list of bootstrap servers from your Red Hat AMQ Streams cluster.
6. Defines the number of partitions of the Kafka topics, backed by the Broker objects. The default is 10.
7. Defines the replication factor of the Kafka topics, backed by the Broker objects. The default is 3.
8. Enables developers to use a Kafka sink in the cluster.

NOTE

The replicationFactor value must be less than or equal to the number of nodes of your Red Hat AMQ Streams cluster.
Using the form is recommended for simpler configurations that do not require full control of KnativeKafka object creation.

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

5. Click Create after you have completed any of the optional configurations for Kafka. You are automatically directed to the Knative Kafka tab where knative-kafka is in the list of resources.

Verification

1. Click on the knative-kafka resource in the Knative Kafka tab. You are automatically directed to the Knative Kafka Overview page.

2. View the list of Conditions for the resource and confirm that they have a status of True.

<table>
<thead>
<tr>
<th>Name</th>
<th>Status</th>
<th>Updated</th>
</tr>
</thead>
<tbody>
<tr>
<td>DeploymentsAvailable</td>
<td>True</td>
<td>Oct 6, 11:29 am</td>
</tr>
<tr>
<td>InstallSucceeded</td>
<td>True</td>
<td>Oct 6, 11:29 am</td>
</tr>
<tr>
<td>Ready</td>
<td>True</td>
<td>Oct 6, 11:29 am</td>
</tr>
</tbody>
</table>

   If the conditions have a status of Unknown or False, wait a few moments to refresh the page.

3. Check that the Knative Kafka resources have been created:

   $ oc get pods -n knative-eventing

   Example output

<table>
<thead>
<tr>
<th>NAME</th>
<th>READY</th>
<th>STATUS</th>
<th>RESTARTS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>kafka-broker-dispatcher-7769fbbcbbxgffn</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>44s</td>
</tr>
<tr>
<td>kafka-broker-receiver-5fb56f7656-fhq8d</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>44s</td>
</tr>
</tbody>
</table>
6.2.2. Security configuration for Knative Kafka

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

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

6.2.2.1. Configuring TLS authentication for Kafka brokers

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

Prerequisites

- You have cluster or dedicated administrator permissions on OpenShift Dedicated.
- The OpenShift Serverless Operator, Knative Eventing, and the KnativeKafka CR are installed on your OpenShift Dedicated cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have a Kafka cluster CA certificate stored as a .pem file.
- You have a Kafka cluster client certificate and a key stored as .pem files.
- Install the OpenShift (oc) CLI.

Procedure

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

   ```
   $ oc create secret -n knative-eventing generic <secret_name> \
   --from-literal=protocol=SSL \
   --from-file=ca.crt=caroot.pem \
   --from-file=user.crt=certificate.pem \
   --from-file=user.key=key.pem
   ```

   IMPORTANT

   Use the key names ca.crt, user.crt, and user.key. Do not change them.

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

   ```
6.2.2.2. Configuring SASL authentication for Kafka brokers

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

Prerequisites

- You have cluster or dedicated administrator permissions on OpenShift Dedicated.
- The OpenShift Serverless Operator, Knative Eventing, and the KnativeKafka CR are installed on your OpenShift Dedicated cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have a username and password for a Kafka cluster.
- You have chosen the SASL mechanism to use, for example PLAIN, SCRAM-SHA-256, or SCRAM-SHA-512.
- If TLS is enabled, you also need the ca.crt certificate file for the Kafka cluster.
- Install the OpenShift CLI (oc).

Procedure

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

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

- Use the key names ca.crt, password, and sasl.mechanism. Do not change them.
- If you want to use SASL with public CA certificates, you must use the tls.enabled=true flag, rather than the ca.crt argument, when creating the secret. For example:

  ```bash
  $ oc create secret -n <namespace> generic <kafka_auth_secret> \
  --from-literal=tls.enabled=true
  ```
---from-literal=password="SecretPassword" \
--from-literal=saslType="SCRAM-SHA-512" \
--from-literal=user="my-sasl-user"

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

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

### 6.2.2.3. Configuring TLS authentication for Kafka channels

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

**Prerequisites**

- You have cluster or dedicated administrator permissions on OpenShift Dedicated.
- The OpenShift Serverless Operator, Knative Eventing, and the KnativeKafka CR are installed on your OpenShift Dedicated cluster.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have a Kafka cluster CA certificate stored as a .pem file.
- You have a Kafka cluster client certificate and a key stored as .pem files.
- Install the OpenShift (oc) CLI.

**Procedure**

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

   ```
   $ oc create secret -n <namespace> generic <kafka_auth_secret> \
       --from-file=ca.crt=caroot.pem \
       --from-file=user.crt=certificate.pem \
       --from-file=user.key=key.pem
   ```

   **IMPORTANT**

   Use the key names ca.crt, user.crt, and user.key. Do not change them.

2. Start editing the KnativeKafka custom resource:
3. Reference your secret and the namespace of the secret:

```yaml
apiVersion: operator.serverless.openshift.io/v1alpha1
kind: KnativeKafka
metadata:
  namespace: knative-eventing
  name: knative-kafka
spec:
  channel:
    authSecretName: <kafka_auth_secret>
    authSecretNamespace: <kafka_auth_secret_namespace>
    bootstrapServers: <bootstrap_servers>
    enabled: true
  source:
    enabled: true
```

**NOTE**

Make sure to specify the matching port in the bootstrap server.

For example:

```yaml
apiVersion: operator.serverless.openshift.io/v1alpha1
kind: KnativeKafka
metadata:
  namespace: knative-eventing
  name: knative-kafka
spec:
  channel:
    authSecretName: tls-user
    authSecretNamespace: kafka
    bootstrapServers: eventing-kafka-bootstrap.kafka.svc:9094
    enabled: true
  source:
    enabled: true
```

### 6.2.2.4. Configuring SASL authentication for Kafka channels

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

**Prerequisites**

- You have cluster or dedicated administrator permissions on OpenShift Dedicated.

- The OpenShift Serverless Operator, Knative Eventing, and the `KnativeKafka` CR are installed on your OpenShift Dedicated cluster.

- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
You have a username and password for a Kafka cluster.

You have chosen the SASL mechanism to use, for example **PLAIN**, **SCRAM-SHA-256**, or **SCRAM-SHA-512**.

If TLS is enabled, you also need the `ca.crt` certificate file for the Kafka cluster.

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

**Procedure**

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

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

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

   * If you want to use SASL with public CA certificates, you must use the `tls.enabled=true` flag, rather than the `ca.crt` argument, when creating the secret. For example:

   ```bash
   $ oc create secret -n <namespace> generic <kafka_auth_secret> \
   --from-literal=tls.enabled=true \
   --from-literal=password="SecretPassword" \
   --from-literal=saslType="SCRAM-SHA-512" \
   --from-literal=user="my-sasl-user"
   ```

2. Start editing the **KnativeKafka** custom resource:

   ```bash
   $ oc edit knativekafka
   ```

3. Reference your secret and the namespace of the secret:

   ```yaml
   apiVersion: operator.serverless.openshift.io/v1alpha1
   kind: KnativeKafka
   metadata:
     namespace: knative-eventing
     name: knative-kafka
   spec:
     channel:
       authSecretName: <kafka_auth_secret>
       authSecretNamespace: <kafka_auth_secret_namespace>
       bootstrapServers: <bootstrap_servers>
       enabled: true
       source:
       enabled: true
   ```

**NOTE**

Make sure to specify the matching port in the bootstrap server.
6.2.3. Additional resources

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

6.3. SERVERLESS COMPONENTS IN THE ADMINISTRATOR PERSPECTIVE

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

6.3.1. Creating serverless applications using the Administrator perspective

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

Example Knative Service object YAML file

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

1 The name of the application.
The namespace the application uses.

The image of the application.

The environment variable printed out by the sample application.

After the service is created and the application is deployed, Knative creates an immutable revision for this version of the application. Knative also performs network programming to create a route, ingress, service, and load balancer for your application and automatically scales your pods up and down based on traffic.

Prerequisites

To create serverless applications using the Administrator perspective, ensure that you have completed the following steps.

- The OpenShift Serverless Operator and Knative Serving are installed.
- You have logged in to the web console and are in the Administrator perspective.

Procedure

1. Navigate to the Serverless → Serving page.
2. In the Create list, select Service.
3. Manually enter YAML or JSON definitions, or by dragging and dropping a file into the editor.
4. Click Create.

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

Knative services are automatically assigned a default domain name based on your cluster configuration. For example, `<service_name>-<namespace>.example.com`. You can customize the domain for your Knative service by mapping a custom domain name that you own to a Knative service.

You can do this by creating a DomainMapping resource for the service. You can also create multiple DomainMapping resources to map multiple domains and subdomains to a single service.

If you have cluster or dedicated administrator permissions, you can create a DomainMapping custom resource (CR) by using the Administrator perspective in the OpenShift Dedicated web console.

Prerequisites

- You have logged in to the web console.
- You are in the Administrator perspective.
- You have installed the OpenShift Serverless Operator.
- You have installed Knative Serving.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
You have created a Knative service and control a custom domain that you want to map to that service.

**NOTE**

Your custom domain must point to the IP address of the OpenShift Dedicated cluster.

**Procedure**

1. Navigate to `CustomResourceDefinitions` and use the search box to find the `DomainMapping` custom resource definition (CRD).

2. Click the `DomainMapping` CRD, then navigate to the `Instances` tab.

3. Click `Create DomainMapping`.

4. Modify the YAML for the `DomainMapping` CR so that it includes the following information for your instance:

   ```yaml
   apiVersion: serving.knative.dev/v1alpha1
   kind: DomainMapping
   metadata:
     name: <domain_name>  
     namespace: <namespace>  
   spec:
     ref:
       name: <target_name>  
       kind: <target_type>  
   apiVersion: serving.knative.dev/v1
   ```

   1. The custom domain name that you want to map to the target CR.
   2. The namespace of both the `DomainMapping` CR and the target CR.
   3. The name of the target CR to map to the custom domain.
   4. The type of CR being mapped to the custom domain.

**Example domain mapping to a Knative service**

```yaml
apiVersion: serving.knative.dev/v1alpha1
kind: DomainMapping
metadata:
  name: custom-ksvc-domain.example.com
  namespace: default
spec:
  ref:
    name: example-service  
    kind: Service  
apiVersion: serving.knative.dev/v1
```
6.3.3. Creating an event source by using the Administrator perspective

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

**Prerequisites**

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Dedicated cluster.
- You have logged in to the web console and are in the Administrator perspective.
- You have cluster or dedicated administrator permissions for OpenShift Dedicated.

**Procedure**

1. In the Administrator perspective of the OpenShift Dedicated web console, navigate to Serverless → Eventing.

2. In the Create list, select Event Source. You will be directed to the Event Sources page.

3. Select the event source type that you want to create.

6.3.4. Creating a broker by using the Administrator perspective

Brokers can be used in combination with triggers to deliver events from an event source to an event sink. Events are sent from an event source to a broker as an HTTP POST request. After events have entered the broker, they can be filtered by CloudEvent attributes using triggers, and sent as an HTTP POST request to an event sink.

![Diagram of events](image)
Prerequisites

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

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

- You have cluster or dedicated administrator permissions for OpenShift Dedicated.

Procedure

1. In the **Administrator** perspective of the OpenShift Dedicated web console, navigate to Serverless → Eventing.

2. In the Create list, select **Broker**. You will be directed to the **Create Broker** page.

3. Optional: Modify the YAML configuration for the broker.

4. Click **Create**.

### 6.3.5. Creating a trigger by using the Administrator perspective

Brokers can be used in combination with triggers to deliver events from an event source to an event sink. Events are sent from an event source to a broker as an HTTP **POST** request. After events have entered the broker, they can be filtered by CloudEvent attributes using triggers, and sent as an HTTP **POST** request to an event sink.

Prerequisites

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

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

- You have cluster or dedicated administrator permissions for OpenShift Dedicated.

- You have created a Knative broker.

- You have created a Knative service to use as a subscriber.

Procedure
1. In the **Administrator** perspective of the OpenShift Dedicated web console, navigate to **Serverless → Eventing**.

2. In the **Broker** tab, select the Options menu for the broker that you want to add a trigger to.

3. Click **Add Trigger** in the list.

4. In the **Add Trigger** dialogue box, select a **Subscriber** for the trigger. The subscriber is the Knative service that will receive events from the broker.

5. Click **Add**.

### 6.3.6. Creating a channel by using the Administrator perspective

Channels are custom resources that define a single event-forwarding and persistence layer. After events have been sent to a channel from an event source or producer, these events can be sent to multiple Knative services or other sinks by using a subscription.

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

**Prerequisites**

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

**Procedure**

1. In the **Administrator** perspective of the OpenShift Dedicated web console, navigate to **Serverless → Eventing**.

2. In the **Create** list, select **Channel**. You will be directed to the **Channel** page.

3. Select the type of **Channel** object that you want to create in the **Type** list.
4. Click Create.

6.3.7. Creating a subscription by using the Administrator perspective

After you have created a channel and an event sink, also known as a subscriber, you can create a subscription to enable event delivery. Subscriptions are created by configuring a Subscription object, which specifies the channel and the subscriber to deliver events to. You can also specify some subscriber-specific options, such as how to handle failures.

Prerequisites

- The OpenShift Serverless Operator and Knative Eventing are installed on your OpenShift Dedicated cluster.
- You have logged in to the web console and are in the Administrator perspective.
- You have cluster or dedicated administrator permissions for OpenShift Dedicated.
- You have created a Knative channel.
- You have created a Knative service to use as a subscriber.

Procedure

1. In the Administrator perspective of the OpenShift Dedicated web console, navigate to Serverless → Eventing.

2. In the Channel tab, select the Options menu for the channel that you want to add a subscription to.

3. Click Add Subscription in the list.

4. In the Add Subscription dialogue box, select a Subscriber for the subscription. The subscriber is the Knative service that receives events from the channel.

5. Click Add.

6.3.8. Additional resources

- Serverless applications
- Event sources
- Brokers
- Triggers
- Channels and subscriptions
6.4. INTEGRATING SERVICE MESH WITH OPENSShift SERVERLESS

The OpenShift Serverless Operator provides Kourier as the default ingress for Knative. However, you can use Service Mesh with OpenShift Serverless whether Kourier is enabled or not. Integrating with Kourier disabled allows you to configure additional networking and routing options that the Kourier ingress does not support, such as mTLS functionality.

IMPORTANT

OpenShift Serverless only supports the use of Red Hat OpenShift Service Mesh functionality that is explicitly documented in this guide, and does not support other undocumented features.

6.4.1. Prerequisites

- The examples in the following procedures use the domain example.com. The example certificate for this domain is used as a certificate authority (CA) that signs the subdomain certificate. To complete and verify these procedures in your deployment, you need either a certificate signed by a widely trusted public CA or a CA provided by your organization. Example commands must be adjusted according to your domain, subdomain, and CA.

- You must configure the wildcard certificate to match the domain of your OpenShift Dedicated cluster. For example, if your OpenShift Dedicated console address is https://console-openshift-console.apps.openshift.example.com, you must configure the wildcard certificate so that the domain is *.apps.openshift.example.com. For more information about configuring wildcard certificates, see the following topic about Creating a certificate to encrypt incoming external traffic.

- If you want to use any domain name, including those which are not subdomains of the default OpenShift Dedicated cluster domain, you must set up domain mapping for those domains. For more information, see the OpenShift Serverless documentation about Creating a custom domain mapping.

6.4.2. Creating a certificate to encrypt incoming external traffic

By default, the Service Mesh mTLS feature only secures traffic inside of the Service Mesh itself, between the ingress gateway and individual pods that have sidecars. To encrypt traffic as it flows into the OpenShift Dedicated cluster, you must generate a certificate before you enable the OpenShift Serverless and Service Mesh integration.

Prerequisites

- You have access to an OpenShift Dedicated account with cluster or dedicated administrator access.

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

- Install the OpenShift CLI (oc).

- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

Procedure
Create a root certificate and private key that signs the certificates for your Knative services:

```bash
$ openssl req -x509 -sha256 -nodes -days 365 -newkey rsa:2048
   -subj '/O=Example Inc./CN=example.com'
   -keyout root.key
   -out root.crt
```

Create a wildcard certificate:

```bash
$ openssl req -nodes -newkey rsa:2048
   -subj "/CN=*.apps.openshift.example.com/O=Example Inc."
   -keyout wildcard.key
   -out wildcard.csr
```

Sign the wildcard certificate:

```bash
$ openssl x509 -req -days 365 -set_serial 0
   -CA root.crt
   -CAkey root.key
   -in wildcard.csr
   -out wildcard.crt
```

Create a secret by using the wildcard certificate:

```bash
$ oc create -n istio-system secret tls wildcard-certs
   --key=wildcard.key
   --cert=wildcard.crt
```

This certificate is picked up by the gateways created when you integrate OpenShift Serverless with Service Mesh, so that the ingress gateway serves traffic with this certificate.

### 6.4.3. Integrating Service Mesh with OpenShift Serverless

You can integrate Service Mesh with OpenShift Serverless without using Kourier as the default ingress. To do this, do not install the Knative Serving component before completing the following procedure. There are additional steps required when creating the `KnativeServing` custom resource definition (CRD) to integrate Knative Serving with Service Mesh, which are not covered in the general Knative Serving installation procedure. This procedure might be useful if you want to integrate Service Mesh as the default and only ingress for your OpenShift Serverless installation.

**Prerequisites**

- You have access to an OpenShift Dedicated account with cluster or dedicated administrator access.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- Install the Red Hat OpenShift Service Mesh Operator and create a `ServiceMeshControlPlane` resource in the `istio-system` namespace. If you want to use mTLS functionality, you must also set the `spec.security.dataPlane.mtls` field for the `ServiceMeshControlPlane` resource to true.
IMPORTANT

Using OpenShift Serverless with Service Mesh is only supported with Red Hat OpenShift Service Mesh version 2.0.5 or later.

- Install the OpenShift Serverless Operator.
- Install the OpenShift CLI (oc).

Procedure

1. Add the namespaces that you would like to integrate with Service Mesh to the ServiceMeshMemberRoll object as members:

```yaml
apiVersion: maistra.io/v1
kind: ServiceMeshMemberRoll
metadata:
  name: default
  namespace: istio-system
spec:
  members:
  - knative-serving
  - <namespace>
```

A list of namespaces to be integrated with Service Mesh.

IMPORTANT

This list of namespaces must include the knative-serving namespace.

2. Apply the ServiceMeshMemberRoll resource:

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

3. Create the necessary gateways so that Service Mesh can accept traffic:

Example knative-local-gateway object using HTTP

```yaml
apiVersion: networking.istio.io/v1alpha3
kind: Gateway
metadata:
  name: knative-ingress-gateway
  namespace: knative-serving
spec:
  selector:
    istio: ingressgateway
  servers:
  - port:
      number: 443
      name: https
      protocol: HTTPS
    hosts:
      - *.*
Add the name of the secret that contains the wildcard certificate.

