





# **Building Resilient Microservices with Istio and Red Hat OpenShift Service Mesh**



**SM 2.0 DO328**

**Building Resilient Microservices with Istio and Red Hat**

**OpenShift Service Mesh**

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# Document Conventions

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This section describes various conventions and practices used throughout all Red Hat Training courses.

## Admonitions

Red Hat Training courses use the following admonitions:



### References

These describe where to find external documentation relevant to a subject.



### Note

These are tips, shortcuts, or alternative approaches to the task at hand. Ignoring a note should have no negative consequences, but you might miss out on something that makes your life easier.



### Important

These provide details of information that is easily missed: configuration changes that only apply to the current session, or services that need restarting before an update will apply. Ignoring these admonitions will not cause data loss, but may cause irritation and frustration.



### Warning

These should not be ignored. Ignoring these admonitions will most likely cause data loss.

## Inclusive Language

Red Hat Training is currently reviewing its use of language in various areas to help remove any potentially offensive terms. This is an ongoing process and requires alignment with the products and services covered in Red Hat Training courses. Red Hat appreciates your patience during this process.



# Introduction

## DO328 Building Resilient Microservices with Istio and Red Hat OpenShift Service Mesh

The Red Hat OpenShift Service Mesh platform facilitates managing service interaction, provides service tracing, and creates a visual representation of communication pathways between microservices deployed on Red Hat OpenShift Container Platform.

Building Resilient Microservices with Istio and Red Hat OpenShift Service Mesh (DO328) is a hands-on, lab-based course that teaches students how to install, configure, and manage Red Hat® OpenShift® Service Mesh. In this course, students learn about service monitoring, service management, distributed tracing, load balancing, and service resilience.

### Course Objectives

- Install, configure, and manage Red Hat OpenShift Service Mesh.
- This course, together with *Introduction to Containers, Kubernetes, and Red Hat OpenShift* (DO180) and *Red Hat OpenShift Developer I: Containerizing Applications* (DO288), prepares the student to take the *Red Hat Certified Specialist in Building Resilient Microservices* exam (EX328).

### Audience

- System and Software Architects
- Software Developers

### Prerequisites

- The courses *Introduction to Containers, Kubernetes, and Red Hat OpenShift* (DO180) and *Red Hat OpenShift Developer I: Containerizing Applications* (DO288), or demonstrate equivalent experience with containers and Kubernetes is strongly recommended, but not required.
- The course *Implementing Microservice Architectures* (DO283), or demonstrate equivalent experience creating microservice applications is strongly recommended, but not required.

# Orientation to the Classroom Environment

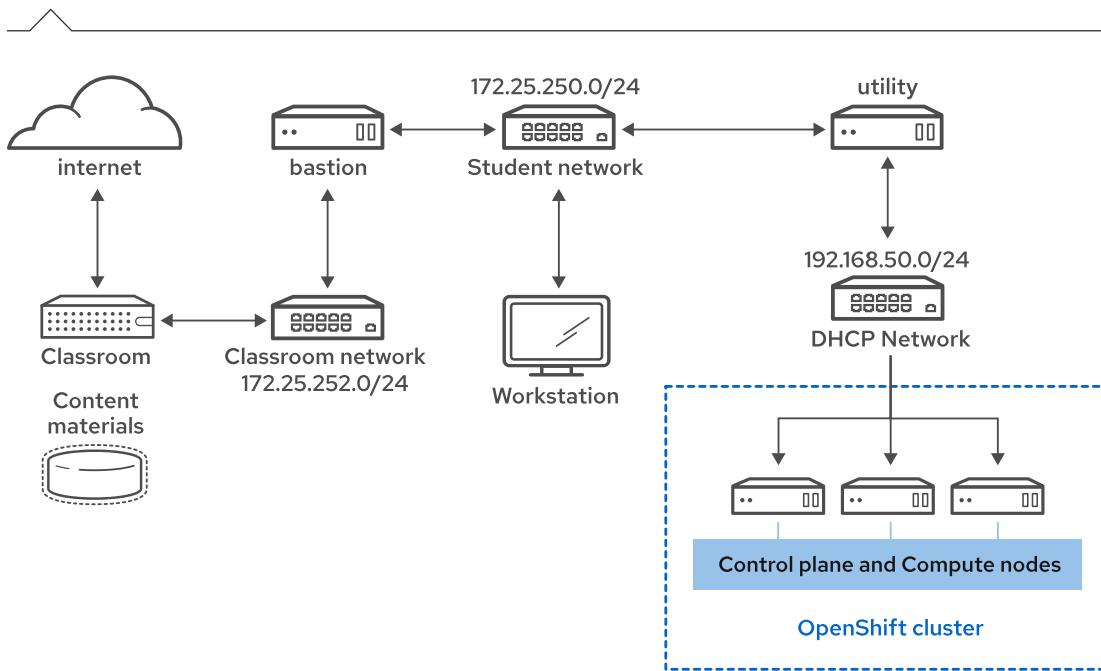


Figure 0.1: Classroom environment

In this course, the main computer system used for hands-on learning activities is **workstation**. The system called **bastion** must always be running. These two systems are in the `lab.example.com` DNS domain.

All student computer systems have a standard user account, **student**, which has the password **student**. The **root** password on all student systems is **redhat**.

## Classroom Machines

Machine name	IP addresses	Role
<code>workstation.lab.example.com</code>	172.25.250.9	Graphical workstation used by students
<code>bastion.lab.example.com</code>	172.25.250.254	Router linking student's VMs to classroom servers
<code>classroom.lab.example.com</code>	172.25.252.254	Server hosting the classroom materials required by the course
<code>utility.lab.example.com</code>	172.25.250.253	Server providing supporting services required by the RHOCP cluster including DHCP and NFS and routing to the RHOCP servers.

Machine name	IP addresses	Role
master01.ocp4.example.com	192.168.50.10	An OpenShift control plane and compute node.
master02.ocp4.example.com	192.168.50.11	An OpenShift control plane and compute node.
master03.ocp4.example.com	192.168.50.12	An OpenShift control plane and compute node.

The **bastion** system acts as a router between the network that connects the student machines and the classroom network. If **bastion** is down, other student machines may not function properly or may even hang during boot.

The **utility** system acts as a router between the network that connects the OpenShift cluster machines and the student network. If **utility** is down, the OpenShift cluster will not function properly or may even hang during boot.

Several systems in the classroom provide supporting services. Two servers, **content.example.com** and **materials.example.com**, are sources for software and lab materials used in hands-on activities. Information on how to use these servers is provided in the instructions for those activities.

Students use the **workstation** machine to access a dedicated OpenShift cluster, for which they have cluster administrator privileges.

## Controlling Your Systems

You are assigned a remote computer in a Red Hat Online Learning classroom, which is accessed through a web application hosted at <http://rol.redhat.com/>. Students should log in to this site using their Red Hat Customer Portal user credentials.

## Controlling the Virtual Machines

The virtual machines in your classroom environment are controlled through a web page. The state of each virtual machine in the classroom is displayed on the page under the **Lab Environment** tab.

### Machine States

Virtual Machine State	Description
active	The virtual machine is running and available (or, when booting, soon will be).
stopped	The virtual machine is completely shut down.
building	The initial creation of the virtual machine is being performed.

Depending on the state of a machine, a selection of the following actions is available.

## Classroom/Machine Actions

Button or Action	Description
CREATE	Create the ROL classroom. Creates all of the virtual machines needed for the classroom and starts them. Can take several minutes to complete.
DELETE	Delete the ROL classroom. Destroys all virtual machines in the classroom. Caution: Any work generated on the disks is lost.
START	Start all virtual machines in the classroom.
STOP	Stop all virtual machines in the classroom.
OPEN CONSOLE	Open a new tab in the browser and connect to the console of the virtual machine. Students can log in directly to the virtual machine and run commands. In most cases, you should log in to the workstation virtual machine and use ssh to connect to the other virtual machines.
ACTION → Start	Start (power on) the virtual machine.
ACTION → Shutdown	Gracefully shut down the virtual machine, preserving the contents of its disk.
ACTION → Power Off	Forcefully shut down the virtual machine, preserving the contents of its disk. This is equivalent to removing the power from a physical machine.
ACTION → Reset	Forcefully shut down the virtual machine and reset the disk to its initial state. Caution: Any work generated on the disk is lost.

At the start of an exercise, if instructed to reset a single virtual machine node, click **ACTION → Reset** for only the specific virtual machine.

At the start of an exercise, if instructed to reset all virtual machines, click **ACTION → Reset**

If you want to return the classroom environment to its original state at the start of the course, you can click **DELETE** to remove the entire classroom environment. After the lab has been deleted, you can click **CREATE** to provision a new set of classroom systems.



### Warning

The **DELETE** operation cannot be undone. Any work you have completed in the classroom environment up to that point will be lost.

## The Autostop Timer

The Red Hat Online Learning enrollment entitles students to a certain amount of computer time. To help conserve allotted computer time, the ROL classroom has an associated countdown timer, which shuts down the classroom environment when the timer expires.

To adjust the timer, click + to add one hour to the timer. Note that there is a maximum time of twelve hours.

## Controlling Your Systems

You are assigned remote computers in a Red Hat Online Learning classroom. They are accessed through a web application hosted at [rol.redhat.com](http://rol.redhat.com) [<http://rol.redhat.com>]. You should log in to this site using your Red Hat Customer Portal user credentials.

### Controlling the Virtual Machines

The virtual machines in your classroom environment are controlled through a web page. The state of each virtual machine in the classroom is displayed on the page under the **Online Lab** tab.

#### Machine States

Virtual Machine State	Description
STARTING	The virtual machine is in the process of booting.
STARTED	The virtual machine is running and available (or, when booting, soon will be).
STOPPING	The virtual machine is in the process of shutting down.
STOPPED	The virtual machine is completely shut down. Upon starting, the virtual machine boots into the same state as when it was shut down (the disk will have been preserved).
PUBLISHING	The initial creation of the virtual machine is being performed.
WAITING_TO_START	The virtual machine is waiting for other virtual machines to start.

Depending on the state of a machine, a selection of the following actions is available.

#### Classroom/Machine Actions

Button or Action	Description
PROVISION LAB	Create the ROL classroom. Creates all of the virtual machines needed for the classroom and starts them. Can take several minutes to complete.
DELETE LAB	Delete the ROL classroom. Destroys all virtual machines in the classroom. <b>Caution: Any work generated on the disks is lost.</b>
START LAB	Start all virtual machines in the classroom.
SHUTDOWN LAB	Stop all virtual machines in the classroom.
OPEN CONSOLE	Open a new tab in the browser and connect to the console of the virtual machine. You can log in directly to the virtual machine and run commands. In most cases, you should log in to the <b>workstation</b> virtual machine and use ssh to connect to the other virtual machines.
ACTION → Start	Start (power on) the virtual machine.

Button or Action	Description
ACTION → Shutdown	Gracefully shut down the virtual machine, preserving the contents of its disk.
ACTION → Power Off	Forcefully shut down the virtual machine, preserving the contents of its disk. This is equivalent to removing the power from a physical machine.
ACTION → Reset	Forcefully shut down the virtual machine and reset the disk to its initial state. <b>Caution: Any work generated on the disk is lost.</b>

At the start of an exercise, if instructed to reset a single virtual machine node, click ACTION → Reset for only the specific virtual machine.

At the start of an exercise, if instructed to reset all virtual machines, click ACTION → Reset

If you want to return the classroom environment to its original state at the start of the course, you can click DELETE LAB to remove the entire classroom environment. After the lab has been deleted, you can click PROVISION LAB to provision a new set of classroom systems.



### Warning

The DELETE LAB operation cannot be undone. Any work you have completed in the classroom environment up to that point will be lost.

## The Autostop Timer

The Red Hat Online Learning enrollment entitles you to a certain amount of computer time. To help conserve allotted computer time, the ROL classroom has an associated countdown timer, which shuts down the classroom environment when the timer expires.

To adjust the timer, click MODIFY to display the New Autostop Time dialog box. Set the number of hours until the classroom should automatically stop. Note that there is a maximum time of ten hours. Click ADJUST TIME to apply this change to the timer settings.

## Chapter 1

# Introducing Red Hat OpenShift Service Mesh

### Goal

Describe the basic concepts of microservice architecture and Red Hat OpenShift Service Mesh.

### Objectives

- Describe the basic concepts behind a distributed architecture and Red Hat OpenShift Service Mesh.
- Describe the fundamental architecture of OpenShift Service Mesh components.

### Sections

- Creating a Lab Environment (Guided Exercise)
- Describing OpenShift Service Mesh Concepts (and Quiz)
- Describing the OpenShift Service Mesh Architecture (and Quiz)
- Verifying OpenShift Credentials (Guided Exercise)

## ► Guided Exercise

# Creating a Lab Environment

In this exercise, you will start the provisioning process of a dedicated OpenShift cluster using the Red Hat Online Learning Environment (ROL). You will also create a new account for using the Quay.io public container image registry.

### Outcomes

You should be able to provision a dedicated Red Hat OpenShift cluster that you will use for all exercises in this course.

You will also create a new account for using the Quay.io container image registry.

### Before You Begin

To perform this exercise, ensure you have access to the Red Hat Online Learning Environment (ROL).

## Instructions

The following procedure describes how to provision an OpenShift cluster from the Red Hat Online Learning platform. You must complete the following procedure before attempting any of the course activities.



#### Note

The provisioning of the cluster takes approximately 10-15 minutes.

- ▶ 1. Open a browser and navigate to the Red Hat Online Learning (ROL) platform at <https://rol.redhat.com>. Log in with your credentials. If you do not have access to ROL, visit Red Hat Learning Subscription [<https://www.redhat.com/en/services/training/learning-subscription>].
- ▶ 2. Access the *Building Resilient Microservices with Istio and Red Hat OpenShift Service Mesh – DO328* course and click **ONLINE TRAINING**.
- ▶ 3. Click the **Lab Environment** tab, and then click **CREATE** to start provisioning the OpenShift cluster.

Once the cluster is provisioned, you should see a list of virtual machines in the classroom. The status of all the virtual machines should be **active**.

		<b>DELETE</b>	<b>STOP</b>	<b>i</b>
bastion	active		ACTION ▾	OPEN CONSOLE
classroom	active		ACTION ▾	OPEN CONSOLE
master01	active		ACTION ▾	OPEN CONSOLE
master02	active		ACTION ▾	OPEN CONSOLE
master03	active		ACTION ▾	OPEN CONSOLE
utility	active		ACTION ▾	OPEN CONSOLE
workstation	active		ACTION ▾	OPEN CONSOLE

Auto-stop in an hour. + Auto-destroy in a month.

**Figure 1.1: Provisioning a cluster**

From this page, you can also control the environment, such as deleting the cluster, and stopping or restarting the cluster.

**Warning**

By default, the cluster is configured to automatically stop after one hour. Click the green plus icon at the bottom to increase the duration. You can increase the duration up to a maximum of 12 hours.