The knative-local-gateway serves HTTP traffic. Using HTTP means that traffic coming from outside of Service Mesh, but using an internal hostname, such as example.default.svc.cluster.local, is not encrypted. You can set up encryption for this path by creating another wildcard certificate and an additional gateway that uses a different protocol spec.

Example knative-local-gateway object using HTTPS

```yaml
---
apiVersion: networking.istio.io/v1alpha3
kind: Gateway
metadata:
  name: knative-local-gateway
  namespace: knative-serving
spec:
  selector:
    istio: ingressgateway
  servers:
    - port:
        number: 8081
        name: http
        protocol: HTTP
        hosts:
          - "*"
---
apiVersion: v1
kind: Service
metadata:
  name: knative-local-gateway
  namespace: istio-system
labels:
  experimental.istio.io/disable-gateway-port-translation: "true"
spec:
  type: ClusterIP
  selector:
    istio: ingressgateway
  ports:
    - name: http2
      port: 80
      targetPort: 8081
---
```
4. Apply the **Gateway** resources:

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

5. Install Knative Serving by creating the following **KnativeServing** custom resource definition (CRD), which also enables the Istio integration:

```yaml
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
spec:
  ingress:
    istio:
      enabled: true
  deployments:
  - name: activator
    annotations:
      "sidecar.istio.io/inject": "true"
      "sidecar.istio.io/rewriteAppHTTPProbers": "true"
  - name: autoscaler
    annotations:
      "sidecar.istio.io/inject": "true"
      "sidecar.istio.io/rewriteAppHTTPProbers": "true"
```

1. Enables Istio integration.
2. Enables sidecar injection for Knative Serving data plane pods.

6. Apply the **KnativeServing** resource:

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

7. Create a Knative Service that has sidecar injection enabled and uses a pass-through route:

```yaml
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: <service_name>
  namespace: <namespace>  
annotations:
```

1. Enables sidecar injection for Knative Serving data plane pods.
1. A namespace that is part of the Service Mesh member roll.

2. Instructs Knative Serving to generate an OpenShift Dedicated pass-through enabled route, so that the certificates you have generated are served through the ingress gateway directly.

3. Injects Service Mesh sidecars into the Knative service pods.

8. Apply the **Service** resource:

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

**Verification**

- Access your serverless application by using a secure connection that is now trusted by the CA:

  ```
  $ curl --cacert root.crt <service_url>
  ```

**Example command**

  ```
  $ curl --cacert root.crt https://hello-default.apps.openshift.example.com
  ```

**Example output**

  ```
  Hello Openshift!
  ```

### 6.4.4. Enabling Knative Serving metrics when using Service Mesh with mTLS

If Service Mesh is enabled with mTLS, metrics for Knative Serving are disabled by default, because Service Mesh prevents Prometheus from scraping metrics. This section shows how to enable Knative Serving metrics when using Service Mesh and mTLS.

**Prerequisites**

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

- You have installed Red Hat OpenShift Service Mesh with the mTLS functionality enabled.

- You have access to an OpenShift Dedicated account with cluster or dedicated administrator access.
- Install the OpenShift CLI (**oc**).
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

**Procedure**

1. Specify **prometheus** as the `metrics.backend-destination` in the `observability` spec of the Knative Serving custom resource (CR):

   ```yaml
   apiVersion: operator.knative.dev/v1beta1
   kind: KnativeServing
   metadata:  
     name: knative-serving
   spec:  
     config:  
       observability:  
         metrics.backend-destination: "prometheus"
   ...
   ```

   This step prevents metrics from being disabled by default.

2. Apply the following network policy to allow traffic from the Prometheus namespace:

   ```yaml
   apiVersion: networking.k8s.io/v1
   kind: NetworkPolicy
   metadata:
     name: allow-from-openshift-monitoring-ns
   namespace: knative-serving
   spec:
     ingress:
     - from:
       - namespaceSelector:  
         matchLabels:
           name: "openshift-monitoring"
       podSelector: {}
   ...
   ```

3. Modify and reapply the default Service Mesh control plane in the **istio-system** namespace, so that it includes the following spec:

   ```yaml
   ...  
   spec:  
     proxy:  
       networking:  
         trafficControl:  
           inbound:  
             excludedPorts:  
             - 8444
   ...
   ```

---

6.4.5. Integrating Service Mesh with OpenShift Serverless when Kourier is enabled
You can use Service Mesh with OpenShift Serverless even if Kourier is already enabled. This procedure might be useful if you have already installed Knative Serving with Kourier enabled, but decide to add a Service Mesh integration later.

**Prerequisites**

- You have access to an OpenShift Dedicated account with cluster or dedicated administrator access.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- Install the OpenShift CLI (`oc`).
- Install the OpenShift Serverless Operator and Knative Serving on your cluster.
- Install Red Hat OpenShift Service Mesh. OpenShift Serverless with Service Mesh and Kourier is supported for use with both Red Hat OpenShift Service Mesh versions 1.x and 2.x.

**Procedure**

1. Add the namespaces that you would like to integrate with Service Mesh to the `ServiceMeshMemberRoll` object as members:

   ```yaml
   apiVersion: maistra.io/v1
   kind: ServiceMeshMemberRoll
   metadata:
     name: default
   namespace: istio-system
   spec:
     members:
     - <namespace>  
     ...
   ```

   1 A list of namespaces to be integrated with Service Mesh.

2. Apply the `ServiceMeshMemberRoll` resource:

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

3. Create a network policy that permits traffic flow from Knative system pods to Knative services:

   a. For each namespace that you want to integrate with Service Mesh, create a `NetworkPolicy` resource:

   ```yaml
   apiVersion: networking.k8s.io/v1
   kind: NetworkPolicy
   metadata:
     name: allow-from-serving-system-namespace
   namespace: <namespace>  
   spec:
     ingress:
     - from:
       - namespaceSelector:
   ```

   1 A list of namespaces to be integrated with Service Mesh.
Add the namespace that you want to integrate with Service Mesh.

### NOTE

The `knative.openshift.io/part-of: "openshift-serverless"` label was added in OpenShift Serverless 1.22.0. If you are using OpenShift Serverless 1.21.1 or earlier, add the `knative.openshift.io/part-of` label to the `knative-serving` and `knative-serving-ingress` namespaces.

Add the label to the `knative-serving` namespace:

```
$ oc label namespace knative-serving knative.openshift.io/part-of=openshift-serverless
```

Add the label to the `knative-serving-ingress` namespace:

```
$ oc label namespace knative-serving-ingress knative.openshift.io/part-of=openshift-serverless
```

b. Apply the NetworkPolicy resource:

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

#### 6.4.6. Improving memory usage by using secret filtering for Service Mesh

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

**Prerequisites**

- You have access to an OpenShift Dedicated account with cluster or dedicated administrator access.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- Install Red Hat OpenShift Service Mesh. OpenShift Serverless with Service Mesh only is supported for use with Red Hat OpenShift Service Mesh version 2.0.5 or later.
- Install the OpenShift Serverless Operator and Knative Serving.
- Install the OpenShift CLI (oc).
Procedure

- Add the `serverless.openshift.io/enable-secret-informer-filtering` annotation to the `KnativeServing` CR:

Example KnativeServing CR

```yaml
apiVersion: operator.knative.dev/v1alpha1
class: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
annotations:
  serverless.openshift.io/enable-secret-informer-filtering: "true"
spec:
  ingress:
    istio:
      enabled: true
deployments:
  - annotations:
      sidecar.istio.io/inject: "true"
      sidecar.istio.io/rewriteAppHTTPProbers: "true"
    name: activator
  - annotations:
      sidecar.istio.io/inject: "true"
      sidecar.istio.io/rewriteAppHTTPProbers: "true"
    name: autoscaler
```

Adding this annotation injects an environment variable, `ENABLE_SECRET_INFORMER_FILTERING_BY_CERT_UID=true`, to the net-istio controller pod.

6.5. SERVERLESS ADMINISTRATOR METRICS

Metrics enable cluster administrators to monitor how OpenShift Serverless cluster components and workloads are performing.

You can view different metrics for OpenShift Serverless by navigating to Dashboards in the OpenShift Dedicated web console Administrator perspective.

6.5.1. Prerequisites

- You have access to an OpenShift Dedicated account with cluster or dedicated administrator access.
- You have access to the Administrator perspective in the OpenShift Dedicated web console.
WARNING
If Service Mesh is enabled with mTLS, metrics for Knative Serving are disabled by default because Service Mesh prevents Prometheus from scraping metrics.

For information about resolving this issue, see Enabling Knative Serving metrics when using Service Mesh with mTLS.

Scraping the metrics does not affect autoscaling of a Knative service, because scraping requests do not go through the activator. Consequently, no scraping takes place if no pods are running.

6.5.2. Controller metrics
The following metrics are emitted by any component that implements a controller logic. These metrics show details about reconciliation operations and the work queue behavior upon which reconciliation requests are added to the work queue.

<table>
<thead>
<tr>
<th>Metric name</th>
<th>Description</th>
<th>Type</th>
<th>Tags</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>work_queue_depth</td>
<td>The depth of the work queue.</td>
<td>Gauge</td>
<td>reconciler</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>reconcile_count</td>
<td>The number of reconcile operations.</td>
<td>Counter</td>
<td>reconciler, success</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>reconcile_latency</td>
<td>The latency of reconcile operations.</td>
<td>Histogram</td>
<td>reconciler, success</td>
<td>Milliseconds</td>
</tr>
<tr>
<td>workqueue_adds_total</td>
<td>The total number of add actions handled by the work queue.</td>
<td>Counter</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>workqueue_queue latency_seconds</td>
<td>The length of time an item stays in the work queue before being requested.</td>
<td>Histogram</td>
<td>name</td>
<td>Seconds</td>
</tr>
<tr>
<td>workqueue_retries_total</td>
<td>The total number of retries that have been handled by the work queue.</td>
<td>Counter</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>Metric name</td>
<td>Description</td>
<td>Type</td>
<td>Tags</td>
<td>Unit</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>------------------------------------------------------------------</td>
<td>-------------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td><code>workqueue_work_duration_seconds</code></td>
<td>The length of time it takes to process and item from the work queue.</td>
<td>Histogram</td>
<td>name</td>
<td>Seconds</td>
</tr>
<tr>
<td><code>workqueue_unfinished_work_seconds</code></td>
<td>The length of time that outstanding work queue items have been in progress.</td>
<td>Histogram</td>
<td>name</td>
<td>Seconds</td>
</tr>
<tr>
<td><code>workqueue_longest_running_processor_seconds</code></td>
<td>The length of time that the longest outstanding work queue items has been in progress.</td>
<td>Histogram</td>
<td>name</td>
<td>Seconds</td>
</tr>
</tbody>
</table>

### 6.5.3. Webhook metrics

Webhook metrics report useful information about operations. For example, if a large number of operations fail, this might indicate an issue with a user-created resource.

| Metric name     | Description                                         | Type     | Tags                                                                 | Unit          |
|-----------------|                                                    |          |                                                                      | Integer (no units) |
| `request_count` | The number of requests that are routed to the webhook. | Counter  | `admission_allowed, kind_group, kind_kind, kind_version, request_operation, resource_group, resource_namespace, resource_resource, resource_version` | Integer (no units) |
request_latencies

The response time for a webhook request.

Histogram

admission_allowed, kind_group, kind_kind, kind_version, request_operation, resource_group, resource_namespace, resource_resource, resource_version

Milliseconds

6.5.4. Knative Eventing metrics

Cluster administrators can view the following metrics for Knative Eventing components.

By aggregating the metrics from HTTP code, events can be separated into two categories; successful events (2xx) and failed events (5xx).

6.5.4.1. Broker ingress metrics

You can use the following metrics to debug the broker ingress, see how it is performing, and see which events are being dispatched by the ingress component.

event_count

Number of events received by a broker.

Counter

broker_name, event_type, namespace_name, response_code, response_code_class, unique_name

Integer (no units)

event_dispatch_latencies

The time taken to dispatch an event to a channel.

Histogram

broker_name, event_type, namespace_name, response_code, response_code_class, unique_name

Milliseconds
6.5.4.2. Broker filter metrics

You can use the following metrics to debug broker filters, see how they are performing, and see which events are being dispatched by the filters. You can also measure the latency of the filtering action on an event.

<table>
<thead>
<tr>
<th>Metric name</th>
<th>Description</th>
<th>Type</th>
<th>Tags</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>event_count</td>
<td>Number of events received by a broker.</td>
<td>Counter</td>
<td>broker_name, container_name, filter_type, namespace_name, response_code, response_code_class, trigger_name, unique_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>event_dispatch_latencies</td>
<td>The time taken to dispatch an event to a channel.</td>
<td>Histogram</td>
<td>broker_name, container_name, filter_type, namespace_name, response_code, response_code_class, trigger_name, unique_name</td>
<td>Milliseconds</td>
</tr>
<tr>
<td>event_processing_latencies</td>
<td>The time it takes to process an event before it is dispatched to a trigger subscriber.</td>
<td>Histogram</td>
<td>broker_name, container_name, filter_type, namespace_name, trigger_name, unique_name</td>
<td>Milliseconds</td>
</tr>
</tbody>
</table>

6.5.4.3. InMemoryChannel dispatcher metrics

You can use the following metrics to debug InMemoryChannel channels, see how they are performing, and see which events are being dispatched by the channels.

<table>
<thead>
<tr>
<th>Metric name</th>
<th>Description</th>
<th>Type</th>
<th>Tags</th>
<th>Unit</th>
</tr>
</thead>
</table>
### Metric name | Description | Type | Tags | Unit |
---|---|---|---|---|
**event_count** | Number of events dispatched by `InMemoryChannel` channels. | Counter | `broker_name, container_name, filter_type, namespace_name, response_code, response_code_class, trigger_name, unique_name` | Integer (no units) |

**event_dispatch_latencies** | The time taken to dispatch an event from an `InMemoryChannel` channel. | Histogram | `broker_name, container_name, filter_type, namespace_name, response_code, response_code_class, trigger_name, unique_name` | Milliseconds |

### 6.5.4.4. Event source metrics

You can use the following metrics to verify that events have been delivered from the event source to the connected event sink.

### Metric name | Description | Type | Tags | Unit |
---|---|---|---|---|
**event_count** | Number of events sent by the event source. | Counter | `broker_name, container_name, filter_type, namespace_name, response_code, response_code_class, trigger_name, unique_name` | Integer (no units) |
### 6.5.5. Knative Serving metrics

Cluster administrators can view the following metrics for Knative Serving components.

#### 6.5.5.1. Activator metrics

You can use the following metrics to understand how applications respond when traffic passes through the activator.

<table>
<thead>
<tr>
<th>Metric name</th>
<th>Description</th>
<th>Type</th>
<th>Tags</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>retry_event_count</td>
<td>Number of retried events sent by the event source after initially failing to be delivered.</td>
<td>Counter</td>
<td>event_source, event_type, name, namespace_name, resource_group, response_code, response_code_class, response_error, response_timeout</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>request_concurrency</td>
<td>The number of concurrent requests that are routed to the activator, or average concurrency over a reporting period.</td>
<td>Gauge</td>
<td>configuration_name, container_name, namespace_name, namespace_name, pod_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>request_count</td>
<td>The number of requests that are routed to activator. These are requests that have been fulfilled from the activator handler.</td>
<td>Counter</td>
<td>configuration_name, container_name, namespace_name, namespace_name, pod_name, response_code, response_code_class, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
</tbody>
</table>
### 6.5.5.2. Autoscaler metrics

The autoscaler component exposes a number of metrics related to autoscaler behavior for each revision. For example, at any given time, you can monitor the targeted number of pods the autoscaler tries to allocate for a service, the average number of requests per second during the stable window, or whether the autoscaler is in panic mode if you are using the Knative pod autoscaler (KPA).

<table>
<thead>
<tr>
<th>Metric name</th>
<th>Description</th>
<th>Type</th>
<th>Tags</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>desired_pods</td>
<td>The number of pods the autoscaler tries to allocate for a service.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>excess_burst_capacity</td>
<td>The excess burst capacity served over the stable window.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>stable_request_concurrency</td>
<td>The average number of requests for each observed pod over the stable window.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>panic_request_concurrency</td>
<td>The average number of requests for each observed pod over the panic window.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>Metric name</td>
<td>Description</td>
<td>Type</td>
<td>Tags</td>
<td>Unit</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>----------</td>
<td>----------------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>target_concurrency_per_pod</td>
<td>The number of concurrent requests that the autoscaler tries to send to each pod.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>stable_requests_per_second</td>
<td>The average number of requests-per-second for each observed pod over the stable window.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>panic_requests_per_second</td>
<td>The average number of requests-per-second for each observed pod over the panic window.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>target_requests_per_second</td>
<td>The number of requests-per-second that the autoscaler targets for each pod.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>panic_mode</td>
<td>This value is 1 if the autoscaler is in panic mode, or 0 if the autoscaler is not in panic mode.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>requested_pods</td>
<td>The number of pods that the autoscaler has requested from the Kubernetes cluster.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>actual_pods</td>
<td>The number of pods that are allocated and currently have a ready state.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>Metric name</td>
<td>Description</td>
<td>Type</td>
<td>Tags</td>
<td>Unit</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>--------</td>
<td>----------------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>not_ready_pods</td>
<td>The number of pods that have a not ready state.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>pending_pods</td>
<td>The number of pods that are currently pending.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>terminating_pods</td>
<td>The number of pods that are currently terminating.</td>
<td>Gauge</td>
<td>configuration_name, namespace_name, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
</tbody>
</table>

6.5.5.3. Go runtime metrics

Each Knative Serving control plane process emits a number of Go runtime memory statistics (MemStats).

**NOTE**

The name tag for each metric is an empty tag.

<table>
<thead>
<tr>
<th>Metric name</th>
<th>Description</th>
<th>Type</th>
<th>Tags</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>go_alloc</td>
<td>The number of bytes of allocated heap objects. This metric is the same as heap_alloc.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_total_alloc</td>
<td>The cumulative bytes allocated for heap objects.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_sys</td>
<td>The total bytes of memory obtained from the operating system.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>Metric name</td>
<td>Description</td>
<td>Type</td>
<td>Tags</td>
<td>Unit</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------</td>
<td>------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>go_lookups</td>
<td>The number of pointer lookups performed by the runtime.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_mallocs</td>
<td>The cumulative count of heap objects allocated.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_frees</td>
<td>The cumulative count of heap objects that have been freed.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_heap_alloc</td>
<td>The number of bytes of allocated heap objects.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_heap_sys</td>
<td>The number of bytes of heap memory obtained from the operating system.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_heap_idle</td>
<td>The number of bytes in idle, unused spans.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_heap_in_use</td>
<td>The number of bytes in spans that are currently in use.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_heap_released</td>
<td>The number of bytes of physical memory returned to the operating system.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_heap_objects</td>
<td>The number of allocated heap objects.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_stack_in_use</td>
<td>The number of bytes in stack spans that are currently in use.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>Metric name</td>
<td>Description</td>
<td>Type</td>
<td>Tags</td>
<td>Unit</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------</td>
<td>------</td>
<td>---------------</td>
</tr>
<tr>
<td>go_stack_sys</td>
<td>The number of bytes of stack memory obtained from the operating system.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_mspan_in_use</td>
<td>The number of bytes of allocated mspan structures.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_mspan_sys</td>
<td>The number of bytes of memory obtained from the operating system for mspan structures.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_mcache_in_use</td>
<td>The number of bytes of allocated mcache structures.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_mcache_sys</td>
<td>The number of bytes of memory obtained from the operating system for mcache structures.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_bucket_hash_sys</td>
<td>The number of bytes of memory in profiling bucket hash tables.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_gc_sys</td>
<td>The number of bytes of memory in garbage collection metadata.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_other_sys</td>
<td>The number of bytes of memory in miscellaneous, off-heap runtime allocations.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_next_gc</td>
<td>The target heap size of the next garbage collection cycle.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>Metric name</td>
<td>Description</td>
<td>Type</td>
<td>Tags</td>
<td>Unit</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-------</td>
<td>--------</td>
<td>----------------</td>
</tr>
<tr>
<td>go_last_gc</td>
<td>The time that the last garbage collection was completed in <em>Epoch</em> or Unix time.</td>
<td>Gauge</td>
<td>name</td>
<td>Nanoseconds</td>
</tr>
<tr>
<td>go_total_gc_pause_ns</td>
<td>The cumulative time in garbage collection <em>stop-the-world</em> pauses since the program started.</td>
<td>Gauge</td>
<td>name</td>
<td>Nanoseconds</td>
</tr>
<tr>
<td>go_num_gc</td>
<td>The number of completed garbage collection cycles.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_num_forced_gc</td>
<td>The number of garbage collection cycles that were forced due to an application calling the garbage collection function.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
<tr>
<td>go_gc_cpu_fraction</td>
<td>The fraction of the available CPU time of the program that has been used by the garbage collector since the program started.</td>
<td>Gauge</td>
<td>name</td>
<td>Integer (no units)</td>
</tr>
</tbody>
</table>

### 6.6. HIGH AVAILABILITY

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

HA in OpenShift Serverless is available through leader election, which is enabled by default after the Knative Serving or Eventing control plane is installed. When using a leader election HA pattern, instances of controllers are already scheduled and running inside the cluster before they are required. These controller instances compete to use a shared resource, known as the leader election lock. The instance of the controller that has access to the leader election lock resource at any given time is called the leader.
6.6.1. Configuring high availability replicas for Knative Serving

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

Prerequisites

- You have access to an OpenShift Dedicated account with cluster administrator or dedicated administrator access.
- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.

Procedure

1. In the OpenShift Dedicated web console Administrator perspective, navigate to OperatorHub → Installed Operators.
2. Select the knative-serving namespace.
3. Click Knative Serving in the list of Provided APIs for the OpenShift Serverless Operator to go to the Knative Serving tab.
4. Click knative-serving, then go to the YAML tab in the knative-serving page.
5. Modify the number of replicas in the KnativeServing CR:

Example YAML
6.6.2. Configuring high availability replicas for Knative Eventing

High availability (HA) is available by default for the Knative Eventing `eventing-controller`, `eventing-webhook`, `imc-controller`, `imc-dispatcher`, and `mt-broker-controller` components, which are configured to have two replicas each by default. You can change the number of replicas for these components by modifying the `spec.high-availability.replicas` value in the `KnativeEventing` custom resource (CR).

**NOTE**

For Knative Eventing, the `mt-broker-filter` and `mt-broker-ingress` deployments are not scaled by HA. If multiple deployments are needed, scale these components manually.

**Prerequisites**

- You have access to an OpenShift Dedicated account with cluster administrator or dedicated administrator access.
- The OpenShift Serverless Operator and Knative Eventing are installed on your cluster.

**Procedure**

1. In the OpenShift Dedicated web console **Administrator** perspective, navigate to **OperatorHub → Installed Operators**.

2. Select the `knative-eventing` namespace.

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

4. Click `knative-eventing`, then go to the **YAML** tab in the `knative-eventing` page.

```yaml
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeServing
metadata:
  name: knative-serving
  namespace: knative-serving
spec:
  high-availability:
    replicas: 3
```
5. Modify the number of replicas in the **KnativeEventing** CR:

**Example YAML**

```
apiVersion: operator.knative.dev/v1alpha1
kind: KnativeEventing
metadata:
  name: knative-eventing
  namespace: knative-eventing
spec:
  high-availability:
    replicas: 3
```

### 6.6.3. Configuring high availability replicas for Knative Kafka

High availability (HA) is available by default for the Knative Kafka **kafka-controller** and **kafka-webhook-eventing** components, which are configured to have two each replicas by default. You can change the number of replicas for these components by modifying the **spec.high-availability.replicas** value in the **KnativeKafka** custom resource (CR).

**Prerequisites**

- You have access to an OpenShift Dedicated account with cluster administrator or dedicated administrator access.
- The OpenShift Serverless Operator and Knative Kafka are installed on your cluster.

**Procedure**
1. In the OpenShift Dedicated web console Administrator perspective, navigate to OperatorHub → Installed Operators.

2. Select the knative-eventing namespace.

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

4. Click knative-kafka, then go to the YAML tab in the knative-kafka page.

5. Modify the number of replicas in the KnativeKafka CR:

Example YAML

```yaml
apiVersion: operator.serverless.openshift.io/v1alpha1
kind: KnativeKafka
metadata:
  name: knative-kafka
  namespace: knative-eventing
spec:
  high-availability:
    replicas: 3
```
CHAPTER 7. MONITOR

7.1. USING OPENSIFT LOGGING WITH OPENSIFT SERVERLESS

7.1.1. About deploying the logging subsystem for Red Hat OpenShift

The **ClusterLogging** CR defines a complete logging subsystem environment that includes all the components of the logging stack to collect, store and visualize logs. The Red Hat OpenShift Logging Operator watches the logging subsystem CR and adjusts the logging deployment accordingly.

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

7.1.2. About deploying and configuring the logging subsystem for Red Hat OpenShift

The logging subsystem is designed to be used with the default configuration, which is tuned for small to medium sized OpenShift Dedicated clusters.

The installation instructions that follow include a sample **ClusterLogging** custom resource (CR), which you can use to create a logging subsystem instance and configure your logging subsystem environment.

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

If you want to customize your deployment, make changes to the sample CR as needed. The following describes the configurations you can make when installing your OpenShift Logging instance or modify after installation. See the Configuring sections for more information on working with each component, including modifications you can make outside of the **ClusterLogging** custom resource.

7.1.2.1. Configuring and Tuning the logging subsystem

You can configure your logging subsystem by modifying the **ClusterLogging** custom resource deployed in the *openshift-logging* project.

You can modify any of the following components upon install or after install:

**Memory and CPU**

You can adjust both the CPU and memory limits for each component by modifying the `resources` block with valid memory and CPU values:

```yaml
spec:
  logStore:
    elasticsearch:
      resources:
        limits:
          cpu:
            memory: 16Gi
          requests:
            cpu: 500m
            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 Red Hat OpenShift Logging Operator creates a persistent volume claim (PVC) for each data node in the Elasticsearch cluster based on these parameters.

```yaml
fluentd:
  resources:
    limits:
      cpu:
      memory:
    requests:
      cpu:
      memory:
    type: "fluentd"
visualization:
  kibana:
    resources:
      limits:
        cpu:
        memory:
      requests:
        cpu:
        memory:
    type: kibana

spec:
logStore:
  type: "elasticsearch"
elasticsearch:
  nodeCount: 3
storage:
  storageClassName: "gp2"
  size: "200G"

```

This example specifies each data node in the cluster will be bound to a PVC that requests "200G" of "gp2" storage. Each primary shard will be backed by a single replica.

**NOTE**

Omitting the `storage` block results in a deployment that includes ephemeral storage only.

```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.

7.1.2.2. Sample modified ClusterLogging custom resource

The following is an example of a ClusterLogging custom resource modified using the options previously described.

**Sample modified ClusterLogging custom resource**

```json
apiVersion: "logging.openshift.io/v1"
kind: "ClusterLogging"
metadata:
  name: "instance"
  namespace: "openshift-logging"
spec:
  managementState: "Managed"
  logStore:
    type: "elasticsearch"
    retentionPolicy:
      application:
        maxAge: 1d
      infra:
        maxAge: 7d
      audit:
        maxAge: 7d
  elasticsearch:
    nodeCount: 3
  resources:
    limits:
      memory: 32Gi
      cpu: 3
      memory: 32Gi
    storage:
      storageClassName: "gp2"
      size: "200G"
      redundancyPolicy: "SingleRedundancy"
  visualization:
    type: "kibana"
  kibana:
    resources:
      limits:
        memory: 1Gi
    requests:
      cpu: 500m
      memory: 1Gi
  replicas: 1
  collection:
  logs:
```
7.1.3. Using OpenShift Logging to find logs for Knative Serving components

Prerequisites

- Install the OpenShift CLI (oc).

Procedure

1. Get the Kibana route:

   ```bash
   $ oc -n openshift-logging get route kibana
   ```

2. Use the route’s URL to navigate to the Kibana dashboard and log in.

3. Check that the index is set to .all. If the index is not set to .all, only the OpenShift Dedicated system logs will be listed.

4. Filter the logs by using the knative-serving namespace. Enter

   ```bash
   kubernetes.namespace_name:knative-serving
   ```

   in the search box to filter results.

   **NOTE**

   Knative Serving uses structured logging by default. You can enable the parsing of these logs by customizing the OpenShift Logging Fluentd settings. This makes the logs more searchable and enables filtering on the log level to quickly identify issues.

7.1.4. Using OpenShift Logging to find logs for services deployed with Knative Serving

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

Prerequisites

- Install the OpenShift CLI (oc).

Procedure

1. Get the Kibana route:

   ```bash
   $ oc -n openshift-logging get route kibana
   ```

2. Use the route’s URL to navigate to the Kibana dashboard and log in.
3. Check that the index is set to \texttt{.all}. If the index is not set to \texttt{.all}, only the OpenShift system logs will be listed.

4. Filter the logs by using the \texttt{knative-serving} namespace. Enter a filter for the service in the search box to filter results.

   \textbf{Example filter}

   \texttt{kubernetes.namespace_name:default AND kubernetes.labels.serving_knative_dev/service: \{service_name\}}

   You can also filter by using \texttt{/configuration} or \texttt{/revision}.

5. Narrow your search by using \texttt{kubernetes.container_name:<user_container>} to only display the logs generated by your application. Otherwise, you will see logs from the queue-proxy.

   \textbf{NOTE}

   Use JSON-based structured logging in your application to allow for the quick filtering of these logs in production environments.

\section*{7.2. SERVERLESS DEVELOPER METRICS}

Metrics enable developers to monitor how Knative services are performing. You can use the OpenShift Dedicated monitoring stack to record and view health checks and metrics for your Knative services.

You can view different metrics for OpenShift Serverless by navigating to \texttt{Dashboards} in the OpenShift Dedicated web console \texttt{Developer} perspective.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{warning.png}
\caption{\textbf{WARNING}}
\end{figure}

\texttt{WARNING}

If Service Mesh is enabled with mTLS, metrics for Knative Serving are disabled by default because Service Mesh prevents Prometheus from scraping metrics.

For information about resolving this issue, see \texttt{Enabling Knative Serving metrics when using Service Mesh with mTLS}.

Scraping the metrics does not affect autoscaling of a Knative service, because scraping requests do not go through the activator. Consequently, no scraping takes place if no pods are running.

\subsection*{7.2.1. Knative service metrics exposed by default}

\begin{table}[h]
\centering
\caption{Metrics exposed by default for each Knative service on port 9090}
\end{table}
<table>
<thead>
<tr>
<th>Metric name, unit, and type</th>
<th>Description</th>
<th>Metric tags</th>
</tr>
</thead>
<tbody>
<tr>
<td>queue_requests_per_second</td>
<td>Number of requests per second that hit the queue proxy.</td>
<td>destination_configuration=&quot;event-display&quot;, destination_namespace=&quot;pingsource1&quot;, destination_pod=&quot;event-display-00001-deployment-6b455479cb-75p6w&quot;, destination_revision=&quot;event-display-00001&quot;</td>
</tr>
<tr>
<td><strong>Metric unit:</strong> dimensionless</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Metric type:</strong> gauge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formula: stats.RequestCount / r.reportingPeriodSeconds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>stats.RequestCount</td>
<td>is calculated directly from the networking pkg stats for the given reporting duration.</td>
<td></td>
</tr>
<tr>
<td>queue_proxied_operations_per_second</td>
<td>Number of proxied requests per second.</td>
<td></td>
</tr>
<tr>
<td><strong>Metric unit:</strong> dimensionless</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Metric type:</strong> gauge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formula: stats.ProxiedRequestCount / r.reportingPeriodSeconds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>stats.ProxiedRequestCount</td>
<td>is calculated directly from the networking pkg stats for the given reporting duration.</td>
<td></td>
</tr>
<tr>
<td>Metric name, unit, and type</td>
<td>Description</td>
<td>Metric tags</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
</tbody>
</table>
| queue_average_concurrent_requests | Number of requests currently being handled by this pod. Average concurrency is calculated at the networking `pkg` side as follows:  
  - When a `req` change happens, the time delta between changes is calculated. Based on the result, the current concurrency number over delta is computed and added to the current computed concurrency. Additionally, a sum of the deltas is kept. Current concurrency over delta is computed as follows: 
    
    $\text{global_concurrency} \times \frac{\text{delta}}{\text{sum of deltas}}$  
  - Each time a reporting is done, the sum and current computed concurrency are reset.  
  - When reporting the average concurrency the current computed concurrency is divided by the sum of deltas.  
  - When a new request comes in, the global concurrency counter is increased. When a request is completed, the counter is decreased. | destination_configuration="event-display", destination_namespace="pingsource1", destination_pod="event-display-00001-deployment-6b455479cb-75p6w", destination_revision="event-display-00001" |
| queue_average_proxied_concurrent_requests | Number of proxied requests currently being handled by this pod: 

`stats.AverageProxiedConcurrency` | destination_configuration="event-display", destination_namespace="pingsource1", destination_pod="event-display-00001-deployment-6b455479cb-75p6w", destination_revision="event-display-00001" |
<table>
<thead>
<tr>
<th>Metric name, unit, and type</th>
<th>Description</th>
<th>Metric tags</th>
</tr>
</thead>
<tbody>
<tr>
<td>process_uptime</td>
<td>The number of seconds that the process has been up.</td>
<td>destination_configuration=&quot;event-display&quot;, destination_namespace=&quot;pingsource1&quot;, destination_pod=&quot;event-display-00001-deployment-6b455479cb-75p6w&quot;, destination_revision=&quot;event-display-00001&quot;</td>
</tr>
</tbody>
</table>

Table 7.2. Metrics exposed by default for each Knative service on port 9091

<table>
<thead>
<tr>
<th>Metric name, unit, and type</th>
<th>Description</th>
<th>Metric tags</th>
</tr>
</thead>
<tbody>
<tr>
<td>request_count</td>
<td>The number of requests that are routed to <code>queue-proxy</code>.</td>
<td>configuration_name=&quot;event-display&quot;, container_name=&quot;queue-proxy&quot;, namespace_name=&quot;apiserversource1&quot;, pod_name=&quot;event-display-00001-deployment-658fd4f9cf-qcnr5&quot;, response_code=&quot;200&quot;, response_code_class=&quot;2xx&quot;, revision_name=&quot;event-display-00001&quot;, service_name=&quot;event-display&quot;</td>
</tr>
<tr>
<td>request_latencies</td>
<td>The response time in milliseconds.</td>
<td>configuration_name=&quot;event-display&quot;, container_name=&quot;queue-proxy&quot;, namespace_name=&quot;apiserversource1&quot;, pod_name=&quot;event-display-00001-deployment-658fd4f9cf-qcnr5&quot;, response_code=&quot;200&quot;, response_code_class=&quot;2xx&quot;, revision_name=&quot;event-display-00001&quot;, service_name=&quot;event-display&quot;</td>
</tr>
<tr>
<td>app_request_count</td>
<td>The number of requests that are routed to <code>user-container</code>.</td>
<td>configuration_name=&quot;event-display&quot;, container_name=&quot;queue-proxy&quot;, namespace_name=&quot;apiserversource1&quot;, pod_name=&quot;event-display-00001-deployment-658fd4f9cf-qcnr5&quot;, response_code=&quot;200&quot;, response_code_class=&quot;2xx&quot;, revision_name=&quot;event-display-00001&quot;, service_name=&quot;event-display&quot;</td>
</tr>
</tbody>
</table>
### Metric name, unit, and type
<table>
<thead>
<tr>
<th>Metric name</th>
<th>Description</th>
<th>Metric tags</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>app_request_latencies</strong></td>
<td>The response time in milliseconds.</td>
<td>configuration_name=&quot;event-display&quot;, container_name=&quot;queue-proxy&quot;, namespace_name=&quot;apiserver-source1&quot;, pod_name=&quot;event-display-00001-deployment-658fd4f9cf-qcnr5&quot;, response_code=&quot;200&quot;, response_code_class=&quot;2xx&quot;, revision_name=&quot;event-display-00001&quot;, service_name=&quot;event-display&quot;</td>
</tr>
<tr>
<td><strong>queue_depth</strong></td>
<td>The current number of items in the serving and waiting queue, or not reported if unlimited concurrency. breaker.inFlight is used.</td>
<td>configuration_name=&quot;event-display&quot;, container_name=&quot;queue-proxy&quot;, namespace_name=&quot;apiserver-source1&quot;, pod_name=&quot;event-display-00001-deployment-658fd4f9cf-qcnr5&quot;, response_code=&quot;200&quot;, response_code_class=&quot;2xx&quot;, revision_name=&quot;event-display-00001&quot;, service_name=&quot;event-display&quot;</td>
</tr>
</tbody>
</table>

#### 7.2.2. Knative service with custom application metrics

You can extend the set of metrics exported by a Knative service. The exact implementation depends on your application and the language used.