- ▶ **4.** While the OpenShift cluster is being provisioned, create a new account in Quay.io. If you already have an account in Quay.io, then you can skip this step.  
If you do not have an account in Quay.io, create a new account to store container images for applications that you will build in this course.

Refer to the detailed steps in the appendix *Appendix B, Creating a Quay account*.

## Finish

This exercise has no command to finish it. Provisioning the cluster takes some time. Continue to the next section in this chapter while you wait for the cluster to become ready.

This concludes the guided exercise.

# Describing OpenShift Service Mesh Concepts

---

## Objectives

After completing this section, you should be able to describe the basic concepts behind a distributed architecture and Red Hat OpenShift Service Mesh.

## Describing the Challenges of Microservice Architectures

Microservice architectures are a method of dividing traditional, monolithic enterprise applications into a set of small, modular services. Using a microservice approach to application development means that each part of your application can scale more easily, is more maintainable, and is ideal for deployment on a cloud platform. This approach has been successful in recent years, including at large companies such as Netflix and Amazon.

Despite introducing many benefits, microservices create several architectural challenges that administrators and developers must understand in order to build a robust and resilient microservices application.

Some of these challenges are related to the development of the microservices themselves.

### Development challenges

An early issue developers run into is *service discovery*. Because services are often changing their IP address, each service needs to be easily discoverable and referred to by a static name. Another issue developers encounter is developing for *elasticity*, or the ability to scale up or down in response to demand. To support elasticity, and leverage one of the most critical benefits of a microservice architecture, developers need to design a system that is scalable as well as have an orchestration solution that appropriately responds to demand.

### Security challenges

Security is a large part of application development and deployment. In microservice applications, microservices implement *authentication* techniques to validate the identity of the request. Because microservice architectures imply a high degree of communication, authentication becomes a critical feature. Microservices must validate the requests are *authorized*, and reject unauthorized requests.

### Operation challenges

In microservice architectures, a failing microservice or element may cascade the failure, causing a large impact on the application. Microservices must be *resilient* to failures of peers or dependencies to avoid service failures and service-level agreement (SLA) breaks.

As applications grow, monitoring becomes difficult. In contrast to a monolithic architecture, microservices are by nature distributed, which can make consolidating information challenging.

Developers and administrators require operational features, such as:

- *Monitoring*: measuring microservices performance and usage.
- *Centralized logging*: capturing and relating logs from all microservices.

- *Tracing:* correlating requests to multiple microservices belonging to the same user transaction.

Microservice orchestration platforms such as Red Hat OpenShift provide some capabilities, such as discovering services or elasticity. Other features require more specialized solutions.

Commonly, developers would implement features such as service resilience in code. This leads to duplicated code and creation of poor separation between service code and network management.

When applications consist of only a few microservices, replicating the same code is not a major problem. When the number of microservices increases, however, maintenance and the ability to make changes grows exponentially more difficult.

## Describing a Service Mesh

*Service mesh* is a technology designed to address microservice architecture problems. This technology abstracts developers from many of the microservice architectural problems. Service mesh creates a centralized point to control features for many or all microservices in an application.

Service mesh operates at the network communication level. That is, service mesh components capture or intercept traffic to and from microservices, either modifying requests, redirecting them, or creating new requests to other services. Consequently, service mesh provides additional features without requiring code-level changes.

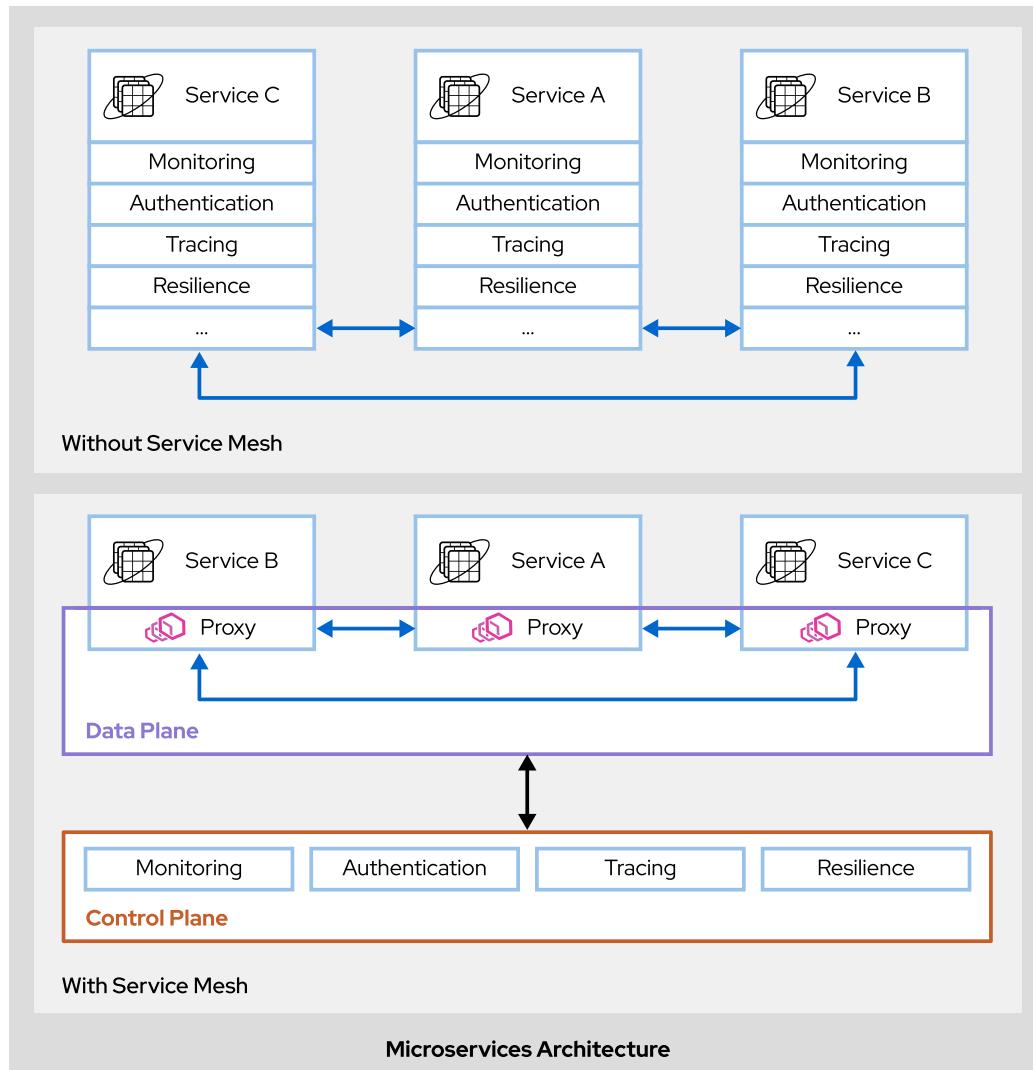


Figure 1.2: Desired features of microservice architectures

## Red Hat OpenShift Service Mesh

Red Hat OpenShift Service Mesh is a service mesh implementation for the Red Hat OpenShift Container Platform. OpenShift Service Mesh complements OpenShift Container Platform capabilities, adding many of the desired features of microservice architectures.

OpenShift Service Mesh incorporates and extends several open source projects and orchestrates them to provide an improved developer experience:

### Istio

Istio is the core implementation of the service mesh architecture for the Kubernetes platform. Istio creates a control plane that centralizes service mesh capabilities and a data plane that creates the structure of the mesh.

The data plane controls communications between services by injecting sidecar containers that capture traffic between microservices.

## **Maistra**

Maistra is an open-source project based on Istio that adapts Istio features to the edge cases of deployment in OpenShift Container Platform. Maistra also adds extended features to Istio, such as simplified multitenancy, explicit sidecar injection, and the use of OpenShift routes instead of Kubernetes ingress.

## **Jaeger**

Jaeger is an open source traceability server that centralizes and displays traces associated with a single request. A trace contains information about all services that a request reached. Maistra is responsible for sending the traces to Jaeger and Jaeger is responsible for displaying traces. Microservices in the mesh are responsible for generating request headers needed for other components to generate and aggregate traces.

## **ElasticSearch**

ElasticSearch is an open source, distributed, JSON-based search and analytics engine. Jaeger uses ElasticSearch for storing and indexing the tracing data. ElasticSearch is an optional component for Red Hat OpenShift Service Mesh.

## **Kiali and Prometheus**

Kiali provides service mesh observability. Kiali discovers microservices in the service mesh and their interactions and visually represents them. It also captures information about communication and services, such as the protocols used, service versions, and failure statistics.

Prometheus is used by OpenShift Service Mesh to store telemetry information from services. Kiali depends on Prometheus to obtain metrics, health status, and mesh topology.

## **Grafana**

Optionally, Grafana can be used to analyze service mesh metrics. Grafana provides mesh administrators with advanced query and metrics analysis.

## **3scale**

The 3scale Istio adapter is an optional component that integrates OpenShift Service Mesh with Red Hat 3scale API Management solutions. The default OpenShift Service Mesh installation does not include this component.



## References

### Istio

<https://istio.io/>

### Maistra

<https://maistra.io/>

### Jaeger

<https://www.jaegertracing.io/>

### ElasticSearch

<https://www.elastic.co/elasticsearch/>

### Kiali

<https://kiali.io/>

### Prometheus

<https://prometheus.io/>

### Grafana

<https://grafana.com/>

For updates and latest product notes, refer to the *Service Mesh Release notes* section in the *Service Mesh* chapter at

[https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.6/html-single/service\\_mesh/index](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.6/html-single/service_mesh/index)

## ► Quiz

# Introducing OpenShift Service Mesh

Choose the correct answers to the following questions:

- ▶ **1. Which two of the following features does Red Hat OpenShift Service Mesh add to applications deployed on an OpenShift cluster? (Choose two.)**
  - a. Scalability. Allows services to adapt the number of replicas to the load requirements.
  - b. Traceability. Allows services to capture traces of the requests between services.
  - c. Resiliency. Provides services with tools to tolerate failures in dependent services.
  - d. Idempotency. Deploying applications multiple times always obtains the same results.
- ▶ **2. Which three of the following open source projects are used in Red Hat OpenShift Service Mesh? (Choose three.)**
  - a. Git
  - b. Kubernetes
  - c. Maistra
  - d. Kiali
  - e. PostgreSQL
  - f. Jaeger
- ▶ **3. Which of the following architectural challenges of microservice architectures is addressed by Red Hat OpenShift Service Mesh?**
  - a. Authentication
  - b. API
  - c. Elasticity
  - d. Pipeline
- ▶ **4. An application consisting of multiple microservices is in production. It is complicated for architects to clarify which services communicate with others. Which two Red Hat OpenShift Service Mesh components can you use to clarify those connections? (Choose two.)**
  - a. Kiali, because visualizing the service mesh clarifies service interactions.
  - b. Jaeger, because tracing queries shows what services are used.
  - c. Grafana, because it can display what nodes have a higher level of usage.
  - d. None of the above. OpenShift Service Mesh needs architects to manually trace all connections.

## ► Solution

# Introducing OpenShift Service Mesh

Choose the correct answers to the following questions:

► 1. **Which two of the following features does Red Hat OpenShift Service Mesh add to applications deployed on an OpenShift cluster? (Choose two.)**

- a. Scalability. Allows services to adapt the number of replicas to the load requirements.
- b. Traceability. Allows services to capture traces of the requests between services.
- c. Resiliency. Provides services with tools to tolerate failures in dependent services.
- d. Idempotency. Deploying applications multiple times always obtains the same results.

► 2. **Which three of the following open source projects are used in Red Hat OpenShift Service Mesh? (Choose three.)**

- a. Git
- b. Kubernetes
- c. Maistra
- d. Kiali
- e. PostgreSQL
- f. Jaeger

► 3. **Which of the following architectural challenges of microservice architectures is addressed by Red Hat OpenShift Service Mesh?**

- a. Authentication
- b. API
- c. Elasticity
- d. Pipeline

► 4. **An application consisting of multiple microservices is in production. It is complicated for architects to clarify which services communicate with others. Which two Red Hat OpenShift Service Mesh components can you use to clarify those connections? (Choose two.)**

- a. Kiali, because visualizing the service mesh clarifies service interactions.
- b. Jaeger, because tracing queries shows what services are used.
- c. Grafana, because it can display what nodes have a higher level of usage.
- d. None of the above. OpenShift Service Mesh needs architects to manually trace all connections.

# Describing the OpenShift Service Mesh Architecture

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## Objectives

After completing this section, you should be able to describe the fundamental architecture of OpenShift Service Mesh components.

## Red Hat OpenShift Service Mesh Architecture

Red Hat OpenShift Service Mesh consists of two logical components, a control plane, and a data plane. The following diagram shows the components in the data plane and the control plane:

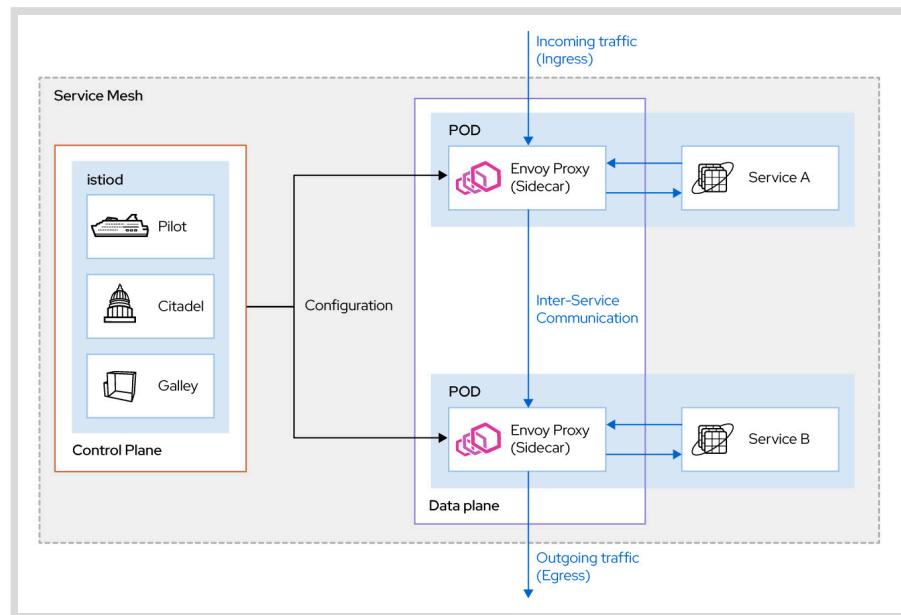


Figure 1.3: Red Hat OpenShift Service Mesh architecture

The data plane consists of a set of proxies, which are deployed alongside applications in an OpenShift cluster. The proxies are deployed as sidecars, an auxiliary container running in the same pod as the application, and providing some supplementary functionality.