The following listing implements a sample Go application that exports the count of processed events custom metric.

```go
package main

import (    "fmt"    "log"    "net/http"    "os"    "github.com/prometheus/client_golang/prometheus" 1    "github.com/prometheus/client_golang/prometheus/promauto"    "github.com/prometheus/client_golang/prometheus/promhttp" )

var (    opsProcessed = promauto.NewCounter(prometheus.CounterOpts{    Name: "myapp_processed_ops_total",    Help: "The total number of processed events",    })
```
Including the Prometheus packages.

2 Defining the **opsProcessed** metric.

3 Incrementing the **opsProcessed** metric.

4 Configuring to use a separate server for metrics requests.

5 Configuring to use the same port as normal requests for metrics and the **metrics** subpath.

7.2.3. Configuration for scraping custom metrics
Custom metrics scraping is performed by an instance of Prometheus purposed for user workload monitoring. After you enable user workload monitoring and create the application, you need a configuration that defines how the monitoring stack will scrape the metrics.

The following sample configuration defines the `ksvc` for your application and configures the service monitor. The exact configuration depends on your application and how it exports the metrics.

```yaml
apiVersion: serving.knative.dev/v1
kind: Service
metadata:
  name: helloworld-go
spec:
  template:
    metadata:
      labels:
        app: helloworld-go
      annotations:
      spec:
        containers:
        - image: docker.io/skonto/helloworld-go:metrics
          resources:
            requests:
              cpu: "200m"
          env:
            - name: TARGET
              value: "Go Sample v1"
---
apiVersion: monitoring.coreos.com/v1
kind: ServiceMonitor
metadata:
  labels:
  name: helloworld-go-sm
spec:
  endpoints:
  - port: queue-proxy-metrics
    scheme: http
  - port: app-metrics
    scheme: http
  namespaceSelector: {}
  selector:
    matchLabels:
    name: helloworld-go-sm
---
apiVersion: v1
kind: Service
metadata:
  labels:
  name: helloworld-go-sm
spec:
  ports:
  - name: queue-proxy-metrics
    port: 9091
    protocol: TCP
  - name: app-metrics
```
Application specification.

2 Configuration of which application's metrics are scraped.

3 Configuration of the way metrics are scraped.

7.2.4. Examining metrics of a service

After you have configured the application to export the metrics and the monitoring stack to scrape them, you can examine the metrics in the web console.

Prerequisites

- You have logged in to the OpenShift Dedicated web console.
- You have installed the OpenShift Serverless Operator and Knative Serving.

Procedure

1. Optional: Run requests against your application that you will be able to see in the metrics:

   ```
   $ hello_route=$(oc get ksvc helloworld-go -n ns1 -o jsonpath='{.status.url}') && \
   curl $hello_route
   ```

   **Example output**

   Hello Go Sample v1!

2. In the web console, navigate to the **Observe → Metrics** interface.

3. In the input field, enter the query for the metric you want to observe, for example:

   ```
   revision_app_request_count{namespace=ns1, job=helloworld-go-sm}
   ```

   Another example:

   ```
   myapp_processed_ops_total{namespace=ns1, job=helloworld-go-sm}
   ```

4. Observe the visualized metrics:
7.2.4.1. Queue proxy metrics

Each Knative service has a proxy container that proxies the connections to the application container. A number of metrics are reported for the queue proxy performance.

You can use the following metrics to measure if requests are queued at the proxy side and the actual delay in serving requests at the application side.

<table>
<thead>
<tr>
<th>Metric name</th>
<th>Description</th>
<th>Type</th>
<th>Tags</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>revision_request_count</td>
<td>The number of requests that are routed to queue-proxy pod.</td>
<td>Counter</td>
<td>configuration_name, container_name, namespace_name, pod_name, response_code, response_code_class, revision_name, service_name</td>
<td>Integer (no units)</td>
</tr>
</tbody>
</table>
### Metric name | Description | Type | Tags | Unit
--- | --- | --- | --- | ---
revision_request_latencies | The response time of revision requests. | Histogram | configuration_name, container_name, namespace_name, pod_name, response_code, response_code_class, revision_name, service_name | Milliseconds

revision_app_request_count | The number of requests that are routed to the user-container pod. | Counter | configuration_name, container_name, namespace_name, pod_name, response_code, response_code_class, revision_name, service_name | Integer (no units)

revision_app_request_latencies | The response time of revision app requests. | Histogram | configuration_name, namespace_name, pod_name, response_code, response_code_class, revision_name, service_name | Milliseconds

revision_queue_depth | The current number of items in the serving and waiting queues. This metric is not reported if unlimited concurrency is configured. | Gauge | configuration_name, event-display, container_name, namespace_name, pod_name, response_code_class, revision_name, service_name | Integer (no units)

#### 7.2.5. Examining metrics of a service in the dashboard

You can examine the metrics using a dedicated dashboard that aggregates queue proxy metrics by namespace.
Prerequisites

- You have logged in to the OpenShift Dedicated web console.
- You have installed the OpenShift Serverless Operator and Knative Serving.

Procedure

1. In the web console, navigate to the **Observe → Metrics** interface.

2. Select the **Knative User Services (Queue Proxy metrics)** dashboard.

3. Select the **Namespace, Configuration, and Revision** that correspond to your application.

4. Observe the visualized metrics:
CHAPTER 8. TRACING REQUESTS

Distributed tracing records the path of a request through the various services that make up an application. It is used to tie information about different units of work together, to understand a whole chain of events in a distributed transaction. The units of work might be executed in different processes or hosts.

8.1. USING JAEGER TO ENABLE DISTRIBUTED TRACING

If you do not want to install all of the components of Red Hat OpenShift distributed tracing, you can still use distributed tracing on OpenShift Dedicated with OpenShift Serverless. To do this, you must install and configure Jaeger as a standalone integration.

Prerequisites

- You have access to an OpenShift Dedicated account with cluster or dedicated administrator access.
- You have installed the OpenShift Serverless Operator and Knative Serving.
- You have installed the Red Hat OpenShift distributed tracing platform Operator.
- You have installed the OpenShift (oc) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

Procedure

1. Create and apply a Jaeger custom resource (CR) that contains the following:

   **Jaeger CR**
   ```yaml
   apiVersion: jaegertracing.io/v1
   kind: Jaeger
   metadata:
     name: jaeger
     namespace: default
   ```

2. Enable tracing for Knative Serving, by editing the KnativeServing CR and adding a YAML configuration for tracing:

   **Tracing YAML example**
   ```yaml
   apiVersion: operator.knative.dev/v1alpha1
   kind: KnativeServing
   metadata:
     name: knative-serving
     namespace: knative-serving
   spec:
     config:
       tracing:
         sample-rate: "0.1"
   ```
The sample-rate defines sampling probability. Using sample-rate: "0.1" means that 1 in 10 traces are sampled.

backend must be set to zipkin.

The zipkin-endpoint must point to your jaeger-collector service endpoint. To get this endpoint, substitute the namespace where the Jaeger CR is applied.

Debugging should be set to false. Enabling debug mode by setting debug: "true" allows all spans to be sent to the server, bypassing sampling.

Verification

You can access the Jaeger web console to see tracing data, by using the jaeger route.

1. Get the jaeger route’s hostname by entering the following command:

   $ oc get route jaeger -n default

   Example output

<table>
<thead>
<tr>
<th>NAME</th>
<th>HOST/PORT</th>
<th>PATH</th>
<th>SERVICES</th>
<th>PORT</th>
<th>TERMINATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>WILDCARD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>jaeger</td>
<td>jaeger-default.apps.example.com</td>
<td>jaeger-query</td>
<td>&lt;all&gt;</td>
<td>reencrypt</td>
<td>None</td>
</tr>
</tbody>
</table>

2. Open the endpoint address in your browser to view the console.
CHAPTER 9. OPENSHIFT SERVERLESS SUPPORT

If you experience difficulty with a procedure described in this documentation, visit the Red Hat Customer Portal at http://access.redhat.com. You can use the Red Hat Customer Portal to search or browse through the Red Hat Knowledgebase of technical support articles about Red Hat products. You can also submit a support case to Red Hat Global Support Services (GSS), or access other product documentation.

If you have a suggestion for improving this guide or have found an error, you can submit a Jira issue for the most relevant documentation component. Provide specific details, such as the section number, guide name, and OpenShift Serverless version so we can easily locate the content.

9.1. ABOUT THE RED HAT KNOWLEDGEBASE

The Red Hat Knowledgebase provides rich content aimed at helping you make the most of Red Hat’s products and technologies. The Red Hat Knowledgebase consists of articles, product documentation, and videos outlining best practices on installing, configuring, and using Red Hat products. In addition, you can search for solutions to known issues, each providing concise root cause descriptions and remedial steps.

9.2. SEARCHING THE RED HAT KNOWLEDGEBASE

In the event of an OpenShift Dedicated issue, you can perform an initial search to determine if a solution already exists within the Red Hat Knowledgebase.

**Prerequisites**

- You have a Red Hat Customer Portal account.

**Procedure**


2. In the main Red Hat Customer Portal search field, input keywords and strings relating to the problem, including:
   - OpenShift Dedicated components (such as etcd)
   - Related procedure (such as installation)
   - Warnings, error messages, and other outputs related to explicit failures

3. Click Search.

4. Select the OpenShift Dedicated product filter.

5. Select the Knowledgebase content type filter.

9.3. SUBMITTING A SUPPORT CASE

**Prerequisites**

- You have access to the Red Hat OpenShift Cluster Manager.
You have a Red Hat Customer Portal account.

Procedure

1. Log in to the Red Hat Customer Portal and select SUPPORT CASES → Open a case.

2. Select the appropriate category for your issue (such as Defect / Bug), product (OpenShift Dedicated), and product version (OpenShift Dedicated, if this is not already autofilled).

3. Review the list of suggested Red Hat Knowledgebase solutions for a potential match against the problem that is being reported. If the suggested articles do not address the issue, click Continue.

4. Enter a concise but descriptive problem summary and further details about the symptoms being experienced, as well as your expectations.

5. Review the updated list of suggested Red Hat Knowledgebase solutions for a potential match against the problem that is being reported. The list is refined as you provide more information during the case creation process. If the suggested articles do not address the issue, click Continue.

6. Ensure that the account information presented is as expected, and if not, amend accordingly.

7. Check that the autofilled OpenShift Dedicated Cluster ID is correct. If it is not, manually obtain your cluster ID.
   
   - To manually obtain your cluster ID using OpenShift Cluster Manager:
     
     a. Navigate to Clusters.
     
     b. Click on the name of the cluster you need to open a support case for.
     
     c. Find the value in the Cluster ID field of the Details section of the Overview tab.

8. Complete the following questions where prompted and then click Continue:
   
   - Where are you experiencing the behavior? What environment?

   - When does the behavior occur? Frequency? Repeatedly? At certain times?

   - What information can you provide around time-frames and the business impact?

9. Upload relevant diagnostic data files and click Continue.

10. Input relevant case management details and click Continue.

11. Preview the case details and click Submit.

9.4. GATHERING DIAGNOSTIC INFORMATION FOR SUPPORT

When you open a support case, it is helpful to provide debugging information about your cluster to Red Hat Support. The must-gather tool enables you to collect diagnostic information about your OpenShift Dedicated cluster, including data related to OpenShift Serverless. For prompt support, supply diagnostic information for both OpenShift Dedicated and OpenShift Serverless.

9.4.1. About the must-gather tool
The **oc adm must-gather** CLI command collects the information from your cluster that is most likely needed for debugging issues, including:

- Resource definitions
- Service logs

By default, the **oc adm must-gather** command uses the default plug-in image and writes into `.must-gather.local`.

Alternatively, you can collect specific information by running the command with the appropriate arguments as described in the following sections:

- To collect data related to one or more specific features, use the `--image` argument with an image, as listed in a following section.
  
  For example:
  ```bash
  $ oc adm must-gather --image=registry.redhat.io/container-native-virtualization/cnv-must-gather-rhel8:v4.11.0
  ```

- To collect the audit logs, use the `-- /usr/bin/gather_audit_logs` argument, as described in a following section.
  
  For example:
  ```bash
  $ oc adm must-gather -- /usr/bin/gather_audit_logs
  ```

  **NOTE**

  Audit logs are not collected as part of the default set of information to reduce the size of the files.

When you run **oc adm must-gather**, a new pod with a random name is created in a new project on the cluster. The data is collected on that pod and saved in a new directory that starts with `must-gather.local`. This directory is created in the current working directory.

For example:

<table>
<thead>
<tr>
<th>NAMESPACE</th>
<th>NAME</th>
<th>READY</th>
<th>STATUS</th>
<th>RESTARTS</th>
<th>AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>openshift-must-gather-5drcj</td>
<td>must-gather-bklx4</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>72s</td>
</tr>
<tr>
<td>openshift-must-gather-5drcj</td>
<td>must-gather-s8sdh</td>
<td>2/2</td>
<td>Running</td>
<td>0</td>
<td>72s</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 9.4.2. About collecting OpenShift Serverless data

You can use the **oc adm must-gather** CLI command to collect information about your cluster, including features and objects associated with OpenShift Serverless. To collect OpenShift Serverless data with **must-gather**, you must specify the OpenShift Serverless image and the image tag for your installed version of OpenShift Serverless.

**Prerequisites**

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

- Collect data by using the **oc adm must-gather** command:

  ```
  $ oc adm must-gather --image=registry.redhat.io/openshift-serverless-1/svls-must-gather-rhel8:<image_version_tag>
  
  Example command
  
  $ oc adm must-gather --image=registry.redhat.io/openshift-serverless-1/svls-must-gather-rhel8:1.14.0
  ```
CHAPTER 10. SECURITY

10.1. CONFIGURING JSON WEB TOKEN AUTHENTICATION FOR KNATIVE SERVICES

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

10.1.1. Using JSON Web Token authentication with Service Mesh 2.x and OpenShift Serverless

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

**IMPORTANT**

Adding sidecar injection to pods in system namespaces, such as knative-serving and knative-serving-ingress, is not supported when Kourier is enabled.

**Prerequisites**

- You have installed the OpenShift Serverless Operator, Knative Serving, and Red Hat OpenShift Service Mesh on your cluster.
- Install the OpenShift CLI (oc).
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

**Procedure**

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

   **Example service**

   ```yaml
   apiVersion: serving.knative.dev/v1
   kind: Service
   metadata:
     name: <service_name>
   spec:
     template:
       metadata:
         annotations:
           sidecar.istio.io/inject: "true" ①
           sidecar.istio.io/rewriteAppHTTPProbers: "true" ②
   ...
   
   ① Add the `sidecar.istio.io/inject="true"` annotation.
   ```
You must set the annotation `sidecar.istio.io/rewriteAppHTTPProbers: "true"` in your Knative service, because OpenShift Serverless versions 1.14.0 and higher use an HTTP probe as the readiness probe for Knative services by default.

2. Apply the `Service` resource:

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

3. Create a `RequestAuthentication` resource in each serverless application namespace that is a member in the `ServiceMeshMemberRoll` object:

```yaml
apiVersion: security.istio.io/v1beta1
kind: RequestAuthentication
metadata:
  name: jwt-example
  namespace: <namespace>
spec:
  jwtRules:
    - issuer: testing@secure.istio.io
      jwksUri: https://raw.githubusercontent.com/istio/istio/release-1.8/security/tools/jwt/samples/jwks.json
```

4. Apply the `RequestAuthentication` resource:

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

5. Allow access to the `RequestAuthentication` resource from system pods for each serverless application namespace that is a member in the `ServiceMeshMemberRoll` object, by creating the following `AuthorizationPolicy` resource:

```yaml
apiVersion: security.istio.io/v1beta1
kind: AuthorizationPolicy
metadata:
  name: allowlist-by-paths
  namespace: <namespace>
spec:
  action: ALLOW
  rules:
    - to:
      - operation:
          paths:
            - /metrics
            - /healthz
```

1. The path on your application to collect metrics by system pod.

2. The path on your application to probe by system pod.

6. Apply the `AuthorizationPolicy` resource:

```bash
$ oc apply -f <filename>
```
7. For each serverless application namespace that is a member in the `ServiceMeshMemberRoll` object, create the following `AuthorizationPolicy` resource:

```yaml
apiVersion: security.istio.io/v1beta1
customKind: AuthorizationPolicy
metadata:
  name: require-jwt
  namespace: <namespace>
spec:
  action: ALLOW
  rules:
    - from:
    - source:
      - requestPrincipals: ["testing@secure.istio.io/testing@secure.istio.io"]
```

8. Apply the `AuthorizationPolicy` resource:

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

Verification

1. If you try to use a `curl` request to get the Knative service URL, it is denied:

   **Example command**
   ```bash
   $ curl http://hello-example-1-default.apps.mycluster.example.com/
   
   **Example output**
   
   RBAC: access denied
   
2. Verify the request with a valid JWT.
   a. Get the valid JWT token:
   ```bash
   $ TOKEN=$(curl https://raw.githubusercontent.com/istio/istio/release-1.8/security/tools/jwt/samples/demo.jwt -s) && echo "$TOKEN" | cut -d '.' -f2 - | base64 --decode
   
   **Example output**
   ```
   
   b. Access the service by using the valid token in the `curl` request header:
   ```bash
   
   The request is now allowed:
   
   **Example output**
   ```
   
   Hello OpenShift!

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

**IMPORTANT**

Adding sidecar injection to pods in system namespaces, such as `knative-serving` and `knative-serving-ingress`, is not supported when Kourier is enabled.

Prerequisites

- You have installed the OpenShift Serverless Operator, Knative Serving, and Red Hat OpenShift Service Mesh on your cluster.
- Install the OpenShift CLI (`oc`).
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

Procedure

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

   **Example service**

   ```yaml
   apiVersion: serving.knative.dev/v1
   kind: Service
   metadata:
     name: <service_name>
   spec:
     template:
       metadata:
         annotations:
           sidecar.istio.io/inject: "true" ¹
           sidecar.istio.io/rewriteAppHTTPProbers: "true" ²
   ...
   
   ¹ Add the `sidecar.istio.io/inject="true"` annotation.
   ² You must set the annotation `sidecar.istio.io/rewriteAppHTTPProbers: "true"` in your Knative service, because OpenShift Serverless versions 1.14.0 and higher use an HTTP probe as the readiness probe for Knative services by default.

2. Apply the Service resource:

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

3. Create a policy in a serverless application namespace which is a member in the `ServiceMeshMemberRoll` object, that only allows requests with valid JSON Web Tokens (JWT):
IMPORTANT

The paths /metrics and /healthz must be included in excludedPaths because they are accessed from system pods in the knative-serving namespace.

apiVersion: authentication.istio.io/v1alpha1
kind: Policy
metadata:
  name: default
  namespace: <namespace>
spec:
  origins:
    - jwt:
      issuer: testing@secure.istio.io
  triggerRules:
    - excludedPaths:
      - prefix: /metrics
      - prefix: /healthz
  principalBinding: USE_ORIGIN

1 The path on your application to collect metrics by system pod.
2 The path on your application to probe by system pod.

4. Apply the Policy resource:

   $ oc apply -f <filename>

Verification

1. If you try to use a curl request to get the Knative service URL, it is denied:

   $ curl http://hello-example-default.apps.mycluster.example.com/

Example output

   Origin authentication failed.

2. Verify the request with a valid JWT.

   a. Get the valid JWT token:

   $ TOKEN=$(curl https://raw.githubusercontent.com/istio/istio/release-1.6/security/tools/jwt/samples/demo.jwt -s) && echo "$TOKEN" | cut -d '.' -f2 - | base64 --decode -

   b. Access the service by using the valid token in the curl request header:

The request is now allowed:

**Example output**

```
Hello OpenShift!
```

### 10.2. CONFIGURING A CUSTOM DOMAIN FOR A KNATIVE SERVICE

Knative services are automatically assigned a default domain name based on your cluster configuration. For example, `<service_name>`-<namespace>.example.com. You can customize the domain for your Knative service by mapping a custom domain name that you own to a Knative service.

You can do this by creating a **DomainMapping** resource for the service. You can also create multiple **DomainMapping** resources to map multiple domains and subdomains to a single service.

#### 10.2.1. Creating a custom domain mapping

You can customize the domain for your Knative service by mapping a custom domain name that you own to a Knative service. To map a custom domain name to a custom resource (CR), you must create a **DomainMapping** CR that maps to an Addressable target CR, such as a Knative service or a Knative route.

**Prerequisites**

- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.
- Install the OpenShift CLI (**oc**).
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You have created a Knative service and control a custom domain that you want to map to that service.

**NOTE**

Your custom domain must point to the IP address of the OpenShift Dedicated cluster.

**Procedure**

1. Create a YAML file containing the **DomainMapping** CR in the same namespace as the target CR you want to map to:

```
apiVersion: serving.knative.dev/v1alpha1
kind: DomainMapping
metadata:
  name: <domain_name>  
  namespace: <namespace>  
spec:
  ref:
```

OpenShift Dedicated 4 Serverless
1. The custom domain name that you want to map to the target CR.
2. The namespace of both the DomainMapping CR and the target CR.
3. The name of the target CR to map to the custom domain.
4. The type of CR being mapped to the custom domain.

**Example service domain mapping**

```yaml
apiVersion: serving.knative.dev/v1alpha1
kind: DomainMapping
metadata:
  name: example-domain
  namespace: default
spec:
  ref:
    name: example-service
    kind: Service
    apiVersion: serving.knative.dev/v1
```

**Example route domain mapping**

```yaml
apiVersion: serving.knative.dev/v1alpha1
kind: DomainMapping
metadata:
  name: example-domain
  namespace: default
spec:
  ref:
    name: example-route
    kind: Route
    apiVersion: serving.knative.dev/v1
```

2. Apply the **DomainMapping** CR as a YAML file:

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

### 10.2.2. Creating a custom domain mapping by using the Knative CLI

You can customize the domain for your Knative service by mapping a custom domain name that you own to a Knative service. You can use the Knative (kn) CLI to create a **DomainMapping** custom resource (CR) that maps to an Addressable target CR, such as a Knative service or a Knative route.

**Prerequisites**

- The OpenShift Serverless Operator and Knative Serving are installed on your cluster.
You have created a Knative service or route, and control a custom domain that you want to map to that CR.

**NOTE**

Your custom domain must point to the DNS of the OpenShift Dedicated cluster.

- You have installed the Knative (**kn**) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

**Procedure**

- Map a domain to a CR in the current namespace:

  ```
  $ kn domain create <domain_mapping_name> --ref <target_name>
  
  Example command
  
  $ kn domain create example-domain-map --ref example-service
  ```

  The `--ref` flag specifies an Addressable target CR for domain mapping.
  
  If a prefix is not provided when using the `--ref` flag, it is assumed that the target is a Knative service in the current namespace.

- Map a domain to a Knative service in a specified namespace:

  ```
  $ kn domain create <domain_mapping_name> --ref <ksvc:service_name:service_namespace>
  
  Example command
  
  $ kn domain create example-domain-map --ref ksvc:example-service:example-namespace
  ```

- Map a domain to a Knative route:

  ```
  $ kn domain create <domain_mapping_name> --ref <kroute:route_name>
  
  Example command
  
  $ kn domain create example-domain-map --ref kroute:example-route
  ```

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

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

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

You are in the Developer perspective.

The OpenShift Serverless Operator and Knative Serving are installed on your cluster. This must be completed by a cluster administrator.

You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.

You have created a Knative service and control a custom domain that you want to map to that service.

NOTE
Your custom domain must point to the IP address of the OpenShift Dedicated cluster.

Procedure

1. Navigate to the Topology page.

2. Right-click on the service that you want to map to a domain, and select the Edit option that contains the service name. For example, if the service is named example-service, select the Edit example-service option.

3. In the Advanced options section, click Show advanced Routing options.
   a. If the domain mapping CR that you want to map to the service already exists, you can select it in the Domain mapping list.
   b. If you want to create a new domain mapping CR, type the domain name into the box, and select the Create option. For example, if you type in example.com, the Create option is Create "example.com".

4. Click Save to save the changes to your service.

Verification

1. Navigate to the Topology page.

2. Click on the service that you have created.

3. In the Resources tab of the service information window, you can see the domain you have mapped to the service listed under Domain mappings.

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

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

Prerequisites

- You configured a custom domain for a Knative service and have a working DomainMapping CR.
- You have a TLS certificate from your Certificate Authority provider or a self-signed certificate.

- You have obtained the cert and key files from your Certificate Authority provider, or a self-signed certificate.

- Install the OpenShift CLI (oc).

**Procedure**

1. Create a Kubernetes TLS secret:

   ```bash
   $ oc create secret tls <tls_secret_name> --cert=<path_to_certificate_file> --key=<path_to_key_file>
   ```

2. If you are using Red Hat OpenShift Service Mesh as the ingress for your OpenShift Serverless installation, label the Kubernetes TLS secret with the following:

   ```bash
   "networking.internal.knative.dev/certificate-uid": "<value>"
   ```

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

   **NOTE**

   The cert-manager Operator for Red Hat OpenShift is a Technology Preview feature. For more information, see the [Installing the cert-manager Operator for Red Hat OpenShift](#) documentation.

3. Update the DomainMapping CR to use the TLS secret that you have created:

   ```yaml
   apiVersion: serving.knative.dev/v1alpha1
   kind: DomainMapping
   metadata:
     name: <domain_name>
     namespace: <namespace>
   spec:
     ref:
       name: <service_name>
       kind: Service
   apiVersion: serving.knative.dev/v1
   # TLS block specifies the secret to be used
   tls:
     secretName: <tls_secret_name>
   ```

**Verification**

1. Verify that the DomainMapping CR status is True, and that the URL column of the output shows the mapped domain with the scheme https:

   ```bash
   $ oc get domainmapping <domain_name>
   ```
Example output

<table>
<thead>
<tr>
<th>NAME</th>
<th>URL</th>
<th>READY</th>
<th>REASON</th>
</tr>
</thead>
<tbody>
<tr>
<td>example.com</td>
<td><a href="https://example.com">https://example.com</a></td>
<td>True</td>
<td></td>
</tr>
</tbody>
</table>

2. Optional: If the service is exposed publicly, verify that it is available by running the following command:

```bash
$ curl https://<domain_name>
```

If the certificate is self-signed, skip verification by adding the `-k` flag to the `curl` command.
CHAPTER 11. FUNCTIONS

11.1. SETTING UP OPENSSHIFT SERVERLESS FUNCTIONS

IMPORTANT

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

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

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

11.1.1. Prerequisites

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

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

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

- The oc CLI is installed on your cluster.

- The Knative (kn) CLI is installed on your cluster. Installing the Knative CLI enables the use of kn func commands which you can use to create and manage functions.

- You have installed Docker Container Engine or podman version 3.3 or higher, and have access to an available image registry.

- If you are using Quay.io as the image registry, you must ensure that either the repository is not private, or that you have allowed pods on your cluster to reference images from other secured registries.

- If you are using the OpenShift Container Registry, a cluster or dedicated administrator must expose the registry.

11.1.2. Setting up podman

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

1. Start the podman service that serves the Docker API on a UNIX socket at
   \:${XDG_RUNTIME_DIR}/podman/podman.sock:
   
   $ systemctl start --user podman.socket

   **NOTE**
   
   On most systems, this socket is located at /run/user/$(id -u)/podman/podman.sock.

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

   $ export DOCKER_HOST="unix://$\{XDG_RUNTIME_DIR\}/podman/podman.sock"

3. Run the build command with -v to see verbose output. You should see a connection to your local UNIX socket:

   $ kn func build -v

11.1.3. Next steps

- See Getting started with functions.

11.2. GETTING STARTED WITH FUNCTIONS

Function lifecycle management includes creating, building, and deploying a function. Optionally, you can also test a deployed function by invoking it. You can do all of these operations on OpenShift Serverless using the `kn func` tool.

**IMPORTANT**

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11.2.1. Prerequisites

Before you can complete the following procedures, you must ensure that you have completed all of the prerequisite tasks in Setting up OpenShift Serverless Functions.

11.2.2. Creating functions
Before you can build and deploy a function, you must create it by using the the Knative (kn) CLI. You can specify the path, runtime, template, and image registry as flags on the command line, or use the -c flag to start the interactive experience in the terminal.

Prerequisites
- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (kn) CLI.

Procedure
- Create a function project:

```bash
$ kn func create -r <repository> -l <runtime> -t <template> <path>
```

- Accepted runtime values include node, go, python, quarkus, and typescript.
- Accepted template values include http and events.

**Example command**

```bash
$ kn func create -l typescript -t events examplefunc
```

**Example output**

```
Project path: /home/user/demo/examplefunc
Function name: examplefunc
Runtime: typescript
Template: events
Writing events to /home/user/demo/examplefunc
```

- Alternatively, you can specify a repository that contains a custom template.

**Example command**

```bash
$ kn func create -r https://github.com/boson-project/templates/ -l node -t hello-world examplefunc
```

**Example output**

```
Project path: /home/user/demo/examplefunc
Function name: examplefunc
Runtime: node
Template: hello-world
Writing events to /home/user/demo/examplefunc
```

11.2.3. Running a function locally

You can use the kn func run command to run a function locally in the current directory or in the directory specified by the --path flag. If the function that you are running has never previously been built, or if the project files have been modified since the last time it was built, the kn func run command builds the function before running it by default.
### Example command to run a function in the current directory

```bash
$ kn func run
```

### Example command to run a function in a directory specified as a path

```bash
$ kn func run --path=<directory_path>
```

You can also force a rebuild of an existing image before running the function, even if there have been no changes to the project files, by using the `--build` flag:

### Example run command using the build flag

```bash
$ kn func run --build
```

If you set the `build` flag as false, this disables building of the image, and runs the function using the previously built image:

### Example run command using the build flag

```bash
$ kn func run --build=false
```

You can use the help command to learn more about `kn func run` command options:

### Build help command

```bash
$ kn func help run
```

#### 11.2.4. Building functions

Before you can run a function, you must build the function project. If you are using the `kn func run` command, the function is built automatically. However, you can use the `kn func build` command to build a function without running it, which can be useful for advanced users or debugging scenarios.

The `kn func build` command creates an OCI container image that can be run locally on your computer or on an OpenShift Dedicated cluster. This command uses the function project name and the image registry name to construct a fully qualified image name for your function.

#### 11.2.4.1. Image container types

By default, `kn func build` creates a container image by using Red Hat Source-to-Image (S2I) technology.

### Example build command using Red Hat Source-to-Image (S2I)

```bash
$ kn func build
```

You can use CNCF Cloud Native Buildpacks technology instead, by adding the `--builder` flag to the command and specifying the `pack` strategy:

### Example build command using CNCF Cloud Native Buildpacks

```bash
$ kn func build --builder=pack
```
11.2.4.2. Image registry types

The OpenShift Container Registry is used by default as the image registry for storing function images.

**Example build command using OpenShift Container Registry**

```
$ kn func build
```

**Example output**

Building function image
Function image has been built, image: registry.redhat.io/example/example-function:latest

You can override using OpenShift Container Registry as the default image registry by using the `--registry` flag:

**Example build command overriding OpenShift Container Registry to use quay.io**

```
$ kn func build --registry quay.io/username
```

**Example output**

Building function image
Function image has been built, image: quay.io/username/example-function:latest

11.2.4.3. Push flag

You can add the `--push` flag to a `kn func build` command to automatically push the function image after it is successfully built:

**Example build command using OpenShift Container Registry**

```
$ kn func build --push
```

11.2.4.4. Help command

You can use the help command to learn more about `kn func build` command options:

**Build help command**

```
$ kn func help build
```

11.2.5. Building and deploying functions on the cluster

You can use the Knative (kn) CLI to initiate a function project build and then deploy the function directly on the cluster. To build a function project in this way, the source code for your function project must exist in a Git repository branch that is accessible to your cluster.
IMPORTANT

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

Prerequisites

- Red Hat OpenShift Pipelines must be installed on your cluster.
- You have installed the OpenShift (oc) CLI.
- You have installed the Knative (kn) CLI.

Procedure

1. In each namespace where you want to run Pipelines and deploy a function, you must create the following resources:
   a. Create the functions buildpacks Tekton task to be able to build the function image:

```
$ oc apply -f https://raw.githubusercontent.com/openshift-knative/kn-plugin-func/serverless-1.22.0/pipelines/resources/tekton/task/func-buildpacks/0.1/func-buildpacks.yaml
```

   b. Create the `kn func` deploy Tekton task to be able to deploy the function in the pipeline:

```
$ oc apply -f https://raw.githubusercontent.com/openshift-knative/kn-plugin-func/serverless-1.22.0/pipelines/resources/tekton/task/func-deploy/0.1/func-deploy.yaml
```

2. Create a function:

```
$ kn func create <function_name> -l <runtime>
```

3. After you have created a new function project, you must add the project to a Git repository and ensure that the repository is available to the cluster. Information about this Git repository is used to update the `func.yaml` file in the next step.

4. Update the configuration in the `func.yaml` file for your function project to enable on-cluster builds for the Git repository:

```
... 
build: git
  git:
    url: <git_repository_url>
    revision: main
    contextDir: <directory_path>
...
```
1. Required. Specify git build type.

2. Required. Specify the Git repository that contains your function’s source code.

3. Optional. Specify the Git repository revision to be used. This can be a branch, tag or commit.

4. Optional. Specify the function’s directory path if the function is not located in the Git repository root folder.

5. Implement the business logic of your function. Then, use Git to commit and push the changes.

6. Deploy your function:

   ```
   $ kn func deploy
   ```

   If you are not logged into the container registry referenced in your function configuration, you are prompted to provide credentials for the remote container registry that hosts the function image:

   **Example output and prompts**

   ```
   Creating Pipeline resources
   Please provide credentials for image registry used by Pipeline.
   ? Server: https://index.docker.io/v1/
   ? Username: my-repo
   ? Password: ********
   Function deployed at URL: http://test-function.default.svc.cluster.local
   ```

7. To update your function, commit and push new changes by using Git, then run the `kn func deploy` command again.

11.2.6. Deploying functions

You can deploy a function to your cluster as a Knative service by using the `kn func deploy` command. If the targeted function is already deployed, it is updated with a new container image that is pushed to a container image registry, and the Knative service is updated.

**Prerequisites**

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (kn) CLI.
- You have created a project or have access to a project with the appropriate roles and permissions to create applications and other workloads in OpenShift Dedicated.
- You must have already created and initialized the function that you want to deploy.