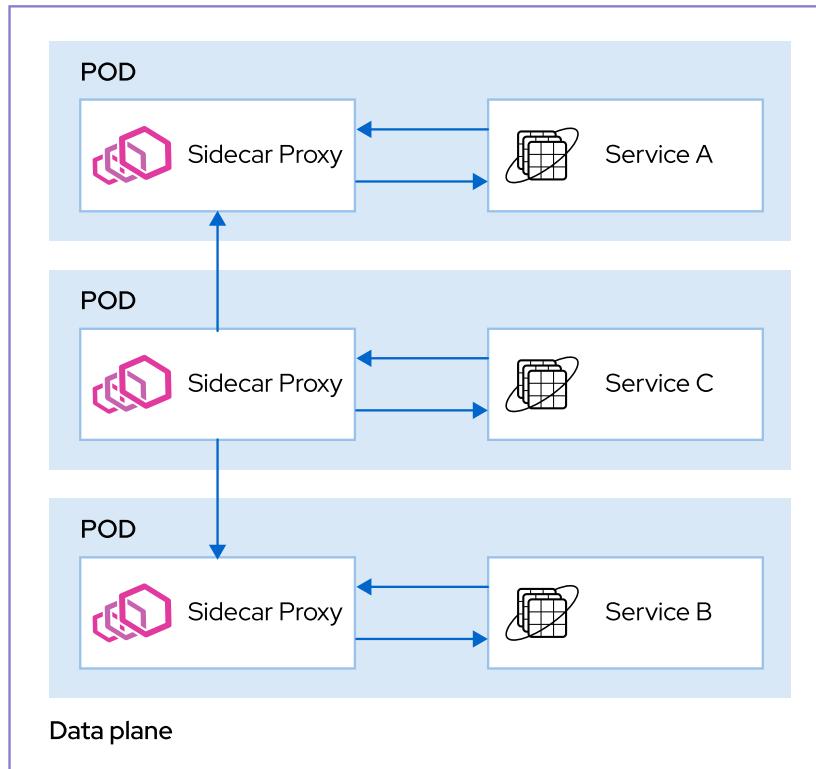
The control plane manages and configures the proxies. It enforces access control and usage policies and collects metrics from the proxies in the service mesh.

## Data Plane Components

The data plane consists of:

- A set of Envoy proxies.
- The `istio-agent` component running in each Envoy proxy.

The Envoy proxy is the main component in the data plane. It handles all data flowing between the services in a service mesh. The Envoy proxy also collects all metrics related to the services in the mesh.

**Figure 1.4: Envoy proxies**

The `istio-agent` component, known also as the *Istio Pilot agent*, is part of every Envoy proxy. It helps to bootstrap the Envoy proxy container during startup. Additionally, it maintains other functions, such as:

- Automating certificate rotation by communicating with the control plane components.
- Automating routing information.
- Automating DNS domain configuration.

Each Envoy proxy contains the `pilot-agent` binary that controls the Istio Pilot agent.

The control plane can automatically inject an instance of the Envoy proxy as a sidecar to a service whenever that service is deployed to a project that is managed by OpenShift Service Mesh. All incoming (ingress) and outgoing (egress) network traffic between services flows through the proxies.

The service offloads functionality such as access control, network routing and rate limiting, ingress and egress traffic control to the service mesh.

The data plane in a service mesh performs the following tasks:

- *Service discovery*: Tracks the services deployed in a mesh.
- *Health checks*: Track the state (healthy or unhealthy) of the services deployed in a mesh.
- *Traffic shaping and routing*: Control the flow of network data between services. Includes tasks such as throttling the amount of traffic, routing based on content, circuit breaking, controlling

the amount of traffic that should be routed among multiple versions of a service, load balancing and more.

- **Security:** Perform authentication and authorization, and secure communication using mutual transport layer security (mTLS) between services in a mesh.
- **Metrics and Telemetry:** Gather metrics, logs, and distributed tracing information from services in the mesh.

## Control Plane Components

The control plane manages the configuration and policies for the service mesh. The control plane does not directly handle the network traffic in the mesh, but maintains configuration and policies that are enforced by the data plane.

The control plane consists of the `istiod` deployment. The `istiod` deployment consists of a single binary that contains a number of APIs used by the OpenShift Service Mesh.

In previous versions of OpenShift Service Mesh, the control plane consisted of separate deployments, such as Citadel, Pilot, Galley. OpenShift Service Mesh 2.x consolidates the APIs and functionality of each of the separate deployment into a single `istiod` binary.

Consolidating APIs into a single binary results in a number of advantages, such as:

- Easier deployment and lifecycle management.
- Easier debugging.
- Faster startup times.
- Gaining reliability because communication between components is now guaranteed.

The change to `istiod` did not change any of the APIs or functionality of the components.

`Istiod` contains the APIs and functionality of the following components:

### Pilot

Maintains the configuration data for the service mesh. Pilot provides service discovery for the Envoy proxy sidecars, traffic management capabilities for intelligent routing (for example, A/B tests), and resiliency (timeouts, retries, and circuit breakers).

### Citadel

Issues and rotates TLS certificates. Citadel provides authentication for inter-service communication, with built-in identity and credential management. You can enforce policies based on service identity rather than relying on network details such as IP addresses and host names.

### Galley

Monitors the service mesh configuration and then validates, processes, and distributes the configuration to the proxies.



## References

For more information, refer to the *Service Mesh Architecture* chapter in the *Service Mesh* guide at

[https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.6/html-single/service\\_mesh/index#service-mesh-architecture](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.6/html-single/service_mesh/index#service-mesh-architecture)

## Istio Architecture

<https://istio.io/v1.6/docs/ops/deployment/architecture/>

## ► Quiz

# Describing the OpenShift Service Mesh Architecture

Choose the correct answers to the following questions:

- 1. Which component of the control plane is responsible for security and certificate management?
- a. Pilot.
  - b. Galley.
  - c. Citadel.
  - d. None of the above.
- 2. Which two of the following statements about the control plane are correct? (Choose two.)
- a. It injects an instance of the Envoy proxy as a sidecar to the application pod.
  - b. It handles all the incoming and outgoing traffic in a service mesh.
  - c. It runs as a sidecar alongside all applications in the service mesh.
  - d. It is responsible for monitoring the health of all services in a service mesh.
  - e. It is responsible for collecting logging data from all services in a service mesh.
  - f. It is responsible for maintaining the configuration of the service mesh.
- 3. A large e-commerce application is deployed on a service mesh, and consists of three services: an Apache web server to serve static assets such as images; a PHP/Nginx based front-end service that handles the HTML web user interface; and a Node.js back-end service to handle ordering, billing, and customer management. All three services are packaged and deployed as containers; one container per service. Assuming that the service mesh handles the traffic for all three services, how many sidecar proxies are injected into the data plane for this application?
- a. 1
  - b. 2
  - c. 3
  - d. 4
  - e. 6

- **4. Which two of the following statements about the Pilot component in the control plane are correct? (Choose two.)**
- a. Pilot handles all the incoming and outgoing traffic in a service mesh.
  - b. Pilot runs as a sidecar alongside all applications in the service mesh.
  - c. Pilot provides service discovery functionality in the service mesh.
  - d. Pilot provides circuit breaker functionality in a service mesh.
  - e. Pilot enforces access control and usage policies in a service mesh.
  - f. Pilot validates the service mesh configuration and distributes the configuration to the proxies.

## ► Solution

# Describing the OpenShift Service Mesh Architecture

Choose the correct answers to the following questions:

- ▶ 1. Which component of the control plane is responsible for security and certificate management?
  - a. Pilot.
  - b. Galley.
  - c. Citadel.
  - d. None of the above.
  
- ▶ 2. Which two of the following statements about the control plane are correct? (Choose two.)
  - a. It injects an instance of the Envoy proxy as a sidecar to the application pod.
  - b. It handles all the incoming and outgoing traffic in a service mesh.
  - c. It runs as a sidecar alongside all applications in the service mesh.
  - d. It is responsible for monitoring the health of all services in a service mesh.
  - e. It is responsible for collecting logging data from all services in a service mesh.
  - f. It is responsible for maintaining the configuration of the service mesh.
  
- ▶ 3. A large e-commerce application is deployed on a service mesh, and consists of three services: an Apache web server to serve static assets such as images; a PHP/Nginx based front-end service that handles the HTML web user interface; and a Node.js back-end service to handle ordering, billing, and customer management. All three services are packaged and deployed as containers; one container per service. Assuming that the service mesh handles the traffic for all three services, how many sidecar proxies are injected into the data plane for this application?
  - a. 1
  - b. 2
  - c. 3
  - d. 4
  - e. 6

► **4. Which two of the following statements about the Pilot component in the control plane are correct? (Choose two.)**

- a. Pilot handles all the incoming and outgoing traffic in a service mesh.
- b. Pilot runs as a sidecar alongside all applications in the service mesh.
- c. Pilot provides service discovery functionality in the service mesh.
- d. Pilot provides circuit breaker functionality in a service mesh.
- e. Pilot enforces access control and usage policies in a service mesh.
- f. Pilot validates the service mesh configuration and distributes the configuration to the proxies.

## ► Guided Exercise

# Verifying OpenShift Credentials

In this exercise, you will configure the lab environment to access the dedicated OpenShift cluster that Red Hat Online Learning (ROL) provides for each student.

### Outcomes

You should be able to access your dedicated OpenShift cluster from your lab environment.

### Before You Begin

To perform this exercise, ensure you have access to:

- The Red Hat Online Learning Environment (ROL).
- The access credentials of your dedicated cluster.
- A free user account in the Quay.io public container registry.



#### Important

The following activity requires that you provision a dedicated OpenShift cluster in *Guided Exercise: Creating a Lab Environment*. Refer to this activity to create a new OpenShift cluster.

You also need to create new Quay.io account before starting this activity. Refer to the appendix *Appendix B, Creating a Quay account*.

The `lab-configure` command saves the connection information of your OpenShift cluster in a configuration file. If you made a mistake, or if you want to change any values, rerun the command to modify the configuration.



#### Note

To avoid problems while pasting text into the workstation machine, open the Firefox browser on workstation and navigate to <https://rol.redhat.com>. Copy the necessary values from Firefox and paste them into the GNOME Terminal window.

## Instructions

- 1. Run the `lab-configure` command to configure your workstation environment to connect to your OpenShift cluster, which you provisioned from ROL in an earlier exercise.
- The `Lab-configure` command provides interactive prompts. It determines the correct parameters to access the OpenShift cluster and requests the username for your Quay.io account. Enter your Quay.io username when prompted.

- 1.1. As the student user on the workstation machine, run the `lab-configure` command. Do not press `Enter` to accept the default value. Enter your Quay.io user account name:

```
[student@workstation ~]$ lab-configure
```

This script configures the connection parameters to access the OpenShift cluster for your lab scripts

- Enter the Quay.io Account User Name: *quayuser*

- 2. The `lab-configure` command displays all the OpenShift parameters and the Quay account that you provided. It does not wait for you to confirm them. It then verifies that it can access your cluster.
- 2.1. Verify that you provided the correct values for your OpenShift cluster to the `lab-configure` command.

Your OpenShift parameters:

· OpenShift API URL:	<a href="https://api.ocp4.example.com:6443">https://api.ocp4.example.com:6443</a>
· Wildcard Domain:	apps.ocp4.example.com
· Web Console URL:	<a href="https://console-openshift-console.apps.ocp4.example.com">https://console-openshift-console.apps.ocp4.example.com</a>
· Developer User Name:	developer
· Developer User Password:	redhat
· Cluster Administrator User Name:	admin
· Cluster Administrator User Password:	redhat

You entered:

· Quay.io Account User Name:	quayuser
------------------------------	----------

- 2.2. Wait until the `lab-configure` command verifies that it can connect to your OpenShift cluster and saves your configuration to the `/usr/local/etc/ocp4.config` file.

Verifying your OpenShift API URL...

Verifying your OpenShift developer user credentials...

Verifying your OpenShift admin user credentials...

Verifying your Quay.io account user name...

Verifying your cluster configuration...

Saving your lab configuration file...

All fine, lab config saved. You can now proceed with your exercises.

- 2.3. If the `lab-configure` command finds any issues then it displays an error message and exits. You must verify the information you entered and run the `lab-configure` command again. The following listing shows an example of a verification error:

```
...output omitted...
```

```
Verifying your OpenShift API URL...
```

ERROR:

Cannot connect to an OpenShift 4 API using your URL.

Please verify your network connectivity and that the URL does not point to an OpenShift 3.x nor to a non-OpenShift Kubernetes API.

No changes made to your lab configuration.



### Note

You may see this error when you run the `lab-configure` script immediately after cluster provisioning. Wait for a few minutes for the cluster to be fully started and the OpenShift API to be available, and re-run the `lab-configure` script.

If your configuration saved without errors, then you are ready to start any of the exercises for this course. If there were any errors, then do not start any exercise until you can execute the `lab-configure` command successfully.

## Finish

This exercise has no command to finish it. You should now be set up to perform any exercise in this course.

This concludes the guided exercise.

# Summary

---

In this section, you learned:

- OpenShift Service Mesh addresses challenges in microservice architectures, like tracing, authentication, elasticity, traceability or resiliency.  
A service mesh works at the network level, that is, it intercepts and alters network communication between services to include the desired features.
- Red Hat OpenShift Service Mesh uses many open source projects, such as Istio, Kiali, Jaeger, ElasticSearch, and Grafana.
- Istio (the core of OpenShift Service Mesh technology) defines the control plane, for controlling service mesh behavior, and the data plane, for enabling features at the service level.
- The data plane injects Envoy proxy sidecars to microservices to enable service mesh features. Control plane components includes Pilot for service discovery, Citadel for authentication, and Galley for configuration.

## Chapter 2

# Installing Red Hat OpenShift Service Mesh

### Goal

Deploy Red Hat OpenShift Service Mesh on OpenShift Container Platform.

### Objectives

Install Red Hat OpenShift Service Mesh on Red Hat OpenShift Container Platform.

### Sections

Installing Red Hat OpenShift Service Mesh (and Guided Exercise)

# Installing Red Hat OpenShift Service Mesh

---

## Objectives

After completing this section, you should be able to install Red Hat OpenShift Service Mesh on Red Hat OpenShift Container Platform.

## Describing Custom Resource Definitions

Red Hat OpenShift is a distribution of Kubernetes focused on the developer experience. Red Hat OpenShift is easily adapted to various projects using available Kubernetes components.

A resource is a Kubernetes API endpoint that stores objects of the same kind.

A Custom Resource Definition (CRD) describes a custom resource used to extend the Kubernetes API.

This feature supports custom object definitions, using them as native Kubernetes objects.

Custom Resource Definitions are used to install software in Kubernetes and Red Hat OpenShift.

The following example shows a CRD definition:

```
apiVersion: apiextensions.k8s.io/v1
kind: CustomResourceDefinition
metadata:
  name: crontabs.stable.example.com 1
spec:
  group: stable.example.com 2
  version: v1
  scope: Namespaced 3
  names:
    plural: crontabs 4
    singular: crontab 5
    kind: CronTab 6
    shortNames: 7
    - ct
```

A crontab is a list of commands to be executed at a specified time. The preceding example implements the crontab concept using Custom Resource Definitions.

- 1** Custom Resource Definition name. Must be in the form `plural.group`.
- 2** Name to use in the REST API.
- 3** Defines the scope of the CRD.
- 4** Plural name of the CRD. Used in the REST API and to form the CRD name.
- 5** Singular name of the CRD. Used as an alias in the command-line interface (CLI) and for display.

❶ Type of objects managed by the CRD.

❷ Short string alias to use in the CLI.

After a CRD is created, Kubernetes enables a new RESTful API endpoint to manage it.

The endpoint created for the preceding example is:

```
/apis/stable.example.com/v1/namespaces/*/crontabs/...
```

The API URL associated with the CRD supports creating and managing custom objects.

## Defining Kubernetes Operators

A Kubernetes operator packages a Kubernetes application to automate installation, updates, and management. Operators rely on Custom Resource Definitions to extend the Kubernetes API.

Operators run on a pod, and monitor the application to ensure it performs as expected. If the application fails to properly execute, then the operator automatically acts to correct it.

There are two types of operators available to choose in Red Hat OpenShift.

### Certified Operators

Operators verified on Red Hat OpenShift by Red Hat or its partners.

### Community Operators

Operators not vetted or verified by Red Hat, so their stability is unknown.

## Installing Red Hat OpenShift Service Mesh

OpenShift Service Mesh is installed using the Web Console, or CLI, and a Kubernetes operator. The installation process requires first installing the required operators, then deploying the Control Plane, and finally creating a Service Mesh Member Roll.

## Installing the OpenShift Service Mesh Operator

OpenShift Service Mesh relies on the following operators:

### Jaeger

Provides tracing features to monitor and troubleshoot your distributed application.

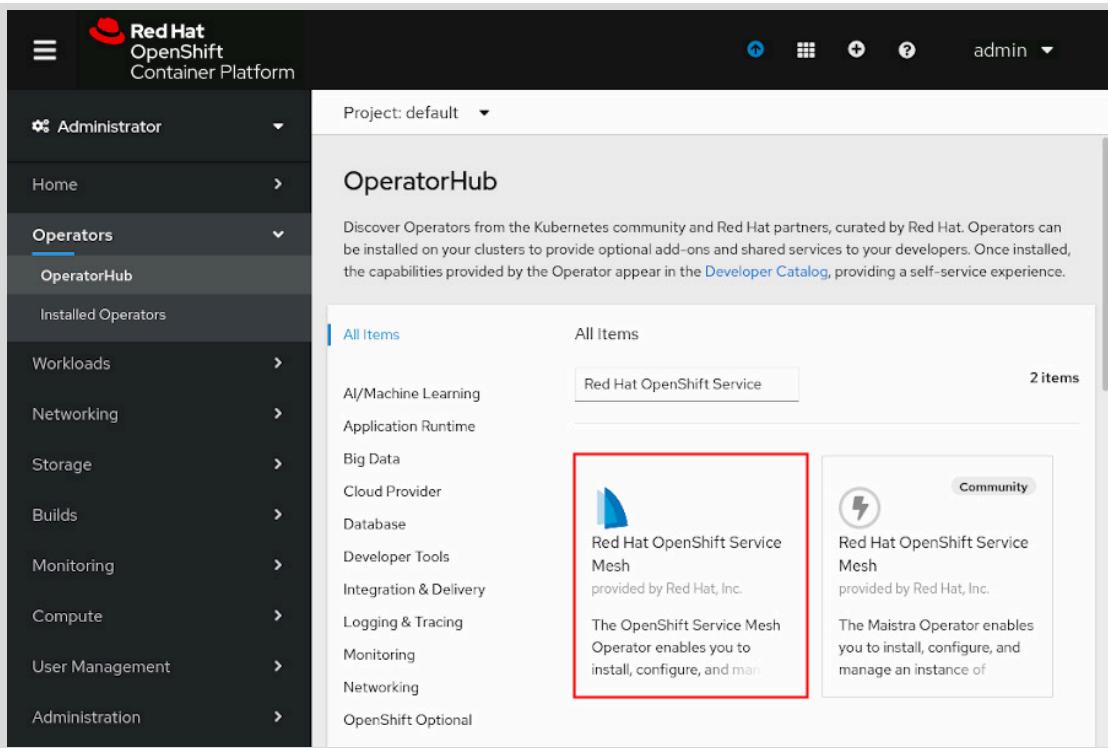
### Elasticsearch

Stores traces and logs generated by Jaeger.

### Kiali

Provides observability to the service mesh through a web user interface (UI).

You can find all the required operators and the Red Hat OpenShift Service Mesh operator in the [OperatorHub](#) page.



**Figure 2.1: Result page in the OperatorHub for Red Hat OpenShift Service Mesh**

The installation process of the operators requires first finding the operator in the OperatorHub page, then reviewing and configuring installation parameters, and finally subscribing the operator to an updates channel.



### Note

Red Hat recommends to install certified operators.

## Deploying the OpenShift Service Mesh Control Plane

The control plane manages the configuration and policies for the service mesh. The OpenShift Service Mesh Operator installation makes the operator available in all namespaces, so you can install the control plane in any project.

To deploy a control plane in a project with the web UI, first navigate to the **Installed Operators** page, then to the **Istio Service Mesh Control Plane** page, and finally review and configure deployment parameters.



### Note

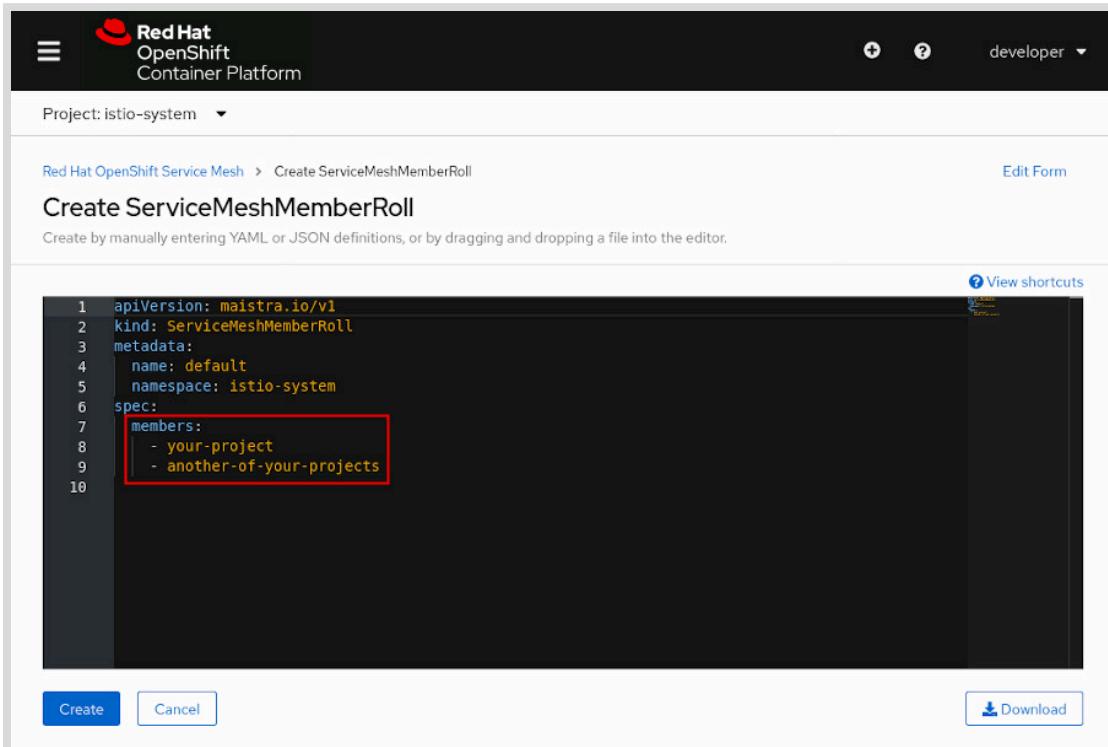
Red Hat recommends to deploy the control plane in a separate project.

## Creating a Service Mesh Member Roll

The **ServiceMeshMemberRoll** custom resource defines the projects belonging to a control plane.

Any number of projects can be added to a `ServiceMeshMemberRoll`, however a project can be added only to one control plane.

To create or edit a Service Mesh Member Roll, first navigate to the project where Red Hat OpenShift Service Mesh is installed, then navigate to the `Istio Service Mesh Member Roll` page, and finally review and configure installation parameters.



```
apiVersion: maistra.io/v1
kind: ServiceMeshMemberRoll
metadata:
  name: default
  namespace: istio-system
spec:
  members:
    - your-project
    - another-of-your-projects
```

**Figure 2.2: List of projects belonging to the control plane**

Only projects listed in the `ServiceMeshMemberRoll` are managed by the Service Mesh.

## Installing OpenShift Service Mesh using CLI

You can install OpenShift Service Mesh using CLI instead of the OpenShift Web Console. The CLI installation method is useful for, for example, automated installation and management of OpenShift Service Mesh.

For more information about installing OpenShift Service Mesh using CLI, refer to *Appendix A, Installing OpenShift Service Mesh with the CLI*.

## Upgrading Red Hat OpenShift Service Mesh

If you select the automatic update stream during installation, then OpenShift Service Mesh is going to be updated automatically.

If you choose to update manually during installation, the Operator Lifecycle Manager (OLM) controls the upgrade.

For more information, refer to the *Operator Lifecycle Manager* documentation at [https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.6/html-single/operators/#olm-overview\\_olm-understanding-olm](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.6/html-single/operators/#olm-overview_olm-understanding-olm).

## Removing Red Hat OpenShift Service Mesh

To remove OpenShift Service Mesh from an existing Red Hat OpenShift Container Platform instance, complete the following tasks:

1. Remove the OpenShift Service Mesh control plane.
2. Remove the installed operators.
  - a. Red Hat OpenShift Service Mesh Operator
  - b. Jaeger Operator
  - c. Kiali Operator
  - d. Elasticsearch Operator
3. Clean up operator resources.

For more information, refer to the *Removing Red Hat OpenShift Service Mesh* section in the *OpenShift Container Platform Service Mesh* documentation at [https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.6/html-single/service\\_mesh/index](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.6/html-single/service_mesh/index).



### References

For more information, refer to the *Service Mesh Installation* section in the *OpenShift Container Platform Service Mesh* documentation at [https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.6/html-single/service\\_mesh/index](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.6/html-single/service_mesh/index)

### Operators in Red Hat OpenShift

<https://www.openshift.com/learn/topics/operators>

### Operator Hub

<https://operatorhub.io/>

## ► Guided Exercise

# Install OpenShift Service Mesh

In this exercise, you will deploy Red Hat OpenShift Service Mesh on Red Hat OpenShift.

### Outcomes

You should be able to deploy OpenShift Service Mesh on Red Hat OpenShift.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.

As the **student** user on the **workstation** machine, use the **lab** command to validate the prerequisites for this exercise:

```
[student@workstation ~]$ lab install-mesh start
```

### Instructions

- 1. Log in as the **admin** user in the OpenShift web console.
- 1.1. Navigate to <https://console-openshift-console.apps.ocp4.example.com> to access the OpenShift web console. If certificate errors appear, then accept the self-signed certificates.

```
[student@workstation ~]$ firefox \
https://console-openshift-console.apps.ocp4.example.com
```

- 1.2. Use the following credentials:
    - Username: admin
    - Password: redhatThen, click **Log in**.
- 2. Install the Elasticsearch operator.
- 2.1. In the Administrator panel, click Operators → OperatorHub.
  - 2.2. Type Elasticsearch into the filter box. Click **Elasticsearch Operator**, and then click **Install**.

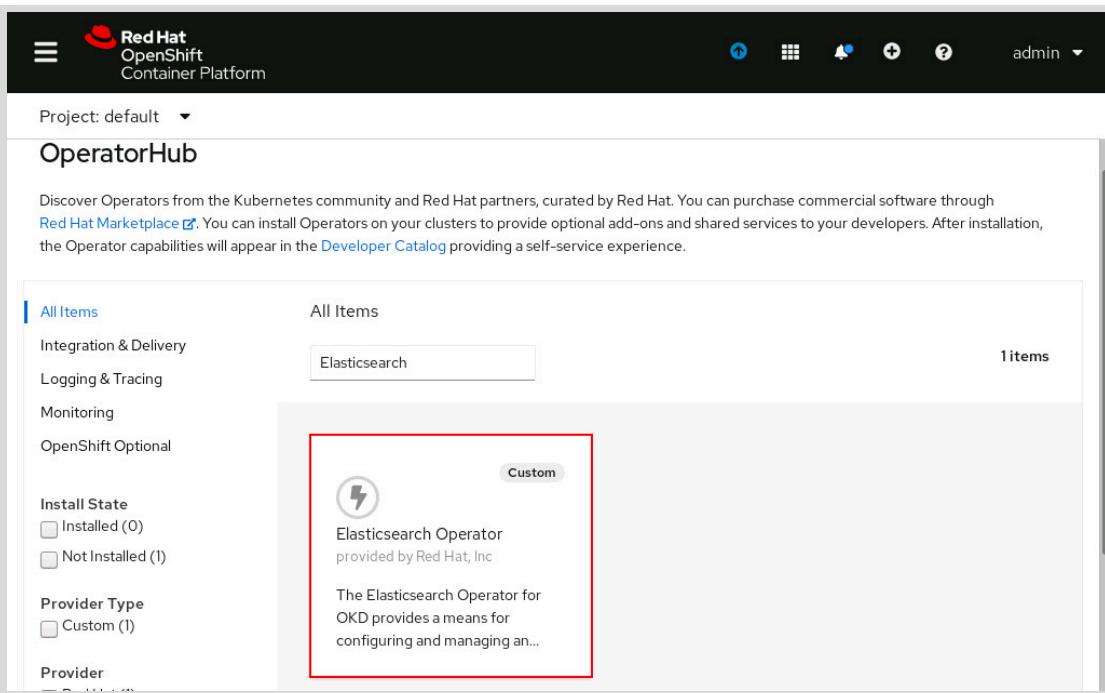


Figure 2.3: Elasticsearch operator

**Note**

All the required operators for this course are packaged in a custom OperatorHub.

For that reason, all the operators included in the custom OperatorHub display a **Custom** tag.

2.3. In the **Install Operator** page, examine the default settings. Then, click **Install**.

► 3. Install the Jaeger operator.

3.1. In the Administrator panel, click **Operators** → **OperatorHub**.

3.2. Type **Jaeger** into the filter box. Click **Red Hat OpenShift Jaeger**, and then click **Install**.

3.3. The **Install Operator** page displays. Examine the default settings, and select **stable** as the **Update Channel**. Then, click **Install**.

► 4. Install the Kiali operator.