**Procedure**

- Deploy a function:

  ```
  $ kn func deploy [-n <namespace> -p <path> -i <image>]
  ```
Example output

- If no namespace is specified, the function is deployed in the current namespace.
- The function is deployed from the current directory, unless a path is specified.
- The Knative service name is derived from the project name, and cannot be changed using this command.

11.2.7. Invoking a deployed function with a test event

You can use the `kn func invoke` CLI command to send a test request to invoke a function either locally or on your OpenShift Dedicated cluster. This command can be used to test that a function is working and able to receive events correctly.

Example command

```bash
$ kn func invoke
```

The `kn func invoke` command executes on the local directory by default, and assumes that this directory is a function project.

11.2.8. Next steps

- See Using functions with Knative Eventing

11.3. DEVELOPING NODE.JS FUNCTIONS

**IMPORTANT**

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After you have created a Node.js function project, you can modify the template files provided to add business logic to your function. This includes configuring function invocation and the returned headers and status codes.

11.3.1. Prerequisites

- Before you can develop functions, you must complete the steps in Setting up OpenShift Serverless Functions.

11.3.2. Node.js function template structure
When you create a Node.js function using the Knative (kn) CLI, the project directory looks like a typical Node.js project. The only exception is the additional `func.yaml` file, which is used to configure the function.

Both http and event trigger functions have the same template structure:

**Template structure**

```
.  ├── func.yaml
    ├── index.js
    │    └── README.md
    ├── package.json
    └── test
        ├── integration.js
        └── unit.js
```

1. The `func.yaml` configuration file is used to determine the image name and registry.
2. Your project must contain an `index.js` file which exports a single function.
3. You are not restricted to the dependencies provided in the template `package.json` file. You can add additional dependencies as you would in any other Node.js project.

**Example of adding npm dependencies**

```
npm install --save opossum
```

When the project is built for deployment, these dependencies are included in the created runtime container image.

4. Integration and unit test scripts are provided as part of the function template.

### 11.3.3. About invoking Node.js functions

When using the Knative (kn) CLI to create a function project, you can generate a project that responds to CloudEvents, or one that responds to simple HTTP requests. CloudEvents in Knative are transported over HTTP as a POST request, so both function types listen for and respond to incoming HTTP events.

Node.js functions can be invoked with a simple HTTP request. When an incoming request is received, functions are invoked with a `context` object as the first parameter.

#### 11.3.3.1. Node.js context objects

Functions are invoked by providing a `context` object as the first parameter. This object provides access to the incoming HTTP request information.

**Example context object**

```
function handle(context, data)
```

This information includes the HTTP request method, any query strings or headers sent with the request, the HTTP version, and the request body. Incoming requests that contain a `CloudEvent` attach the
incoming instance of the CloudEvent to the context object so that it can be accessed by using `context.cloudEvent`.

### 11.3.3.1.1. Context object methods

The `context` object has a single method, `cloudEventResponse()`, that accepts a data value and returns a CloudEvent.

In a Knative system, if a function deployed as a service is invoked by an event broker sending a CloudEvent, the broker examines the response. If the response is a CloudEvent, this event is handled by the broker.

#### Example context object method

```javascript
// Expects to receive a CloudEvent with customer data
function handle(context, customer) {
  // process the customer
  const processed = handle(customer);
  return context.cloudEventResponse(customer)
    .source('/handle')
    .type('fn.process.customer')
    .response();
}
```

### 11.3.3.1.2. CloudEvent data

If the incoming request is a CloudEvent, any data associated with the CloudEvent is extracted from the event and provided as a second parameter. For example, if a CloudEvent is received that contains a JSON string in its data property that is similar to the following:

```json
{
  "customerId": "0123456",
  "productId": "6543210"
}
```

When invoked, the second parameter to the function, after the `context` object, will be a JavaScript object that has `customerId` and `productId` properties.

#### Example signature

```javascript
function handle(context, data)
```

The `data` parameter in this example is a JavaScript object that contains the `customerId` and `productId` properties.

### 11.3.4. Node.js function return values

Functions can return any valid JavaScript type or can have no return value. When a function has no return value specified, and no failure is indicated, the caller receives a 204 No Content response.

Functions can also return a CloudEvent or a `Message` object in order to push events into the Knative Eventing system. In this case, the developer is not required to understand or implement the CloudEvent messaging specification. Headers and other relevant information from the returned values are extracted and sent with the response.
11.3.4.1. Returning headers

You can set a response header by adding a `headers` property to the `return` object. These headers are extracted and sent with the response to the caller.

Example response header

```javascript
function handle(context, customer) {
    // process customer and return custom headers
    // the response will be '204 No content'
    return { headers: { customerid: customer.id } }
}
```

11.3.4.2. Returning status codes

You can set a status code that is returned to the caller by adding a `statusCode` property to the `return` object:

Example status code

```javascript
function handle(context, customer) {
    // process customer
    if (customer.restricted) {
        return { statusCode: 451 }
    }
}
```

Status codes can also be set for errors that are created and thrown by the function:

Example error status code

```javascript
function handle(context, customer) {
    // process customer
    if (customer.restricted) {
        const err = new Error('Unavailable for legal reasons');
        err.statusCode = 451;
        throw err;
    }
}
```

11.3.5. Testing Node.js functions
Node.js functions can be tested locally on your computer. In the default project that is created when you create a function by using `kn func create`, there is a test folder that contains some simple unit and integration tests.

### Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (kn) CLI.
- You have created a function by using `kn func create`.

### Procedure

1. Navigate to the test folder for your function.
2. Run the tests:
   ```bash
   $ npm test
   ```

### 11.3.6. Next steps

- See the Node.js context object reference documentation.
- Build and deploy a function.

### 11.4. DEVELOPING TYPESCRIPT FUNCTIONS

**IMPORTANT**

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

After you have created a TypeScript function project, you can modify the template files provided to add business logic to your function. This includes configuring function invocation and the returned headers and status codes.

### 11.4.1. Prerequisites

- Before you can develop functions, you must complete the steps in Setting up OpenShift Serverless Functions.

### 11.4.2. TypeScript function template structure
When you create a TypeScript function using the Knative (kn) CLI, the project directory looks like a typical TypeScript project. The only exception is the additional `func.yaml` file, which is used for configuring the function.

Both `http` and `event` trigger functions have the same template structure:

**Template structure**

```
├── func.yaml 1
├── package.json 2
├── package-lock.json
├── README.md
├── src
│   └── index.ts 3
├── test
│   ├── integration.ts
│   └── unit.ts
└── tsconfig.json
```

1. The `func.yaml` configuration file is used to determine the image name and registry.
2. You are not restricted to the dependencies provided in the template `package.json` file. You can add additional dependencies as you would in any other TypeScript project.

**Example of adding npm dependencies**

```bash
npm install --save opossum
```

When the project is built for deployment, these dependencies are included in the created runtime container image.

3. Your project must contain an `src/index.js` file which exports a function named `handle`.
4. Integration and unit test scripts are provided as part of the function template.

### 11.4.3. About invoking TypeScript functions

When using the Knative (kn) CLI to create a function project, you can generate a project that responds to CloudEvents or one that responds to simple HTTP requests. CloudEvents in Knative are transported over HTTP as a POST request, so both function types listen for and respond to incoming HTTP events.

TypeScript functions can be invoked with a simple HTTP request. When an incoming request is received, functions are invoked with a `context` object as the first parameter.

#### 11.4.3.1. TypeScript context objects

To invoke a function, you provide a `context` object as the first parameter. Accessing properties of the `context` object can provide information about the incoming HTTP request.

**Example context object**

```typescript
function handle(context: Context): string
```
This information includes the HTTP request method, any query strings or headers sent with the request, the HTTP version, and the request body. Incoming requests that contain a `CloudEvent` attach the incoming instance of the CloudEvent to the context object so that it can be accessed by using `context.cloudevent`.

11.4.3.1.1. Context object methods

The `context` object has a single method, `cloudEventResponse()`, that accepts a data value and returns a `CloudEvent`.

In a Knative system, if a function deployed as a service is invoked by an event broker sending a CloudEvent, the broker examines the response. If the response is a CloudEvent, this event is handled by the broker.

Example context object method

```javascript
// Expects to receive a CloudEvent with customer data
export function handle(context: Context, cloudevent?: CloudEvent): CloudEvent {
  // process the customer
  const customer = cloudevent.data;
  const processed = processCustomer(customer);  
  return context.cloudEventResponse(customer)
    .source('/customer/process')
    .type('customer.processed')
    .response();
}
```

11.4.3.1.2. Context types

The TypeScript type definition files export the following types for use in your functions.

Exported type definitions

```javascript
// Invokable is the expected Function signature for user functions
export interface Invokable {
  (context: Context, cloudevent?: CloudEvent): any
}

// Logger can be used for structural logging to the console
export interface Logger {
  debug: (msg: any) => void,
  info:  (msg: any) => void,
  warn:  (msg: any) => void,
  error: (msg: any) => void,
  fatal: (msg: any) => void,
  trace: (msg: any) => void,
}

// Context represents the function invocation context, and provides
// access to the event itself as well as raw HTTP objects.
export interface Context {
  log: Logger;
  req: IncomingMessage;
  query?: Record<string, any>;
  body?: Record<string, any> | string;
}
```
If the incoming request is a CloudEvent, any data associated with the CloudEvent is extracted from the event and provided as a second parameter. For example, if a CloudEvent is received that contains a JSON string in its data property that is similar to the following:

```
{
  "customerId": "0123456",
  "productId": "6543210"
}
```

When invoked, the second parameter to the function, after the `context` object, will be a JavaScript object that has `customerId` and `productId` properties.

**Example signature**

```javascript
function handle(context: Context, cloudevent?: CloudEvent): CloudEvent
```

The `cloudevent` parameter in this example is a JavaScript object that contains the `customerId` and `productId` properties.

### 11.4.4. TypeScript function return values

Functions can return any valid JavaScript type or can have no return value. When a function has no return value specified, and no failure is indicated, the caller receives a **204 No Content** response.

Functions can also return a CloudEvent or a `Message` object in order to push events into the Knative Eventing system. In this case, the developer is not required to understand or implement the CloudEvent messaging specification. Headers and other relevant information from the returned values are extracted and sent with the response.

**Example**

```javascript
export const handle: Invokable = function (context: Context,
```

---

**OpenShift Dedicated 4 Serverless**

274
11.4.4.1. Returning headers

You can set a response header by adding a `headers` property to the `return` object. These headers are extracted and sent with the response to the caller.

**Example response header**

```javascript
export function handle(context: Context, cloudevent?: CloudEvent): Record<string, any> {
  // process customer and return custom headers
  const customer = cloudevent.data as Record<string, any>;
  return { headers: { 'customer-id': customer.id } };
}
```

11.4.4.2. Returning status codes

You can set a status code that is returned to the caller by adding a `statusCode` property to the `return` object:

**Example status code**

```javascript
export function handle(context: Context, cloudevent?: CloudEvent): Record<string, any> {
  // process customer
  const customer = cloudevent.data as Record<string, any>;
  if (customer.restricted) {
    return { statusCode: 451
  }
  // business logic, then
  return { statusCode: 240
  }
}
```

Status codes can also be set for errors that are created and thrown by the function:

**Example error status code**

```javascript
export function handle(context: Context, cloudevent?: CloudEvent): Record<string, string> {
  // process customer
  const customer = cloudevent.data as Record<string, any>;
  if (customer.restricted) {
```
11.4.5. Testing TypeScript functions

TypeScript functions can be tested locally on your computer. In the default project that is created when you create a function using `kn func create`, there is a test folder that contains some simple unit and integration tests.

**Prerequisites**

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (kn) CLI.
- You have created a function by using `kn func create`.

**Procedure**

1. If you have not previously run tests, install the dependencies first:
   
   ```sh
   $ npm install
   ```

2. Navigate to the test folder for your function.

3. Run the tests:
   
   ```sh
   $ npm test
   ```

**11.4.6. Next steps**

- See the TypeScript context object reference documentation.
- Build and deploy a function.
- See the Pino API documentation for more information on logging with functions.

11.5. DEVELOPING GO FUNCTIONS

**IMPORTANT**

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

For more information about the support scope of Red Hat Technology Preview features, see [https://access.redhat.com/support/offerings/techpreview/](https://access.redhat.com/support/offerings/techpreview/).
After you have created a Go function project, you can modify the template files provided to add business logic to your function. This includes configuring function invocation and the returned headers and status codes.

### 11.5.1. Prerequisites

- Before you can develop functions, you must complete the steps in Setting up OpenShift Serverless Functions.

### 11.5.2. Go function template structure

When you create a Go function using the Knative *(kn)* CLI, the project directory looks like a typical Go project. The only exception is the additional `func.yaml` configuration file, which is used for specifying the image.

Go functions have few restrictions. The only requirements are that your project must be defined in a function module, and must export the function `Handle()`.

Both **http** and **event** trigger functions have the same template structure:

**Template structure**

```
fn
| README.md
| func.yaml
| go.mod
| go.sum
| handle.go
| handle_test.go
```

1. The `func.yaml` configuration file is used to determine the image name and registry.
2. You can add any required dependencies to the `go.mod` file, which can include additional local Go files. When the project is built for deployment, these dependencies are included in the resulting runtime container image.

**Example of adding dependencies**

```
$ go get gopkg.in/yaml.v2@v2.4.0
```

### 11.5.3. About invoking Go functions

When using the Knative *(kn)* CLI to create a function project, you can generate a project that responds to CloudEvents, or one that responds to simple HTTP requests. Go functions are invoked by using different methods, depending on whether they are triggered by an HTTP request or a CloudEvent.

#### 11.5.3.1. Functions triggered by an HTTP request

When an incoming HTTP request is received, functions are invoked with a standard Go `Context` as the first parameter, followed by the `http.ResponseWriter` and `http.Request` parameters. You can use standard Go techniques to access the request, and set a corresponding HTTP response for your function.
Example HTTP response

```go
func Handle(ctx context.Context, res http.ResponseWriter, req *http.Request) {
    // Read body
    body, err := ioutil.ReadAll(req.Body)
    defer req.Body.Close()
    if err != nil {
        http.Error(res, err.Error(), 500)
        return
    }
    // Process body and function logic
    // ...}
}
```

11.5.3.2. Functions triggered by a cloud event

When an incoming cloud event is received, the event is invoked by the CloudEvents Go SDK. The invocation uses the `Event` type as a parameter.

You can leverage the Go `Context` as an optional parameter in the function contract, as shown in the list of supported function signatures:

**Supported function signatures**

- `Handle() error`
- `Handle(context.Context) error`
- `Handle(cloudevents.Event) error`
- `Handle(context.Context, cloudevents.Event) error`
- `Handle(cloudevents.Event) *cloudevents.Event`
- `Handle(cloudevents.Event) (*cloudevents.Event, error)`

11.5.3.2.1. CloudEvent trigger example

A cloud event is received which contains a JSON string in the data property:

```json
{
    "customerId": "0123456",
    "productId": "6543210"
}
```

To access this data, a structure must be defined which maps properties in the cloud event data, and retrieves the data from the incoming event. The following example uses the `Purchase` structure:

```go
type Purchase struct {
    CustomerId string `json:"customerId"
    ProductId string `json:"productId"
}

func Handle(ctx context.Context, event cloudevents.Event) (err error) {

```
Alternatively, a Go encoding/json package could be used to access the cloud event directly as JSON in the form of a bytes array:

```go
func Handle(ctx context.Context, event cloudevents.Event) {
    bytes, err := json.Marshal(event)
    // ...
}
```

### 11.5.4. Go function return values

Functions triggered by HTTP requests can set the response directly. You can configure the function to do this by using the Go http.ResponseWriter.

**Example HTTP response**

```go
func Handle(ctx context.Context, res http.ResponseWriter, req *http.Request) {
    // Set response
    res.Header().Add("Content-Type", "text/plain")
    res.Header().Add("Content-Length", "3")
    res.WriteHeader(200)
    _, err := fmt.Fprintf(res, "OK\n")
    if err != nil {
        fmt.Fprintf(os.Stderr, "error or response write: %v", err)
    }
}
```

Functions triggered by a cloud event might return nothing, error, or CloudEvent in order to push events into the Knative Eventing system. In this case, you must set a unique ID, proper Source, and a Type for the cloud event. The data can be populated from a defined structure, or from a map.

**Example CloudEvent response**

```go
func Handle(ctx context.Context, event cloudevents.Event) (resp *cloudevents.Event, err error) {
    // ...
    response := cloudevents.NewEvent()
    response.SetID("example-uuid-32943bac6fea")
    response.SetSource("purchase/getter")
    response.SetType("purchase")
    // Set the data from Purchase type
    response.SetData(cloudevents.ApplicationJSON, Purchase{
        CustomerId: custId,
        ProductId:  prodId,
    })
    // OR set the data directly from map
    response.SetData(cloudevents.ApplicationJSON, map[string]string{"customerId": custId, "productId":
```
11.5.5. Testing Go functions

Go functions can be tested locally on your computer. In the default project that is created when you create a function using `kn func create`, there is a `handle_test.go` file, which contains some basic tests. These tests can be extended as needed.

Prerequisites

- The OpenShift Serverless Operator and Knative Serving are installed on the cluster.
- You have installed the Knative (`kn`) CLI.
- You have created a function by using `kn func create`.

Procedure

1. Navigate to the `test` folder for your function.
2. Run the tests:

```
$ go test
```

11.5.6. Next steps

- Build and deploy a function.

11.6. DEVELOPING PYTHON FUNCTIONS

**IMPORTANT**

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

After you have created a Python function project, you can modify the template files provided to add business logic to your function. This includes configuring function invocation and the returned headers and status codes.
11.6.1. Prerequisites

- Before you can develop functions, you must complete the steps in Setting up OpenShift Serverless Functions.

11.6.2. Python function template structure

When you create a Python function by using the Knative (kn) CLI, the project directory looks similar to a typical Python project. Python functions have very few restrictions. The only requirements are that your project contains a `func.py` file that contains a `main()` function, and a `func.yaml` configuration file.