4.1. In the Administrator pane, click **Operators** → **OperatorHub**.

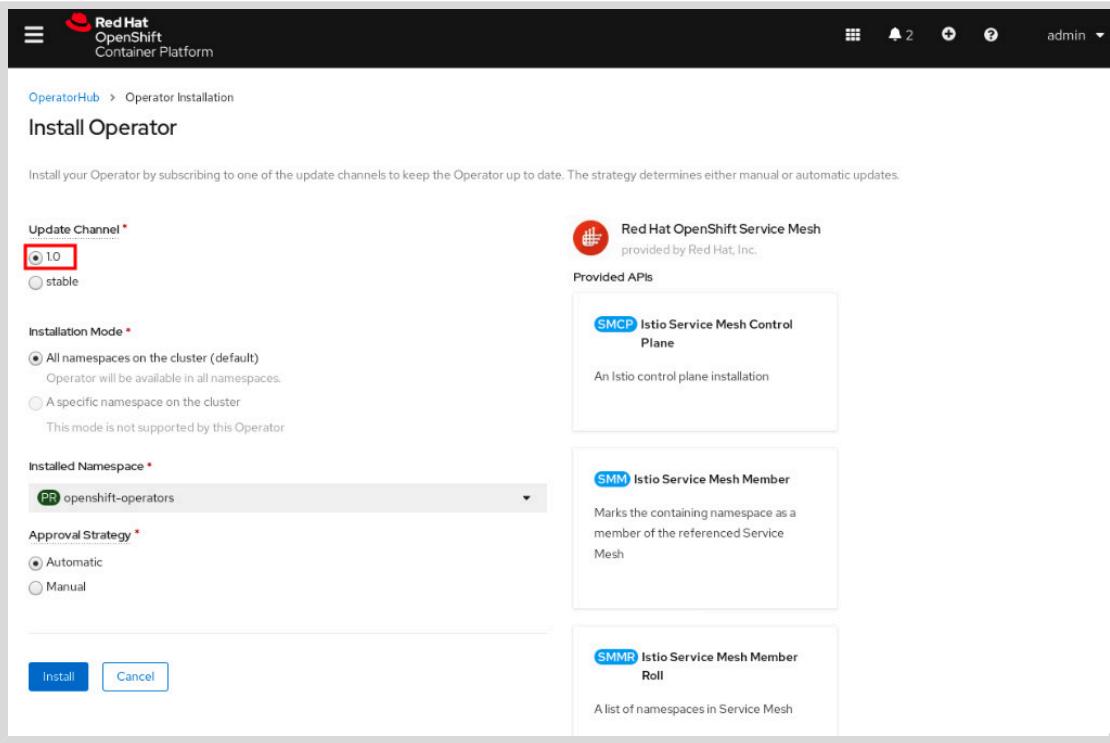
4.2. Type **Kiali** into the filter box. Click **Kiali Operator**, and then click **Install**.

4.3. The **Install Operator** page displays. Examine the default settings, and then click **Install**.

► 5. Install the Red Hat OpenShift Service Mesh operator.

5.1. In the Administrator pane, click **Operators** → **OperatorHub**.

- 5.2. Type OpenShift Service Mesh into the filter box. Click **Red Hat OpenShift Service Mesh**, and then click **Install**.
- 5.3. In the **Install Operator** page, examine the default settings and select 1.0 as the **Update Channel**. Then, click **Install**.



**Figure 2.4: OpenShift Service Mesh subscription options**

- 5.4. In the **Installed Operators** page, wait until you see **Succeeded** in the **Status** column of all the operators.
- 6. Log in as the **Developer** user. Then, create the **istio-system** project.
- 6.1. In the OpenShift web console, click **admin** → **Log out**. Then, log in as the **developer** user. Use the following credentials:
    - **Username:** developer
    - **Password:** redhat
  - 6.2. In the OpenShift web console, click **Home** → **Projects**, and then click **Create Project**.
  - 6.3. Type **istio-system** into the **Name** field, and then click **Create**.
- 7. Deploy the OpenShift Service Mesh control plane.
- 7.1. On the **Administrator** pane, click **Operators** → **Installed Operators**.
  - 7.2. Ensure that the project **istio-system** is selected in the **Project** list. Then, click **Red Hat OpenShift Service Mesh**.

Name	Namespace	Status	Deployment	Provided APIs
Elasticsearch Operator	istio-system	Succeeded	elasticsearch-operator	Elasticsearch
Red Hat OpenShift Jaeger	istio-system	Succeeded	jaeger-operator	Jaeger
Kiali Operator	istio-system	Succeeded	kiali-operator	Kiali Monitoring Dashboard
Red Hat OpenShift Service Mesh	istio-system	Succeeded	istio-operator	Istio Service Mesh Control Plane Istio Service Mesh Member Istio Service Mesh

Figure 2.5: Project selection in OperatorHub

**Note**

If Red Hat OpenShift Service Mesh Operator does not display, the operator installation into the `istio-system` project is still in progress.

The operator displays after a few seconds.

- 7.3. Click the **Istio Service Mesh Control Plane** tab. Then, click **Create ServiceMeshControlPlane**.
- 7.4. Examine the default options of the Service Mesh Control Plane installation. Then, click **Create**.
- 7.5. Click the **Istio Service Mesh Member Roll** tab. Then, click **Create ServiceMeshMemberRoll**.
- 7.6. In the **Configure via** options, click **YAML view**. Examine the default options of the `ServiceMeshMemberRoll` custom resource and remove the sample members. Then, click **Create**.

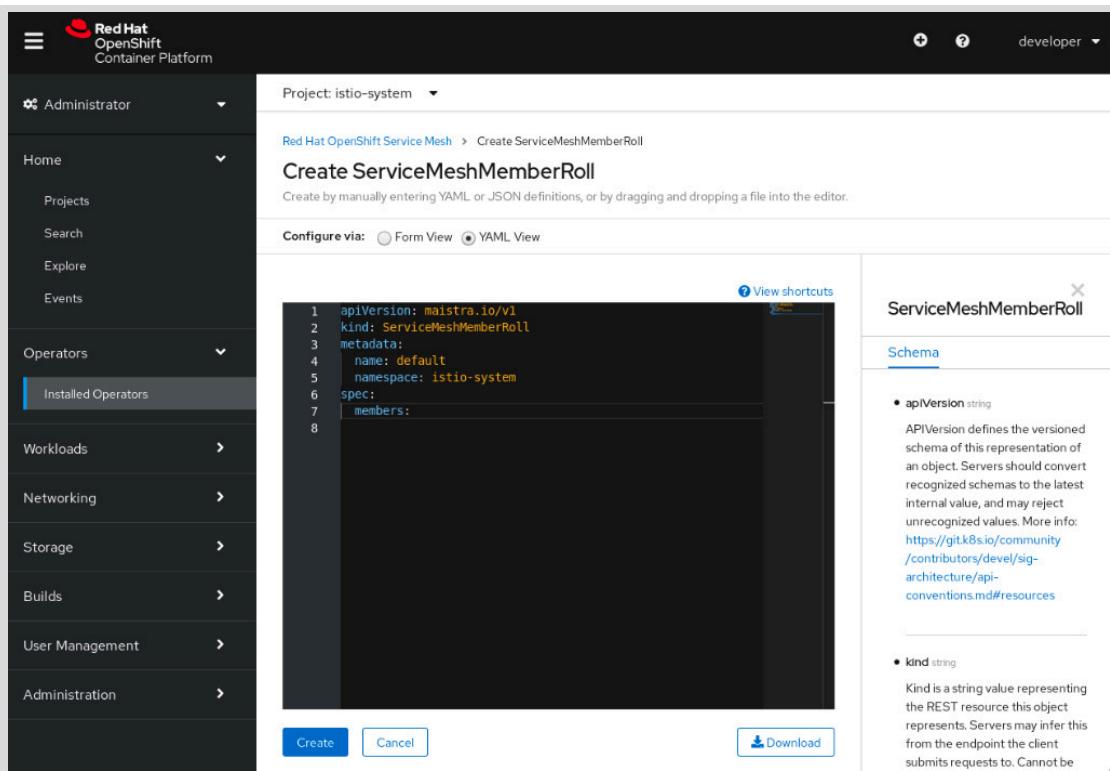


Figure 2.6: ServiceMeshMemberRoll custom resource creation

- 8. Verify that the Service Mesh Control Plane installation was successful.
- 8.1. Click the **Istio Service Mesh Control Plane** tab.
  - 8.2. Click **basic** to see the details of your Service Mesh Control Plane installation.
  - 8.3. Scroll down to see the **Conditions** panel of the page.
  - 8.4. Wait until the **Ready** row status changes to **True**.
  - 8.5. As the **student** user on the **workstation** machine, use the **lab** command to verify the successful installation:

```
[student@workstation ~]$ lab install-mesh grade
```

**Note**

To remove OpenShift Service Mesh from your OpenShift cluster, execute **lab uninstall-mesh start**.

## Finish

On the **workstation** machine, use the **lab** command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab install-mesh finish
```

This concludes the guided exercise.

# Summary

---

In this chapter, you learned:

- The role of the `ServiceMeshMemberRoll` and `ServiceMeshControlPlane` resources in Red Hat OpenShift Service Mesh.
- Installing Red Hat OpenShift Service Mesh using the OpenShift web console.
- Installing Red Hat OpenShift Service Mesh using the OpenShift command-line client.
- Configure Red Hat OpenShift Service Mesh to manage projects with the `ServiceMeshMemberRoll` resource.

## Chapter 3

# Observing a Service Mesh

### Goal

Trace and visualize an OpenShift Service Mesh with Jaeger and Kiali.

### Objectives

- Configure distributed tracing to track service traffic.
  - Collect and inspect critical metrics with Prometheus and Grafana.
  - Monitor and visualize service interactions with Kiali.
- 
- Tracing Services with Jaeger (and Guided Exercise)
  - Collecting Service Metrics (and Guided Exercise)
  - Observing Service Interactions with Kiali (and Guided Exercise)

### Sections

Observing an OpenShift Service Mesh

### Lab

# Tracing Services with Jaeger

## Objectives

After completing this section, you should be able to configure distributed tracing to track service traffic.

## Describing Distributed Tracing

*Distributed Tracing* is the process of tracking the performance of individual services in an application by tracing the path of the service calls in the application. Each time a user takes action in an application, a request is executed that might require many services to interact to produce a response. The path of this request is called a distributed transaction.

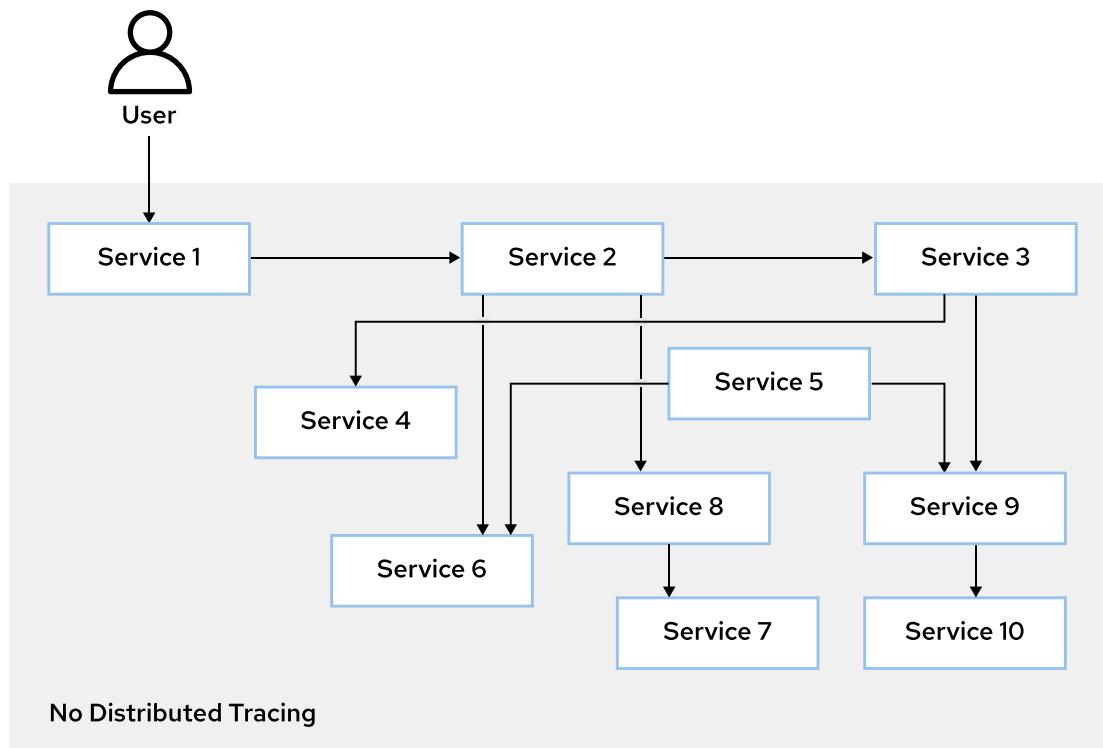
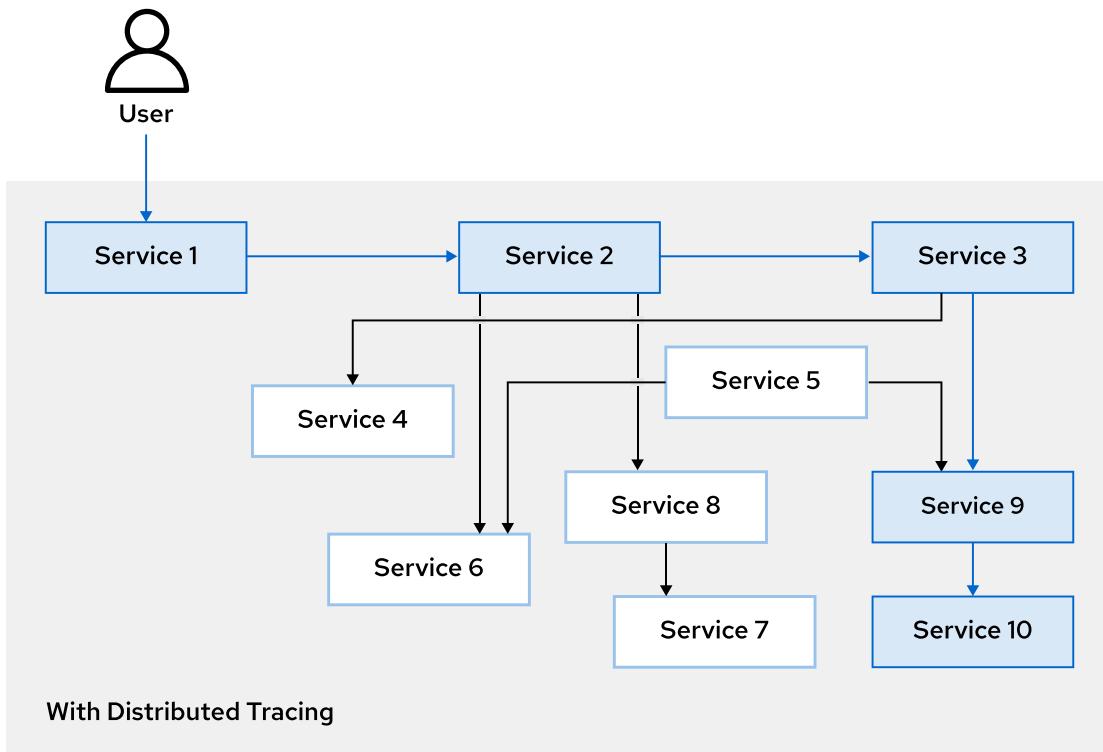


Figure 3.1: Without distributed tracing



**Figure 3.2: With distributed tracing**

In a microservices enabled architecture with a large number of individual microservices, a single client request that achieves a certain business requirement might involve calling multiple individual microservices in a particular sequence. An important aspect of maintaining and developing a distributed system is troubleshooting performance issues. Because a single client call can interact with multiple services, analyzing the debugging logs of an individual service might not help troubleshooting performance issues.

Distributed tracing allows developers to visualize call flows in a microservices application. Understanding the sequence of calls (how many calls occur in a serial fashion versus how many occur in parallel), and sources of latency is useful when maintaining a distributed system.

For example, if a request takes too long, causing performance issues, then identify the service or services causing the slowdown and examine the network latency between service calls.

Distributed tracing is useful for monitoring, network profiling, and troubleshooting the interaction between services in modern, cloud-native, microservices-based applications.

## Traces and Spans in Distributed Tracing

In the context of distributed tracing, it is important to understand two terms:

### Span

A *Span* represents a logical unit of work, which has a unique name, a start time, and the duration of execution. To model the service call flow in a service mesh, spans are nested and executed in a particular order.

### Trace

A *Trace* is an execution path of services in the service mesh. A trace is comprised of one or more spans.

Consider an application with the following microservices:

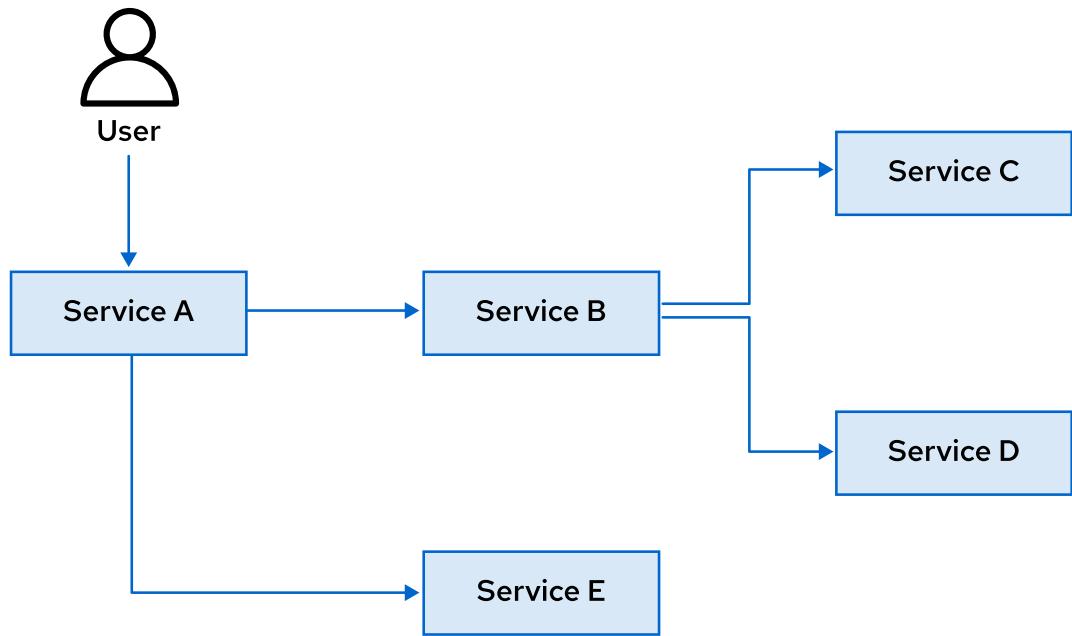


Figure 3.3: Request call path

In this example:

- Service A is the request entry point for the application.
- Because Service A is the entry point for the application, it is called the `parent span`. Service A makes two service calls: one to Service B and one to Service E. Thus, Service B and Service E are `child spans` of Service A.
- Service B in turn calls Service C and Service D before returning the response to Service A. Service B is a `parent span`. Service C and Service D are `child spans`.

The following is a line graph representation of a single trace and its constituent spans:

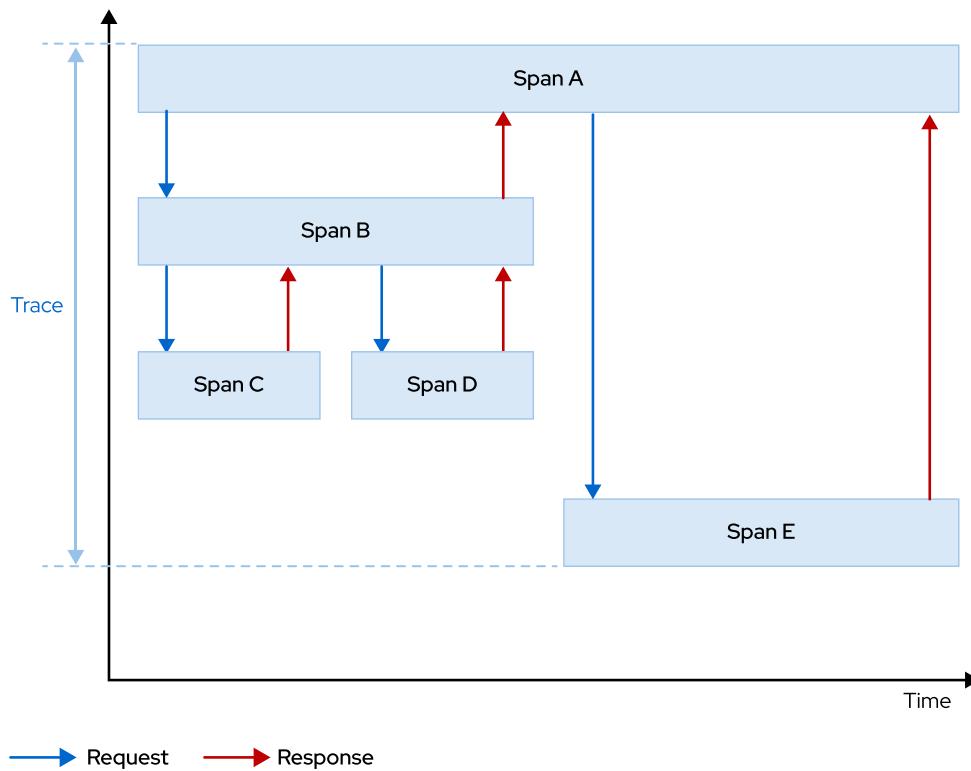


Figure 3.4: Traces and spans

## Introducing Jaeger

Jaeger is a distributed tracing platform. Jaeger allows developers to configure their services to enable gathering runtime statistics about their performance.

Jaeger is installed by default as part of Red Hat OpenShift Service Mesh.

Jaeger is made up of several components that work together to collect, store, and display tracing data.

### Jaeger Components

#### Jaeger Client

Jaeger clients are language specific implementations of the OpenTracing API. They are used to configure applications for distributed tracing. The OpenTracing API defines standard APIs for instrumentation and distributed tracing of microservices applications.

#### Jaeger Agent

The Jaeger agent is a network daemon that listens for span data sent over User Datagram Protocol (UDP), which it batches and sends to the collector. The agent is meant to be placed on the same host as the application being traced. This is accomplished by the Envoy proxy sidcar in container environments like OpenShift.

#### Jaeger Collector

The Collector receives runtime statistics from the agent and places them in an internal queue for processing. This allows the collector to return a response immediately to the agent.

## **Storage**

Collectors require a persistent storage back end. Jaeger has a pluggable mechanism for storage. For Red Hat OpenShift Service Mesh, the only supported storage is **Elasticsearch**, which is a distributed search and analytics engine for all types of data.

## **Query**

Query is a service that retrieves runtime statistics from storage.

## **Jaeger Console**

Jaeger provides a web based console that lets you visualize your distributed tracing data. The Jaeger web console is tightly integrated with the OpenShift web console. Using the console, you can trace the path of requests as they flow through the services in a mesh.

## **Trace Context Propagation**

A system with a large number of microservices interact in numerous ways and cannot be planned upfront, these services typically receive and send multiple requests concurrently. *Trace context propagation* is a process which tracks unique requests throughout the call paths in the service mesh.

A new span is generated for each logical service call in the request. This span contains the same request id, a new span id, and the parent span id (which points to the span id of the parent span). Spans are placed on a timeline, and visualized using graphical representations, based on timestamps and durations.

Red Hat OpenShift Service Mesh uses a standard set of HTTP headers for trace context propagation. The Envoy proxy sidecar tracks these headers and forwards them to Jaeger for storage and analysis. Services in the mesh are responsible for collecting and propagating the following headers from the incoming request to any outgoing requests:

- x-request-id
- x-b3-traceid
- x-b3-spanid
- x-b3-parentspanid
- x-b3-sampled
- x-b3-flags
- x-ot-span-context

## **Enabling Distributed Tracing in Quarkus Applications**

Envoy proxies are configured by default to propagate tracing related headers for traffic flowing into the service mesh. You must explicitly enable tracing in your applications to generate traces and spans and to propagate context information.

Enabling tracing for Quarkus based applications is very simple. Quarkus supports tracing with minimum source code changes.

For example, to enable tracing in applications based on the Quarkus framework, the following steps are required:

- Include the `quarkus-smallrye-opentracing` dependency in the project `pom.xml` file. This dependency implements the OpenTracing API, an open standard based on Jaeger for distributed tracing.

```
<dependency>
  <groupId>io.quarkus</groupId>
  <artifactId>quarkus-smallrye-opentracing</artifactId>
</dependency>
```

- Enable tracing related properties in the Quarkus application.properties file. This file is used to externalize configuration for Quarkus applications.

```
quarkus.jaeger.service-name=myservice ①
quarkus.jaeger.sampler-type=const ②
quarkus.jaeger.sampler-param=1 ③
quarkus.jaeger.endpoint=http://jaeger-collector.istio-system.svc:14268/api/
traces ④
quarkus.jaeger.propagation=b3 ⑤
quarkus.jaeger.reporter-log-spans=true ⑥
```

- A unique service name to identify traces and spans sent to Jaeger. You will be able to identify traces and spans using this name in the Jaeger web console.
  - Indicates the rate at which traces and spans should be collected from this application. Options include; const (collect all samples), probabilistic (random sampling), ratelimiting (collect samples at a configurable rate per second), and remote (control sampling from a central Jaeger backend). Refer to <https://www.jaegertracing.io/docs/1.20/sampling/> for more details.
  - Indicates the percentage of requests for which spans should be collected. It should value between 0 and 1. For const sampling type 0 indicates no sample collection, while a 1 indicates collecting all samples (100%). This value should not be set to 1 in production environments with a large number of requests. This is usually set to 1 in development and QA environments to debug and troubleshoot inter-service latency and performance issues.
  - The URL of the Jaeger collector. In Red Hat OpenShift Service Mesh, the Jaeger collector URL is <http://jaeger-collector.istio-system.svc:14268/api/traces>.
  - Indicates Jaeger to propagate all x-b3-\* related headers. This is required to construct the parent-child relationships in the call graph. Failure to set this will not show the parent-child relationships between spans in the Jaeger web console.
  - Log span information for all incoming and outgoing traffic from the application.
- The first two steps are enough to enable tracing for all classes and methods in the application. However, for more complex applications you can control which classes and methods must be enabled for tracing.
- Annotate classes with @Traced annotation to enable tracing for the entire class. You can also add this annotation at a method level to enable tracing for specific methods and exclude the rest.

**Note**

The above steps are enough to enable distributed tracing for Quarkus applications. All incoming and outgoing traffic is traced and the context propagation of relevant headers is taken care of automatically.

To customize the tracing (for example, add more contextual information to traces and spans using tags and other metadata), you can use the OpenTracing API. Refer to the OpenTracing documentation at <https://opentracing.io/guides/java/> for more details.

## Enabling Distributed Tracing in Node.js Applications

To enable distributed tracing for Node.js based applications, you should use the `jaeger-client` and `opentracing` NPM packages.

You must add code to your application to start traces and spans. You must manually control the context propagation by manipulating the HTTP headers of incoming and outgoing traffic in an application. Parent child relationships are explicitly controlled by the developer.

To enable distributed tracing for Node.js applications, do the following:

- Install the `jaeger-client` and `opentracing` NPM packages.

```
[user@demo ~]$ npm install --save \
  jaeger-client opentracing
```

- Import the Jaeger client library.

```
const initJaegerTracer = require("jaeger-client").initTracer;
```

- Configure and initialize the Jaeger tracer

```
const config = {
  serviceName: 'myservice',
  sampler: {
    type: "const",
    param: 1,
  },
  reporter: {
    collectorEndpoint: 'http://jaeger-collector.istio-system.svc:14268/api/traces',
    logSpans: true
  },
};
const options = { } ;
const tracer = initJaegerTracer(config, options);
```

**Note**

The configuration options are similar to the ones outlined in the previous section about configuring Quarkus applications using the `application.properties` file. Refer to the call out list in the previous section for details about the configuration parameters.

- Start a new span, for example at the start of a function. Pass in a suitable string identifier as argument. The Jaeger web console displays spans and will show the corresponding identifier for each span.

```
const span = tracer.startSpan("mymethod");
```

You can add contextual information to this span using the `setTag()` method. You can pass any relevant object as an argument, which will help you troubleshoot issues as the request flows across services in the mesh. You can add multiple tags to a span.

```
span.setTag("mymethod", "some-message");
```

- Once the function finishes executing, invoke the `span.finish()` function to end the span.

```
span.finish();
```

## Context Propagation and Child Spans

When you create a new span using the `startSpan()` method, it creates a new root span by default. A request can call multiple services in a certain order. You must link these different calls using parent child relationships so that the Jaeger web console can display the appropriate service call graph, and help you trace the call flow.

To declare a span as a child of another span, add the `childOf` property with a value of the parent span to the `startSpan()` method.

```
const childSpan = tracer.startSpan("another-method", { childOf: span });
```

For any non-trivial Node.js application, with code organized in modules spread across multiple files, a side effect of the above code is the need to keep passing the span object around. This is required to keep building the call flow and maintain parent child relationships between spans.

A better approach is to create a context object and encapsulate the span inside it. You can then pass the context object around, and use it to store other application related data as well.