Developers are not restricted to the dependencies provided in the template `requirements.txt` file. Additional dependencies can be added as they would be in any other Python project. When the project is built for deployment, these dependencies will be included in the created runtime container image.

Both http and event trigger functions have the same template structure:

**Template structure**

```plaintext
fn
├── func.py 1
├── func.yaml 2
├── requirements.txt 3
└── test_func.py 4
```

1. Contains a `main()` function.
2. Used to determine the image name and registry.
3. Additional dependencies can be added to the `requirements.txt` file as they are in any other Python project.
4. Contains a simple unit test that can be used to test your function locally.

11.6.3. About invoking Python functions

Python functions can be invoked with a simple HTTP request. When an incoming request is received, functions are invoked with a `context` object as the first parameter.

The `context` object is a Python class with two attributes:

- The `request` attribute is always present, and contains the Flask `request` object.
- The second attribute, `cloud_event`, is populated if the incoming request is a `CloudEvent` object.

Developers can access any `CloudEvent` data from the context object.

**Example context object**

```python
def main(context: Context):
    ""
    The context parameter contains the Flask request object and any CloudEvent received with the request.
    """```
11.6.4. Python function return values

Functions can return any value supported by Flask. This is because the invocation framework proxies these values directly to the Flask server.

Example

```python
def main(context: Context):
    body = { "message": "Howdy!" }
    headers = { "content-type": "application/json" }
    return body, 200, headers
```

Functions can set both headers and response codes as secondary and tertiary response values from function invocation.

11.6.4.1. Returning CloudEvents

Developers can use the @event decorator to tell the invoker that the function return value must be converted to a CloudEvent before sending the response.

Example

```python
@event("event_source="/my/function", "event_type"="my.type")
def main(context):
    # business logic here
    data = do_something()
    # more data processing
    return data
```

This example sends a CloudEvent as the response value, with a type of "my.type" and a source of "/my/function". The CloudEvent data property is set to the returned data variable. The event_source and event_type decorator attributes are both optional.

11.6.5. Testing Python functions

You can test Python functions locally on your computer. The default project contains a test_func.py file, which provides a simple unit test for functions.

NOTE

The default test framework for Python functions is unittest. You can use a different test framework if you prefer.

Prerequisites

- To run Python functions tests locally, you must install the required dependencies:

  $ pip install -r requirements.txt
**Procedure**

1. Navigate to the folder for your function that contains the `test_func.py` file.

2. Run the tests:

   ```bash
   $ python3 test_func.py
   ```

**11.6.6. Next steps**

- **Build** and **deploy** a function.

**11.7. DEVELOPING QUARKUS FUNCTIONS**

**IMPORTANT**

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

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

After you have [created a Quarkus function project], you can modify the template files provided to add business logic to your function. This includes configuring function invocation and the returned headers and status codes.

**11.7.1. Prerequisites**

- Before you can develop functions, you must complete the setup steps in [Setting up OpenShift Serverless Functions].

**11.7.2. Quarkus function template structure**

When you create a Quarkus function by using the Knative (`kn`) CLI, the project directory looks similar to a typical Maven project. Additionally, the project contains the `func.yaml` file, which is used for configuring the function.

Both **http** and **event** trigger functions have the same template structure:

**Template structure**

```
├── func.yaml
├── mvnw
├── mvnw.cmd
├── pom.xml
├── README.md
└── src
    └── main
```
1. Used to determine the image name and registry.

2. The Project Object Model (POM) file contains project configuration, such as information about dependencies. You can add additional dependencies by modifying this file.

Example of additional dependencies

```xml
<dependencies>
  <dependency>
    <groupId>junit</groupId>
    <artifactId>junit</artifactId>
    <version>4.11</version>
    <scope>test</scope>
  </dependency>
  <dependency>
    <groupId>org.assertj</groupId>
    <artifactId>assertj-core</artifactId>
    <version>3.8.0</version>
    <scope>test</scope>
  </dependency>
</dependencies>
```

Dependencies are downloaded during the first compilation.

3. The function project must contain a Java method annotated with `@Funq`. You can place this method in the `Function.java` class.

4. Contains simple test cases that can be used to test your function locally.

11.7.3. About invoking Quarkus functions

You can create a Quarkus project that responds to cloud events, or one that responds to simple HTTP requests. Cloud events in Knative are transported over HTTP as a POST request, so either function type can listen and respond to incoming HTTP requests.

When an incoming request is received, Quarkus functions are invoked with an instance of a permitted type.

Table 11.1. Function invocation options
### 11.7.3.1. Invocation examples

The following example code defines three functions named `withBeans`, `withCloudEvent`, and `withBinary`:

**Example**

```java
import io.quarkus.funqy.Funq;
import io.quarkus.funqy.knative.events.CloudEvent;

public class Input {
    private String message;
    // getters and setters
}

public class Output {
    // methods
}
```

The following example shows a function that receives and processes the `customerId` and `productId` purchase data that is listed in the previous table:

**Example Quarkus function**

```java
public class Functions {
    @Funq
    public void processPurchase(Purchase purchase) {
        // process the purchase
    }
}
```

The corresponding `Purchase` JavaBean class that contains the purchase data looks as follows:

**Example class**

```java
public class Purchase {
    private long customerId;
    private long productId;
    // getters and setters
}
```
The `withBeans` function of the `Functions` class can be invoked by:

- An HTTP POST request with a JSON body:

```bash
$ curl "http://localhost:8080/withBeans" -X POST \
-H "Content-Type: application/json" \
-d '{"message": "Hello there."}"
```

- An HTTP GET request with query parameters:

```bash
```

- A `CloudEvent` object in binary encoding:

```bash
$ curl "http://localhost:8080/" -X POST \
-H "Content-Type: application/json" \
-H "Ce-SpecVersion: 1.0" \
-H "Ce-Type: withBeans" \
-H "Ce-Source: cURL" \
-H "Ce-Id: 42" \
-d '{"message": "Hello there."}"
```

- A `CloudEvent` object in structured encoding:

```bash
$ curl http://localhost:8080/ \
-H "Content-Type: application/cloudevents+json" \
-d '{
  "data": {
    "message": "Hello there.",
    "datacontenttype": "application/json",
    "id": "42",
    "source": "curl",
    "type": "withBeans",
    "specversion": "1.0"
  }
}
```
The **withCloudEvent** function of the **Functions** class can be invoked by using a **CloudEvent** object, similarly to the **withBeans** function. However, unlike **withBeans**, **withCloudEvent** cannot be invoked with a plain HTTP request.

The **withBinary** function of the **Functions** class can be invoked by:

- A **CloudEvent** object in binary encoding:

```bash
$ curl "http://localhost:8080/" -X POST \
-H "Content-Type: application/octet-stream" \
-H "Ce-SpecVersion: 1.0" \
-H "Ce-Type: withBinary" \
-H "Ce-Source: cURL" \
-H "Ce-Id: 42" \n--data-binary '@img.jpg'
```

- A **CloudEvent** object in structured encoding:

```bash
$ curl http://localhost:8080/ \
-H "Content-Type: application/cloudevents+json" \
-d '{ "data_base64": "$\$(base64 --wrap=0 img.jpg)\n", \"datacontenttype\": \"application/octet-stream\", \"id\": \"42\", \"source\": \"curl\", \"type\": \"withBinary\", \"specversion\": \"1.0\"}"
```

### 11.7.4. CloudEvent attributes

If you need to read or write the attributes of a CloudEvent, such as **type** or **subject**, you can use the **CloudEvent<T>** generic interface and the **CloudEventBuilder** builder. The **<T>** type parameter must be one of the permitted types.

In the following example, **CloudEventBuilder** is used to return success or failure of processing the purchase:

```java
public class Functions {

    private boolean _processPurchase(Purchase purchase) {
        // do stuff
    }

    public CloudEvent<Void> processPurchase(CloudEvent<Purchase> purchaseEvent) {
        System.out.println("subject is: " + purchaseEvent.subject());

        if (!_processPurchase(purchaseEvent.data())) {
            return CloudEventBuilder.create() 
                .type("purchase.error") 
                .build();
        }

        return CloudEventBuilder.create()
            .type("purchase.success")
            .build();
    }
}
```
11.7.5. Quarkus function return values

Functions can return an instance of any type from the list of permitted types. Alternatively, they can return the \texttt{Uni<T>} type, where the \texttt{<T>} type parameter can be of any type from the permitted types.

The \texttt{Uni<T>} type is useful if a function calls asynchronous APIs, because the returned object is serialized in the same format as the received object. For example:

- If a function receives an HTTP request, then the returned object is sent in the body of an HTTP response.
- If a function receives a \texttt{CloudEvent} object in binary encoding, then the returned object is sent in the data property of a binary-encoded \texttt{CloudEvent} object.

The following example shows a function that fetches a list of purchases:

Example command

```java
public class Functions {
    @Funq
    public List<Purchase> getPurchasesByName(String name) {
        // logic to retrieve purchases
    }
}
```

- Invoking this function through an HTTP request produces an HTTP response that contains a list of purchases in the body of the response.
- Invoking this function through an incoming \texttt{CloudEvent} object produces a \texttt{CloudEvent} response with a list of purchases in the \texttt{data} property.

11.7.5.1. Permitted types

The input and output of a function can be any of the \texttt{void}, \texttt{String}, or \texttt{byte[]} types. Additionally, they can be primitive types and their wrappers, for example, \texttt{int} and \texttt{Integer}. They can also be the following complex objects: Javabeans, maps, lists, arrays, and the special \texttt{CloudEvents<T>} type.

Maps, lists, arrays, the \texttt{<T>} type parameter of the \texttt{CloudEvents<T>} type, and attributes of Javabeans can only be of types listed here.

Example

```java
public class Functions {
    public List<Integer> getIds();
    public Purchase[] getPurchasesByName(String name);
    public String getNameById(int id);
    public Map<String,Integer> getNameIdMapping();
    public void processImage(byte[] img);
}
```

11.7.6. Testing Quarkus functions
Quarkus functions can be tested locally on your computer. In the default project that is created when you create a function using `kn func create`, there is the `src/test/` directory, which contains basic Maven tests. These tests can be extended as needed.

**Prerequisites**

- You have created a Quarkus function.
- You have installed the Knative (kn) CLI.

**Procedure**

1. Navigate to the project folder for your function.
2. Run the Maven tests:

   ```sh
   $ ./mvnw test
   ```

**11.7.7. Next steps**

- Build and deploy a function.

**11.8. USING FUNCTIONS WITH KNATIVE EVENTING**

Functions are deployed as Knative services on an OpenShift Dedicated cluster. You can connect functions to Knative Eventing components so that they can receive incoming events.

**IMPORTANT**

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**11.8.1. Connect an event source to a function using the Developer perspective**

Functions are deployed as Knative services on an OpenShift Dedicated cluster. When you create an event source by using the OpenShift Dedicated web console, you can specify a deployed function that events are sent to from that source.

**Prerequisites**

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

Procedure

1. Create an event source of any type, by navigating to +Add → Event Source and selecting the event source type that you want to create.

2. In the Sink section of the Create Event Source form view, select your function in the Resource list.

3. Click Create.

Verification

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

1. In the Developer perspective, navigate to Topology.

2. View the event source and click the connected function to see the function details in the right panel.

11.9. FUNCTION PROJECT CONFIGURATION IN FUNC.YAML

The func.yaml file contains the configuration for your function project. Values specified in func.yaml are used when you execute a kn func command. For example, when you run the kn func build command, the value in the build field is used. In some cases, you can override these values with command line flags or environment variables.

11.9.1. Configurable fields in func.yaml

Many of the fields in func.yaml are generated automatically when you create, build, and deploy your function. However, there are also fields that you modify manually to change things, such as the function name or the image name.

11.9.1.1. buildEnvs

The buildEnvs field enables you to set environment variables to be available to the environment that builds your function. Unlike variables set using envs, a variable set using buildEnv is not available during function runtime.

You can set a buildEnv variable directly from a value. In the following example, the buildEnv variable named EXAMPLE1 is directly assigned the one value:

```yaml
buildEnvs:
- name: EXAMPLE1
  value: one
```

You can also set a buildEnv variable from a local environment variable. In the following example, the buildEnv variable named EXAMPLE2 is assigned the value of the LOCAL_ENV_VAR local environment variable:

```yaml
buildEnvs:
- name: EXAMPLE1
  value: '{{ env:LOCAL_ENV_VAR }}'
```
11.9.1.2. envs

The **envs** field enables you to set environment variables to be available to your function at runtime. You can set an environment variable in several different ways:

1. Directly from a value.
2. From a value assigned to a local environment variable. See the section "Referencing local environment variables from func.yaml fields" for more information.
3. From a key-value pair stored in a secret or config map.
4. You can also import all key-value pairs stored in a secret or config map, with keys used as names of the created environment variables.

This examples demonstrates the different ways to set an environment variable:

```yaml
name: test
namespace: ""
runtime: go
...
envs:
- name: EXAMPLE1
  value: value
- name: EXAMPLE2
  value: '{{ env:LOCAL_ENV_VALUE }}'
- name: EXAMPLE3
  value: '{{ secret:mysecret:key }}'
- name: EXAMPLE4
  value: '{{ configMap:myconfigmap:key }}'
- value: '{{ secret:mysecret2 }}'
- value: '{{ configMap:myconfigmap2 }}'
```

1. An environment variable set directly from a value.
2. An environment variable set from a value assigned to a local environment variable.
3. An environment variable assigned from a key-value pair stored in a secret.
4. An environment variable assigned from a key-value pair stored in a config map.
5. A set of environment variables imported from key-value pairs of a secret.
6. A set of environment variables imported from key-value pairs of a config map.

11.9.1.3. builder

The **builder** field specifies the strategy used by the function to build the image. It accepts values of pack or s2i.

11.9.1.4. build
The **build** field indicates how the function should be built. The value **local** indicates that the function is built locally on your machine. The value **git** indicates that the function is built on a cluster by using the values specified in the **git** field.

### 11.9.1.5. volumes

The **volumes** field enables you to mount secrets and config maps as a volume accessible to the function at the specified path, as shown in the following example:

```yaml
name: test
namespace: ""
runtime: go
...
volumes:
  - secret: mysecret
    path: /workspace/secret
  - configMap: myconfigmap
    path: /workspace/configmap
```

1. The **mysecret** secret is mounted as a volume residing at `/workspace/secret`.
2. The **myconfigmap** config map is mounted as a volume residing at `/workspace/configmap`.

### 11.9.1.6. options

The **options** field enables you to modify Knative Service properties for the deployed function, such as autoscaling. If these options are not set, the default ones are used.

These options are available:

- **scale**
  - **min**: The minimum number of replicas. Must be a non-negative integer. The default is 0.
  - **max**: The maximum number of replicas. Must be a non-negative integer. The default is 0, which means no limit.
  - **metric**: Defines which metric type is watched by the Autoscaler. It can be set to **concurrency**, which is the default, or **rps**.
  - **target**: Recommendation for when to scale up based on the number of concurrently incoming requests. The **target** option can be a float value greater than 0.01. The default is 100, unless the **options.resources.limits.concurrency** is set, in which case **target** defaults to its value.
  - **utilization**: Percentage of concurrent requests utilization allowed before scaling up. It can be a float value between 1 and 100. The default is 70.

- **resources**
  - **requests**
    - **cpu**: A CPU resource request for the container with deployed function.
    - **memory**: A memory resource request for the container with deployed function.
• limits
  ■ cpu: A CPU resource limit for the container with deployed function.
  ■ memory: A memory resource limit for the container with deployed function.
  ■ concurrency: Hard Limit of concurrent requests to be processed by a single replica. It can be integer value greater than or equal to 0, default is $0$ - meaning no limit.

This is an example configuration of the `scale` options:

```yaml
name: test
namespace: ""
runtime: go
...
options:
scale:
  min: 0
  max: 10
  metric: concurrency
  target: 75
  utilization: 75
resources:
  requests:
    cpu: 100m
    memory: 128Mi
  limits:
    cpu: 1000m
    memory: 256Mi
  concurrency: 100
```

11.9.1.7. image

The `image` field sets the image name for your function after it has been built. You can modify this field. If you do, the next time you run `kn func build` or `kn func deploy`, the function image will be created with the new name.

11.9.1.8. imageDigest

The `imageDigest` field contains the SHA256 hash of the image manifest when the function is deployed. Do not modify this value.

11.9.1.9. labels

The `labels` field enables you to set labels on a deployed function.

You can set a label directly from a value. In the following example, the label with the `role` key is directly assigned the value of `backend`:

```yaml
labels:
  - key: role
    value: backend
```

You can also set a label from a local environment variable. In the following example, the label with the `author` key is assigned the value of the `USER` local environment variable:
11.9.10. name

The name field defines the name of your function. This value is used as the name of your Knative service when it is deployed. You can change this field to rename the function on subsequent deployments.

11.9.11. namespace

The namespace field specifies the namespace in which your function is deployed.

11.9.12. runtime

The runtime field specifies the language runtime for your function, for example, python.

11.9.2. Referencing local environment variables from func.yaml fields

If you want to avoid storing sensitive information such as an API key in the function configuration, you can add a reference to an environment variable available in the local environment. You can do this by modifying the envs field in the func.yaml file.

Prerequisites

- You need to have the function project created.
- The local environment needs to contain the variable that you want to reference.

Procedure

- To refer to a local environment variable, use the following syntax:

  ```
  {{ env:ENV_VAR }}
  ```

  Substitute ENV_VAR with the name of the variable in the local environment that you want to use.

  For example, you might have the API_KEY variable available in the local environment. You can assign its value to the MY_API_KEY variable, which you can then directly use within your function:

Example function

```yaml
name: test
namespace: ""
runtime: go
...
envs:
  - name: MY_API_KEY
    value: '{{ env:API_KEY }}'
...```
11.10. ACCESSING SECRETS AND CONFIG MAPS FROM FUNCTIONS

After your functions have been deployed to the cluster, they can access data stored in secrets and config maps. This data can be mounted as volumes, or assigned to environment variables. You can configure this access interactively by using the Knative CLI, or by manually by editing the function configuration YAML file.