```
const ctx = { span };
ctx = {
  span: tracer.startSpan("mymethod", { childOf: ctx.span }),
};
```

Note that context propagation as outlined previously will work only between method calls running in the same Node.js runtime process.

Passing contextual information between completely isolated microservices connected by a network brings more challenges. The OpenTracing API provides some helper methods to solve this problem.

You can inject the contextual information using HTTP headers to outgoing traffic, and then extract contextual information from requests coming into the application. The following code illustrates this:

```
const { Tags, FORMAT_HTTP_HEADERS } = require('opentracing');
...code omitted...

const method = 'GET';
const headers = {};
const url = "some-remote-URL"

span.setTag(Tags.HTTP_URL, url);
span.setTag(Tags.HTTP_METHOD, method);
span.setTag(Tags.SPAN_KIND, Tags.SPAN_KIND_RPC_CLIENT);

tracer.inject(span, FORMAT_HTTP_HEADERS, headers);
```

You can then invoke other remote services, for example, using the NPM `request-promise` module and pass on the HTTP headers.

```
request({url, method, headers})
  .then( data => {
    span.finish();
    return data;
  }, e => {
    span.finish();
    throw e;
  });
});
```

For incoming traffic, you can extract the contextual information using the `tracer.extract()` method as per the following.

```
const { Tags, FORMAT_HTTP_HEADERS } = require('opentracing');
...code omitted...

const parentSpanContext = tracer.extract(FORMAT_HTTP_HEADERS, req.headers);
const span = tracer.startSpan('another-method', {
  childOf: parentSpanContext,
  tags: {[Tags.SPAN_KIND]: Tags.SPAN_KIND_RPC_SERVER}
});
```

With this approach, trace, span and context information is maintained across service calls in a service mesh.

**Note**

You can also configure Jaeger using environment variables. Support for configuration through environment variables differs based on the client implementation. See <https://www.jaegertracing.io/docs/1.20/client-features/> for more details.

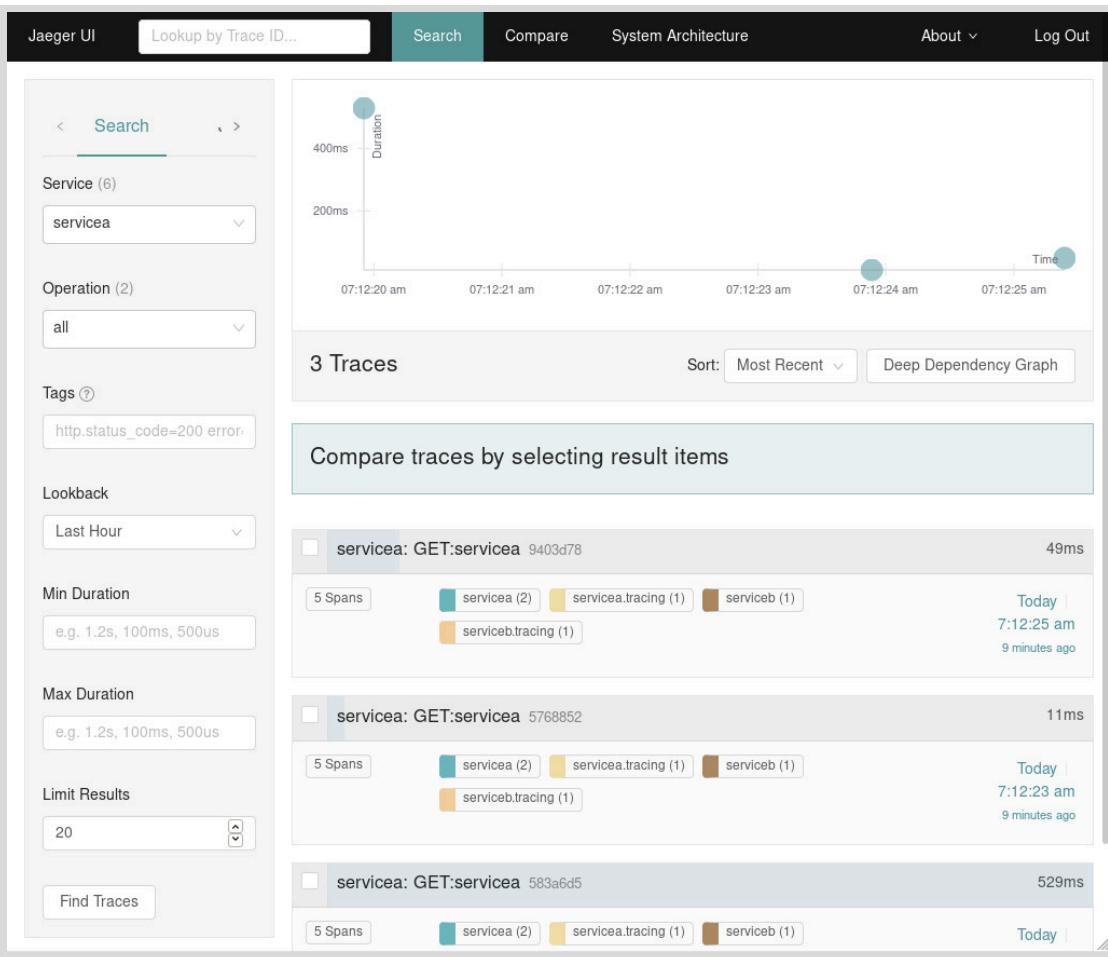
You can declare these environment variables in Dockerfiles, but it is recommended to use configuration maps or secrets to inject these variables to comply with the 12-factor methodology.

## Viewing Traces and Spans Using the Jaeger Web Console

The Jaeger web console is installed by default with Red Hat OpenShift Service Mesh and is tightly integrated with the OpenShift web console.

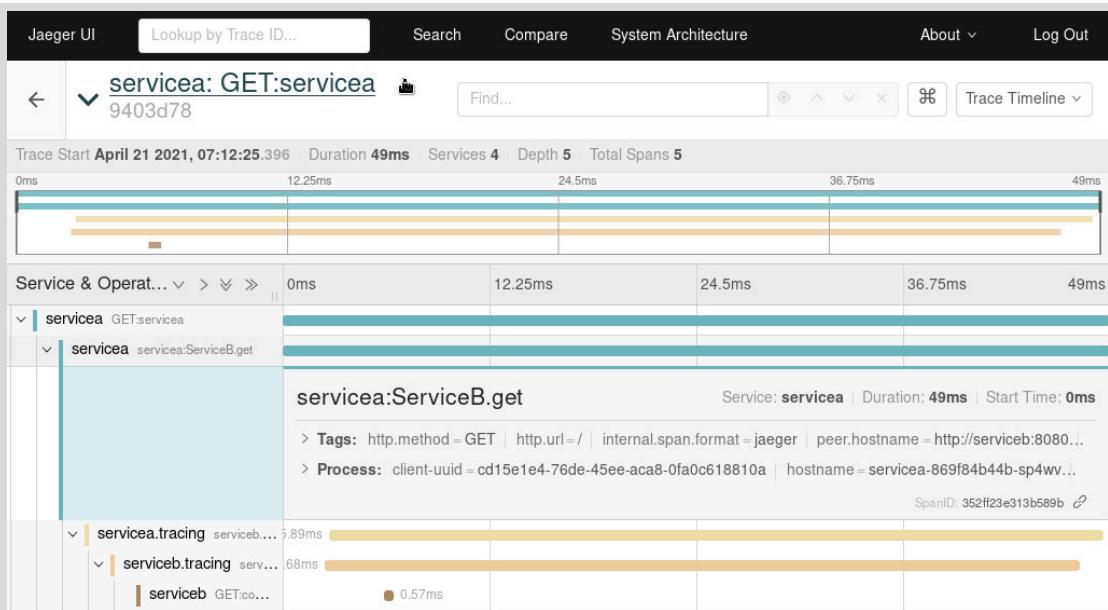
To view details about traces and spans in the Jaeger console, do the following:

1. In the OpenShift web console, navigate to **Networking** → **Routes** and search for the jaeger route, which is the URL listed in the **Location** column.
2. Log in using the same user name and password that is used to access the OpenShift web console. You should see the Jaeger web console home page.
3. In the left pane of the Jaeger console, from the **Service** menu, select your application and click **Find Traces** at the bottom of the pane. A list of traces gathered for the application are displayed.



**Figure 3.5: List of traces**

- Click one of the traces in the list to open a detailed view of that trace.



**Figure 3.6: Trace details**



## References

For more information, refer to the *Understanding Jaeger* section in the *Red Hat Service Mesh Guide* at

[https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.6/html-single/service\\_mesh/index#understanding-jaeger](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.6/html-single/service_mesh/index#understanding-jaeger)

### Istio Distributed Tracing

<https://archive.istio.io/v1.6/docs/tasks/observability/distributed-tracing/>

## ► Guided Exercise

# Tracing Services with Jaeger

In this exercise, you will deploy two microservices on OpenShift Service Mesh, and trace the service communication using Jaeger.

- `servicea`: written in JavaScript using the Node.js runtime.
- `serviceb`: written in Java using the Quarkus framework.

Traffic enters the service mesh through `servicea`. `servicea` calls `serviceb` and returns a response.

You will do the following in this exercise:

1. Enable distributed tracing in both microservices using Jaeger.
2. Build container images locally for both microservices using `podman`.
3. Push the built container images to the `Quay.io` public container registry.
4. Deploy both microservices to the service mesh, and trace the service calls between the two microservices.

## Outcomes

You should be able to deploy applications to OpenShift Service Mesh, and trace the path of the service calls for requests entering the service mesh.

## Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- An installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (`/usr/local/bin/oc`).
- An account with the `Quay.io` container registry, and `podman` installed locally on your workstation.

As the `student` user on the `workstation` machine, use the `lab` command to validate the prerequisites for this exercise:

```
[student@workstation ~]$ lab observe-jaeger start
```

## Instructions

- 1. Clone the source code for the microservices from GitHub. Inspect the source code for both microservices.

Use a text editor like VSCode, which supports syntax highlighting for editing JavaScript and Java source files.

- 1.1. Open a new terminal window on your workstation. From the home directory, clone the source code for the microservices from GitHub.

```
[student@workstation ~]$ git clone https://github.com/RedHatTraining/D0328-apps
...output omitted...
Cloning into 'D0328-apps'...
...output omitted...
```

- 1.2. Copy the contents of the /home/student/D0328-apps/tracing-ge folder from your local Git repository to the /home/student/D0328/labs/observe-jaeger folder.

```
[student@workstation ~]$ cp -Rv ~/D0328-apps/tracing-ge/* \
~/D0328/labs/observe-jaeger/
```

You should now see two folders called servicea and serviceb in the /home/student/D0328/labs/observe-jaeger/ folder.

You should also see shell scripts and service mesh related YAML files in the same folder. These were created by the lab start script.

- 1.3. Review the source code for servicea in the /home/student/D0328/labs/observe-jaeger/servicea/index.js file.

This microservice exposes a single HTTP GET endpoint, which calls serviceb and returns a response to the client.

```
...output omitted...
server.get("/", async (request) => {
  const { rootSpan } = request;
  const msg = await serviceb.callServiceB(rootSpan);

  return 'Hello from ServiceA!.\\nResponse from ServiceB => ' + msg + '\\n';
});
...output omitted...
```

- 1.4. Review the source code for serviceb in the /home/student/D0328/labs/observe-jaeger/serviceb/src/main/java/com/redhat/training/serviceb/ServiceB.java file.

This microservice contains a single HTTP GET endpoint that returns a string.

```
...output omitted...
String message = "Hello from ServiceB!";

@GET
@Produces(MediaType.TEXT_PLAIN)
public String sayHello() {
    return message;
}
...output omitted...
```

► 2. Enable tracing for servicea using the Jaeger and OpenTracing libraries.

- 2.1. Navigate to the /home/student/D0328/labs/observe-jaeger/servicea folder on the command line terminal. All references to file paths in this step are relative to this folder.

```
[student@workstation ~]$ cd ~/D0328/labs/observe-jaeger/servicea
```

- 2.2. Inspect the package.json file, which declares all the NPM packages required for running this microservice.

Install the packages declared in package.json, followed by installing the opentracing and jaeger-client dependencies.

```
[student@workstation servicea]$ npm install
[student@workstation servicea]$ npm install --save \
  jaeger-client@3.17.2 opentracing@0.14.4
...output omitted...
+ opentracing@0.14.4
+ jaeger-client@3.17.2
...output omitted...
```

- 2.3. Edit the index.js file.

Add the default value for the TRACE\_COLLECTOR\_URL variable. This should be the URL of the Jaeger collector that is running in the service mesh.

```
const TRACE_COLLECTOR_URL = ...output omitted... || "http://jaeger-
collector.istio-system.svc:14268/api/traces";
```

Note how the collector URL is used to initialize the tracer.

```
const tracer = Tracer.create("servicea", TRACE_COLLECTOR_URL, logger);
```

The service name servicea is also passed to the Tracer.create() method, which indicates the starting point of the trace.

- 2.4. Edit the Tracer.js file, which configures the tracer properties for this microservice.

Add the parameters for the config and reporter properties in the create function as follows:

```
const config = {
  serviceName: serviceName,
  sampler: {
    type: "const",
    param: 1,
  },
  reporter: {
    logSpans: true,
    collectorEndpoint
  }
};
```

You can also copy the code from the solution file /home/student/D0328/solutions/observe-jaeger/servicea/Tracer.js.

Note the use of HTTP headers to propagate the trace context using the `tracer.registerInjector()` and `tracer.registerExtractor()` methods.

```
tracer.registerInjector(FORMAT_HTTP_HEADERS, codec);
tracer.registerExtractor(FORMAT_HTTP_HEADERS, codec);
```

- 2.5. Edit the `HttpServer.js` file. Note the callback methods, `traceRequest` and `traceResponse` registered as hooks to the server. These methods are called after every HTTP request to the microservice, and before sending the response to the client respectively.

Edit the `traceRequest` method and add code to create a new root span with a unique string id. Add OpenTracing tags to the span to identify the original URL of the request and the HTTP method (GET, POST, PUT, DELETE and more).

```
const span = tracer.startSpan(`[${method}]:servicea`);
span.setTag(OpenTracing.Tags.HTTP_URL, originalUrl);
span.setTag(OpenTracing.Tags.HTTP_METHOD, method);
```

You can also copy the code from the solution file `/home/student/D0328/solutions/observe-jaeger/servicea/HttpServer.js`.

- 2.6. Briefly review the `Services/ServiceB.js` file. Do not make any changes to this file. The `get()` method is invoked on every request to the root URL of the microservice ("").

The implementation is inherited from the parent `RestClient` class. Edit the `Services/RestClient.js` file.

Create a new span for the `get()` method, which is a child span of the root span. Add Tags to indicate which endpoint is being called, as well as the caller URL, the HTTP method, and the type of span.

```
async get(url, rootspan) {
  ...output omitted...
  const span = this.tracer.startSpan(spanName, { childOf: rootSpan.context() });
  span.setTag(Tags.PEER_HOSTNAME, this.baseUrl);
  span.setTag(Tags.HTTP_URL, url);
  span.setTag(Tags.HTTP_METHOD, "GET");
  span.setTag(Tags.SPAN_KIND, Tags.SPAN_KIND_RPC_CLIENT);
  ...output omitted...
}
```

Inject the span data as HTTP headers to propagate the span context. Add the following code to the `_buildAxiosRequestConfig()` method.