**IMPORTANT**

To access secrets and config maps, the function must be deployed on the cluster. This functionality is not available to a function running locally.

If a secret or config map value cannot be accessed, the deployment fails with an error message specifying the inaccessible values.

11.10.1. Modifying function access to secrets and config maps interactively

You can manage the secrets and config maps accessed by your function by using the `kn func config` interactive utility. The available operations include listing, adding, and removing values stored in config maps and secrets as environment variables, as well as listing, adding, and removing volumes. This functionality enables you to manage what data stored on the cluster is accessible by your function.

**Prerequisites**

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

**Procedure**

1. Run the following command in the function project directory:

   ```bash
   $ kn func config
   ``

   Alternatively, you can specify the function project directory using the `--path` or `-p` option.

2. Use the interactive interface to perform the necessary operation. For example, using the utility to list configured volumes produces an output similar to this:

   ```bash
   $ kn func config
   ? What do you want to configure? Volumes
   ```
This scheme shows all operations available in the interactive utility and how to navigate to them:

```
kn func config
  └── Environment variables
      └── Add
          └── ConfigMap: Add all key-value pairs from a config map
          └── ConfigMap: Add value from a key in a config map
          └── Secret: Add all key-value pairs from a secret
          └── Secret: Add value from a key in a secret
          └── List: List all configured environment variables
          └── Remove: Remove a configured environment variable
      └── Volumes
          └── Add
              └── ConfigMap: Mount a config map as a volume
              └── Secret: Mount a secret as a volume
              └── List: List all configured volumes
              └── Remove: Remove a configured volume
```

3. Optional. Deploy the function to make the changes take effect:

```
$ kn func deploy -p test
```

### 11.10.2. Modifying function access to secrets and config maps interactively by using specialized commands

Every time you run the `kn func config` utility, you need to navigate the entire dialogue to select the operation you need, as shown in the previous section. To save steps, you can directly execute a specific operation by running a more specific form of the `kn func config` command:

- To list configured environment variables:
  
  ```
  $ kn func config envs [-p <function-project-path>]
  ```

- To add environment variables to the function configuration:
  
  ```
  $ kn func config envs add [-p <function-project-path>]
  ```

- To remove environment variables from the function configuration:
  
  ```
  $ kn func config envs remove [-p <function-project-path>]
  ```

- To list configured volumes:
  
  ```
  $ kn func config volumes [-p <function-project-path>]
  ```

- To add a volume to the function configuration:
  
  ```
  $ kn func config volumes add [-p <function-project-path>]
  ```
To remove a volume from the function configuration:

```
$ kn func config volumes remove [-p <function-project-path>]
```

### 11.10.3. Adding function access to secrets and config maps manually

You can manually add configuration for accessing secrets and config maps to your function. This might be preferable to using the `kn func config` interactive utility and commands, for example when you have an existing configuration snippet.

#### 11.10.3.1. Mounting a secret as a volume

You can mount a secret as a volume. Once a secret is mounted, you can access it from the function as a regular file. This enables you to store on the cluster data needed by the function, for example, a list of URIs that need to be accessed by the function.

**Prerequisites**

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

**Procedure**

1. Open the `func.yaml` file for your function.

2. For each secret you want to mount as a volume, add the following YAML to the `volumes` section:

```yaml
name: test
namespace: ""
runtime: go
...
volumes:
- secret: mysecret
  path: /workspace/secret
```

- Substitute `mysecret` with the name of the target secret.
- Substitute `/workspace/secret` with the path where you want to mount the secret. For example, to mount the addresses secret, use the following YAML:

```yaml
name: test
namespace: ""
runtime: go
...
volumes:
- configMap: addresses
  path: /workspace/secret-addresses
```

3. Save the configuration.
11.10.3.2. Mounting a config map as a volume

You can mount a config map as a volume. Once a config map is mounted, you can access it from the function as a regular file. This enables you to store on the cluster data needed by the function, for example, a list of URLs that need to be accessed by the function.

Prerequisites

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

Procedure

1. Open the `func.yaml` file for your function.

2. For each config map you want to mount as a volume, add the following YAML to the `volumes` section:

   ```yaml
   name: test
   namespace: ""
   runtime: go
   ...
   volumes:
     - configMap: myconfigmap
       path: /workspace/configmap
   ```

   - Substitute `myconfigmap` with the name of the target config map.
   - Substitute `/workspace/configmap` with the path where you want to mount the config map.

   For example, to mount the `addresses` config map, use the following YAML:

   ```yaml
   name: test
   namespace: ""
   runtime: go
   ...
   volumes:
     - configMap: addresses
       path: /workspace/configmap-addresses
   ```

3. Save the configuration.

11.10.3.3. Setting environment variable from a key value defined in a secret

You can set an environment variable from a key value defined as a secret. A value previously stored in a secret can then be accessed as an environment variable by the function at runtime. This can be useful for getting access to a value stored in a secret, such as the ID of a user.

Prerequisites

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

Procedure

1. Open the `func.yaml` file for your function.

2. For each value from a secret key-value pair that you want to assign to an environment variable, add the following YAML to the `envs` section:

```yaml
- name: EXAMPLE
  value: '{{ secret:mysecret:key }}'
```

- Substitute `EXAMPLE` with the name of the environment variable.
- Substitute `mysecret` with the name of the target secret.
- Substitute `key` with the key mapped to the target value.

For example, to access the user ID that is stored in `userdetailssecret`, use the following YAML:

```yaml
- value: '{{ configMap:userdetailssecret:userid }}'
```

3. Save the configuration.

11.10.3.4. Setting environment variable from a key value defined in a config map

You can set an environment variable from a key value defined as a config map. A value previously stored in a config map can then be accessed as an environment variable by the function at runtime. This can be useful for getting access to a value stored in a config map, such as the ID of a user.

Prerequisites

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

Procedure

1. Open the `func.yaml` file for your function.

2. For each value from a config map key-value pair that you want to assign to an environment variable, add the following YAML to the `envs` section:
Substitute `EXAMPLE` with the name of the environment variable.

Substitute `myconfigmap` with the name of the target config map.

Substitute `key` with the key mapped to the target value.

For example, to access the user ID that is stored in `userdetailsmap`, use the following YAML:

```yaml
name: test
namespace: ""
runtime: go
...
envs:
- name: EXAMPLE
  value: '{configMap:myconfigmap:key}'
```

3. Save the configuration.

### 11.10.3.5. Setting environment variables from all values defined in a secret

You can set an environment variable from all values defined in a secret. Values previously stored in a secret can then be accessed as environment variables by the function at runtime. This can be useful for simultaneously getting access to a collection of values stored in a secret, for example, a set of data pertaining to a user.

**Prerequisites**

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

**Procedure**

1. Open the `func.yaml` file for your function.

2. For every secret for which you want to import all key-value pairs as environment variables, add the following YAML to the `envs` section:

```yaml
name: test
namespace: ""
runtime: go
...
envs:
- value: '{configMap:userdetailsmap:userid}'
```

3. Save the configuration.
Substitute `mysecret` with the name of the target secret.

For example, to access all user data that is stored in `userdetailssecret`, use the following YAML:

```yaml
name: test
namespace: ""
runtime: go
...
envs:
- value: '{{ configMap:userdetailssecret }}'
```

3. Save the configuration.

11.10.3.6. Setting environment variables from all values defined in a config map

You can set an environment variable from all values defined in a config map. Values previously stored in a config map can then be accessed as environment variables by the function at runtime. This can be useful for simultaneously getting access to a collection of values stored in a config map, for example, a set of data pertaining to a user.

Prerequisites

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

Procedure

1. Open the `func.yaml` file for your function.

2. For every config map for which you want to import all key-value pairs as environment variables, add the following YAML to the `envs` section:

```yaml
name: test
namespace: ""
runtime: go
...
envs:
- value: '{{ configMap:myconfigmap }}'  
```

1 Substitute `myconfigmap` with the name of the target config map.

For example, to access all user data that is stored in `userdetailsmap`, use the following YAML:

```yaml
name: test
namespace: ""
runtime: go
...
envs:
- value: '{{ configMap:userdetailsmap }}'
```
11.11. ADDING ANNOTATIONS TO FUNCTIONS

You can add Kubernetes annotations to a deployed Serverless function. Annotations enable you to attach arbitrary metadata to a function, for example, a note about the function’s purpose. Annotations are added to the `annotations` section of the `func.yaml` configuration file.

There are two limitations of the function annotation feature:

- After a function annotation propagates to the corresponding Knative service on the cluster, it cannot be removed from the service by deleting it from the `func.yaml` file. You must remove the annotation from the Knative service by modifying the YAML file of the service directly, or by using the OpenShift Dedicated web console.

- You cannot set annotations that are set by Knative, for example, the `autoscaling` annotations.

11.11.1. Adding annotations to a function

You can add annotations to a function. Similar to a label, an annotation is defined as a key-value map. Annotations are useful, for example, for providing metadata about a function, such as the function’s author.

**Prerequisites**

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

**Procedure**

1. Open the `func.yaml` file for your function.

2. For every annotation that you want to add, add the following YAML to the `annotations` section:

```yaml
name: test
namespace: ""
runtime: go
...
annotations:
  <annotation_name>: "<annotation_value>"  # 1
```

   1 Substitute `<annotation_name>: "<annotation_value>"` with your annotation.

For example, to indicate that a function was authored by Alice, you might include the following annotation:

```yaml
name: test
namespace: ""
runtime: go
```
3. Save the configuration.

The next time you deploy your function to the cluster, the annotations are added to the corresponding Knative service.

11.12. FUNCTIONS DEVELOPMENT REFERENCE GUIDE

IMPORTANT

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

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

OpenShift Serverless Functions provides templates that can be used to create basic functions. A template initiates the function project boilerplate and prepares it for use with the `kn func` tool. Each function template is tailored for a specific runtime and follows its conventions. With a template, you can initiate your function project automatically.

Templates for the following runtimes are available:

- Node.js
- Python
- Go
- Quarkus
- TypeScript

11.12.1. Node.js context object reference

The `context` object has several properties that can be accessed by the function developer. Accessing these properties can provide information about HTTP requests and write output to the cluster logs.

11.12.1.1. log

Provides a logging object that can be used to write output to the cluster logs. The log adheres to the Pino logging API.

Example log

```javascript
... annotations:
   author: "alice@example.com"
```
function handle(context) {
    context.log.info("Processing customer");
}

You can access the function by using the `kn func invoke` command:

Example command

$ kn func invoke --target 'http://example.function.com'

Example output

{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"Processing customer"}

You can change the log level to one of fatal, error, warn, info, debug, trace, or silent. To do that, change the value of `logLevel` by assigning one of these values to the environment variable `FUNC_LOG_LEVEL` using the `config` command.

11.12.1.2. query

Returns the query string for the request, if any, as key-value pairs. These attributes are also found on the context object itself.

Example query

function handle(context) {
    // Log the 'name' query parameter
    context.log.info(context.query.name);
    // Query parameters are also attached to the context
    context.log.info(context.name);
}

You can access the function by using the `kn func invoke` command:

Example command

$ kn func invoke --target 'http://example.com?name=tiger'

Example output

{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"tiger"}

11.12.1.3. body

Returns the request body if any. If the request body contains JSON code, this will be parsed so that the attributes are directly available.

Example body

function handle(context) {

74x787
function handle(count) {
    context.log.info("Processing customer");
}

You can access the function by using the `kn func invoke` command:

Example command

$ kn func invoke --target 'http://example.function.com'

Example output

{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"Processing customer"}

You can change the log level to one of fatal, error, warn, info, debug, trace, or silent. To do that, change the value of `logLevel` by assigning one of these values to the environment variable `FUNC_LOG_LEVEL` using the `config` command.

11.12.1.2. query

Returns the query string for the request, if any, as key-value pairs. These attributes are also found on the context object itself.

Example query

function handle(context) {
    // Log the 'name' query parameter
    context.log.info(context.query.name);
    // Query parameters are also attached to the context
    context.log.info(context.name);
}

You can access the function by using the `kn func invoke` command:

Example command

$ kn func invoke --target 'http://example.com?name=tiger'

Example output

{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"tig er"}

11.12.1.3. body

Returns the request body if any. If the request body contains JSON code, this will be parsed so that the attributes are directly available.

Example body

function handle(context) {

74x787
function handle(count) {
    context.log.info("Processing customer");
}

You can access the function by using the `kn func invoke` command:

Example command

$ kn func invoke --target 'http://example.function.com'

Example output

{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"Processing customer"}

You can change the log level to one of fatal, error, warn, info, debug, trace, or silent. To do that, change the value of `logLevel` by assigning one of these values to the environment variable `FUNC_LOG_LEVEL` using the `config` command.

11.12.1.2. query

Returns the query string for the request, if any, as key-value pairs. These attributes are also found on the context object itself.

Example query

function handle(context) {
    // Log the 'name' query parameter
    context.log.info(context.query.name);
    // Query parameters are also attached to the context
    context.log.info(context.name);
}

You can access the function by using the `kn func invoke` command:

Example command

$ kn func invoke --target 'http://example.com?name=tiger'

Example output

{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"tig er"}

11.12.1.3. body

Returns the request body if any. If the request body contains JSON code, this will be parsed so that the attributes are directly available.

Example body

function handle(context) {

74x787
function handle(count) {
    context.log.info("Processing customer");
}

You can access the function by using the `kn func invoke` command:

Example command

$ kn func invoke --target 'http://example.function.com'

Example output

{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"Processing customer"}

You can change the log level to one of fatal, error, warn, info, debug, trace, or silent. To do that, change the value of `logLevel` by assigning one of these values to the environment variable `FUNC_LOG_LEVEL` using the `config` command.

11.12.1.2. query

Returns the query string for the request, if any, as key-value pairs. These attributes are also found on the context object itself.

Example query

function handle(context) {
    // Log the 'name' query parameter
    context.log.info(context.query.name);
    // Query parameters are also attached to the context
    context.log.info(context.name);
}

You can access the function by using the `kn func invoke` command:

Example command

$ kn func invoke --target 'http://example.com?name=tiger'

Example output

{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"tig er"}

11.12.1.3. body

Returns the request body if any. If the request body contains JSON code, this will be parsed so that the attributes are directly available.

Example body

function handle(context) {
You can access the function by using the `curl` command to invoke it:

**Example command**

```
$ kn func invoke -d '{"Hello": "world"}'
```

**Example output**

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"world"}
```

11.12.1.4. headers

Returns the HTTP request headers as an object.

**Example header**

```javascript
function handle(context) {
    context.log.info(context.headers["custom-header"]);
}
```

You can access the function by using the `kn func invoke` command:

**Example command**

```
$ kn func invoke --target 'http://example.function.com'
```

**Example output**

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"some-value"}
```

11.12.1.5. HTTP requests

- **method**
  Returns the HTTP request method as a string.
- **httpVersion**
  Returns the HTTP version as a string.
- **httpVersionMajor**
  Returns the HTTP major version number as a string.
- **httpVersionMinor**
  Returns the HTTP minor version number as a string.

11.12.2. TypeScript context object reference

```javascript
// log the incoming request body's 'hello' parameter
context.log.info(context.body.hello);
```

You can access the function by using the `curl` command to invoke it:

**Example command**

```
$ kn func invoke -d '{"Hello": "world"}'
```

**Example output**

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"world"}
```
OpenShift Dedicated 4 Serverless

The context object has several properties that can be accessed by the function developer. Accessing
these properties can provide information about incoming HTTP requests and write output to the cluster
logs.

11.12.2.1. log
Provides a logging object that can be used to write output to the cluster logs. The log adheres to the
Pino logging API .

Example log
export function handle(context: Context): string {
// log the incoming request body's 'hello' parameter
if (context.body) {
context.log.info((context.body as Record<string, string>).hello);
} else {
context.log.info('No data received');
}
return 'OK';
}
You can access the function by using the kn func invoke command:

Example command
$ kn func invoke --target 'http://example.function.com'

Example output
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"Pr
ocessing customer"}
You can change the log level to one of fatal, error, warn, info, debug, trace, or silent. To do that,
change the value of logLevel by assigning one of these values to the environment variable
FUNC_LOG_LEVEL using the config command.

11.12.2.2. query
Returns the query string for the request, if any, as key-value pairs. These attributes are also found on the
context object itself.

Example query
export function handle(context: Context): string {
// log the 'name' query parameter
if (context.query) {
context.log.info((context.query as Record<string, string>).name);
} else {
context.log.info('No data received');
}
return 'OK';
}

306


You can access the function by using the `kn func invoke` command:

**Example command**

```
$ kn func invoke --target 'http://example.function.com' --data '{"name": "tiger"}'
```

**Example output**

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"tiger"}
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"tiger"}
```

### 11.12.2.3. body

Returns the request body, if any. If the request body contains JSON code, this will be parsed so that the attributes are directly available.

**Example body**

```typescript
export function handle(context: Context): string {
  // log the incoming request body's 'hello' parameter
  if (context.body) {
    context.log.info((context.body as Record<string, string>).hello);
  } else {
    context.log.info('No data received');
  }
  return 'OK';
}
```

You can access the function by using the `kn func invoke` command:

**Example command**

```
$ kn func invoke --target 'http://example.function.com' --data '{"hello": "world"}'
```

**Example output**

```
{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"world"}
```

### 11.12.2.4. headers

Returns the HTTP request headers as an object.

**Example header**

```typescript
export function handle(context: Context): string {
  // log the incoming request body's 'hello' parameter
  if (context.headers) {
    context.log.info((context.headers as Record<string, string>)["custom-header"]);
  } else {
```

---

**CHAPTER 11. FUNCTIONS**

307
context.log.info('No data received');
} return 'OK';
}

You can access the function by using the curl command to invoke it:

Example command

$ curl -H'x-custom-header: some-value' http://example.function.com

Example output

{"level":30,"time":1604511655265,"pid":3430203,"hostname":"localhost.localdomain","reqId":1,"msg":"some-value"}

11.12.2.5. HTTP requests

method
Returns the HTTP request method as a string.

httpVersion
Returns the HTTP version as a string.

httpVersionMajor
Returns the HTTP major version number as a string.

httpVersionMinor
Returns the HTTP minor version number as a string.