```
_buildAxiosRequestConfig(span) {
  const headers = {};
  this.tracer.inject(span, FORMAT_HTTP_HEADERS, headers);
  return { headers };
}
```

You can also copy the code from the solution file `/home/student/D0328/solutions/observe-jaeger/servicea/Services/RestClient.js`.

- 2.7. Save your changes. To ensure that there are no syntax errors, run `npm start` and ensure that the microservice starts without any errors.

If there are errors, then compare your changes with the solution files in the `/home/student/D0328/solutions/observe-jaeger/servicea` folder.

```
[student@workstation servicea]$ npm start

servicea@1.0.0 start ...output omitted...
node index.js

...output omitted...: "Initializing Jaeger Tracer ...output omitted...
...output omitted...: "Server listening at http://0.0.0.0:8080 "}
```

Press `Ctrl+C` to stop the server.

► 3. Enable tracing for `serviceb` using the `quarkus-smallrye-opentracing` library.

- 3.1. Change to the `/home/student/D0328/labs/observe-jaeger/serviceb` folder. All references to file paths in this step are relative to this folder.

```
[student@workstation ~]$ cd ~/D0328/labs/observe-jaeger/serviceb
```

- 3.2. Inspect the maven `pom.xml` file, which declares the dependencies for this microservice.

Include the `quarkus-smallrye-opentracing` dependency for enabling tracing.

```
<dependency>
  <groupId>io.quarkus</groupId>
  <artifactId>quarkus-smallrye-opentracing</artifactId>
</dependency>
```

You can also copy the code from the solution file `/home/student/D0328/solutions/observe-jaeger/serviceb/pom.xml`.

- 3.3. Briefly review the code in the `src/main/java/com/redhat/training/serviceb/ServiceB.java` file. Do not make any changes to this file.

Tracing is automatically enabled by adding the `quarkus-smallrye-opentracing` maven dependency, and then enabling some jaeger related environment variables in the Quarkus `application.properties` file.

- 3.4. Edit the `src/main/resources/application.properties` file and add the jaeger related properties.

```
quarkus.jaeger.service-name=serviceb
quarkus.jaeger.sampler-type=const
quarkus.jaeger.sampler-param=1
quarkus.log.console.format=%d{HH:mm:ss} %-5p traceId=%X{traceId}, spanId=
%X{spanId}, sampled=%X{sampled} [%c{2.}] (%t) %s%e%n
quarkus.jaeger.endpoint=http://jaeger-collector.istio-system.svc:14268/api/traces
quarkus.jaeger.propagation=b3
quarkus.jaeger.reporter-log-spans=true
```

You can also copy the code from the solution file /home/student/D0328/solutions/observe-jaeger/serviceb/src/main/resources/application.properties.

- 3.5. Save your changes. To ensure that there are no syntax errors, run `mvn clean package` and ensure that a fat JAR is created in the `target` folder.

```
[student@workstation serviceb]$ mvn clean package
...output omitted...
[INFO] Building serviceb 1.0.0
...output omitted...
...output omitted... Building fat jar: observe-jaeger/serviceb/target/
serviceb-1.0.0-runner.jar
[INFO] [io.quarkus.deployment.QuarkusAugmentor] Quarkus augmentation completed in
2440ms
...output omitted...
[INFO] BUILD SUCCESS
...output omitted...
```

- 3.6. Start the microservice and verify that there are no errors.

```
[student@workstation serviceb]$ java -jar target/serviceb-1.0.0-runner.jar
...output omitted... (powered by Quarkus 1.3.2.Final) started in 0.747s.
Listening on: http://0.0.0.0:8080
...output omitted...
```

Verify that there are no errors. If there are errors, then compare your changes with the solution files in the /home/student/D0328/solutions/observe-jaeger/serviceb folder. Press `Ctrl+C` to stop the server.

#### ▶ 4. Build container images for both microservices using podman.

- 4.1. Load your classroom environment configuration.

Run the following command to load the environment variables:

```
[student@workstation serviceb]$ source /usr/local/etc/ocp4.config
```

- 4.2. Review the `Dockerfile` for `servicea`. Use Red Hat Universal Base Images (UBI) as the base for building your container image. Do not make any changes to the `Dockerfile`.

- 4.3. Build the container image for `servicea` using podman.

```
[student@workstation serviceb]$ cd ~/D0328/labs/observe-jaeger/servicea
[student@workstation servicea]$ podman build -t \
quay.io/${RHT_OCP4_QUAY_USER}/ossm-tracing-servicea:1.0 .
STEP 1: FROM registry.access.redhat.com/ubi8/nodejs-12
...output omitted...
STEP 13: COMMIT quay.io/youruser/ossm-tracing-servicea:1.0
```

- 4.4. Similarly, build the container for `serviceb` after reviewing the `Dockerfile`.

```
[student@workstation servicea]$ cd ~/DO328/labs/observe-jaeger/serviceb
[student@workstation serviceb]$ podman build -t \
quay.io/${RHT_OCP4_QUAY_USER}/ossm-tracing-serviceb:1.0 .
STEP 1: FROM registry.access.redhat.com/ubi8:8.1
...output omitted...
STEP 15: COMMIT quay.io/youruser/ossm-tracing-serviceb:1.0
```

4.5. Verify that the container images for servicea and serviceb are built successfully.

```
[student@workstation serverb]$ podman images
REPOSITORY                                     TAG ...output omitted...
quay.io/youruser/ossm-tracing-serviceb        1.0 ...output omitted...
quay.io/youruser/ossm-tracing-servicea        1.0 ...output omitted...
...output omitted...
```

- ▶ 5. Create new public image repositories in Quay.io to store the newly built container images. Push the container images to Quay.io.
  - 5.1. Create two new public container image repositories called `ossm-tracing-servicea`, and `ossm-tracing-serviceb` in Quay.io. Refer to the instructions in *Appendix B, Creating a Quay account* for creating public container image repositories.



### Warning

If you skip this step and push the container images without creating public repositories, then the `podman push` commands create private container image repositories by default.

5.2. Login to your Quay.io account using `podman`.

```
[student@workstation serverb]$ podman login -u ${RHT_OCP4_QUAY_USER} quay.io
```

You will be prompted for your Quay.io password.

5.3. Push the container image for `servicea` to Quay.io.

```
[student@workstation serverb]$ podman push \
quay.io/${RHT_OCP4_QUAY_USER}/ossm-tracing-servicea:1.0
...output omitted...
Writing manifest to image destination
Storing signatures
```

5.4. Push the container image for `serviceb` to Quay.io.

```
[student@workstation serverb]$ podman push \
quay.io/${RHT_OCP4_QUAY_USER}/ossm-tracing-serviceb:1.0
...output omitted...
Writing manifest to image destination
Storing signatures
```

- ▶ 6. Create the tracing project and then add it to the `ServiceMeshMemberRoll` resource.

- 6.1. Log in to OpenShift as the developer user.

```
[student@workstation serverb]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

- 6.2. Create the tracing project.

```
[student@workstation serverb]$ oc new-project tracing
Now using project "tracing" on server
"https://api.cluster.domain.example.com:6443".
...output omitted...
```

- 6.3. Add the tracing project to the list of members in the ServiceMeshMemberRoll resource. Edit the default ServiceMeshMemberRoll resource in the OpenShift web console and add the tracing project to the member list.

```
apiVersion: maistra.io/v1
kind: ServiceMeshMemberRoll
metadata:
...output omitted...
spec:
members:
- tracing
...output omitted...
```

You can also run the `add-project-to-smmr.sh` script in the `/home/student/D0328/labs/observe-jaeger` folder to add the metrics project to the list of members in the ServiceMeshMemberRoll resource.

```
[student@workstation serverb]$ cd /home/student/D0328/labs/observe-jaeger
[student@workstation observe-jaeger]$ oc patch servicemeshmemberroll/default \
-n istio-system --type=merge \
-p '{"spec": {"members": ["tracing"]}}'
servicemeshmemberroll.maistra.io/default patched
```



#### Note

You can also use the `oc edit smmr default -n istio-system` command and add the tracing project to the member list.

7. Deploy the microservices to OpenShift service mesh.

- 7.1. Edit the `*-deploy.yaml` files in the `/home/student/D0328/labs/observe-jaeger` folder, which describes the necessary resources to deploy both applications. The deployment files have the `sidecar.istio.io/inject: "true"` annotation included to inject the Envoy proxy after deployment.
- 7.2. Edit the `/home/student/D0328/labs/observe-jaeger/servicea-deploy.yaml` file. Edit the `spec.template.spec.containers.image` attribute and add the Quay.io URL of the newly built container image.

```
...output omitted...
spec:
  containers:
    - name: servicea
      image: quay.io/youruser/ossm-tracing-servicea:1.0
      imagePullPolicy: IfNotPresent
...output omitted...
```

- 7.3. Edit the `/home/student/D0328/labs/observe-jaeger/serviceb-deploy.yaml` file. Add the Quay.io URL of the container image for `serverb`.

```
...output omitted...
spec:
  containers:
    - name: serviceb
      image: quay.io/youruser/ossm-tracing-serviceb:1.0
      imagePullPolicy: IfNotPresent
...output omitted...
```

- 7.4. Run the `oc create` command to deploy the applications.

```
[student@workstation observe-jaeger]$ oc create -f servicea-deploy.yaml
deployment.apps/servicea created
service/servicea created
[student@workstation observe-jaeger]$ oc create -f serviceb-deploy.yaml
deployment.apps/serviceb created
service/serviceb created
```

- 7.5. Run the `oc get pods` command and verify that both microservices are deployed and in `Running` state.

```
[student@workstation observe-jaeger]$ oc get pods
NAME          READY   STATUS    RESTARTS   AGE
servicea-6c9fffc58-v699r   2/2     Running   0          10m
serviceb-78489f94bf-z4vdh   2/2     Running   0          10m
```

- 7.6. Inspect the `/home/student/D0328/labs/observe-jaeger/gateway.yaml` file, which describes the ingress gateway for traffic entering the mesh.

Use the `oc create` command to create the ingress gateway.

```
[student@workstation observe-jaeger]$ oc create -f gateway.yaml
gateway.networking.istio.io/observe-jaeger-gateway created
```

- 7.7. Create a `VirtualService` to redirect the ingress traffic to `servicea`, which acts as an entry point into the mesh.

Examine the `virtual-service.yaml` file, which routes the ingress traffic to `servicea`.

Use the `oc create` command to create the virtual service.

```
[student@workstation observe-jaeger]$ oc create -f virtual-service.yaml
virtualservice.networking.istio.io/observe-jaeger-vs created
```

► 8. Test the microservices.

- 8.1. Run the `oc get route` command to get the URL of the Istio gateway.

You can also cut and paste the full command from the `get-ingress-gateway-url.sh` file.

Export the ingress gateway URL to an environment variable called `GATEWAY_URL`.

```
[student@workstation observe-jaeger]$ GATEWAY_URL=$( \
  oc get route istio-ingressgateway -n istio-system \
  -o template --template '{{ "http://" }}{{ .spec.host }}')
```

- 8.2. Execute the `curl` command in combination with the `GATEWAY_URL` variable to access the application.

```
[student@workstation observe-jaeger]$ curl ${GATEWAY_URL}/trace
Hello from ServiceA!.
Response from ServiceB => Hello from ServiceB!
```

► 9. Visualize traces generated by the microservices using the Jaeger web console.

- 9.1. Run the `oc get route` command to gather the Jaeger web console URL. You can also copy the commands from the `get-jaeger-url.sh` file.

```
[student@workstation observe-jaeger]$ JAEGER_URL=$( \
  oc get route jaeger -n istio-system \
  -o template --template '{{ "https://" }}{{ .spec.host }}')
```

- 9.2. Use Firefox web browser to access the Jaeger web console.

```
[student@workstation observe-jaeger]$ firefox ${JAEGER_URL} &
```

- 9.3. Click **Log in with OpenShift**.

Log in using your developer user account. Your user name is the `RHT_OCP4_DEV_USER` variable in the `/usr/local/etc/ocp4.config` classroom configuration file. Your password is the `RHT_OCP4_DEV_PASSWORD` variable in the same file.

If you are accessing the Jaeger web console for the first time, then you will be prompted with a page asking you to authorize service account access to your account.

Click **Allow selected permissions** to bring up the Jaeger web console.

## Authorize Access

Service account jaeger-ui-proxy in project istio-system is requesting permission to access your account (developer)

### Requested permissions

**user:info**

Read-only access to your user information (including username, identities, and group membership)

**user:check-access**

Read-only access to view your privileges (for example, "can I create builds?")

You will be redirected to <https://jaeger-istio-system.apps.cluster.domain.example.com/oauth/callback>

[Allow selected permissions](#)

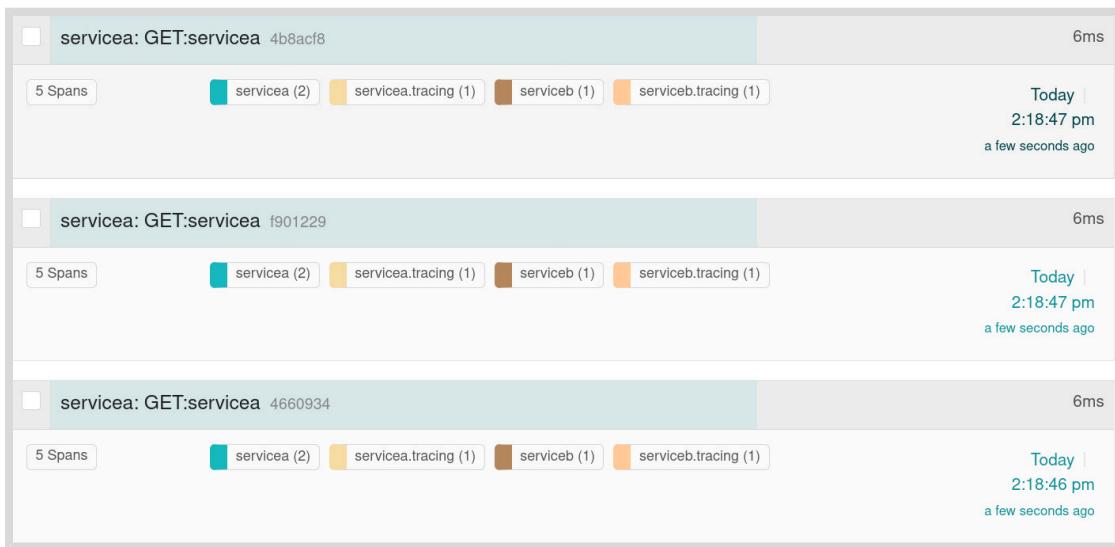
[Deny](#)

- 9.4. Execute the `curl` command against the URL  `${GATEWAY_URL} /trace` multiple times to generate some load and allow the microservices to send traces and span information to Jaeger.
- 9.5. In the Jaeger web console, refresh the page and then select the `servicea` in the left panel. Click **Find Traces** to retrieve the traces.

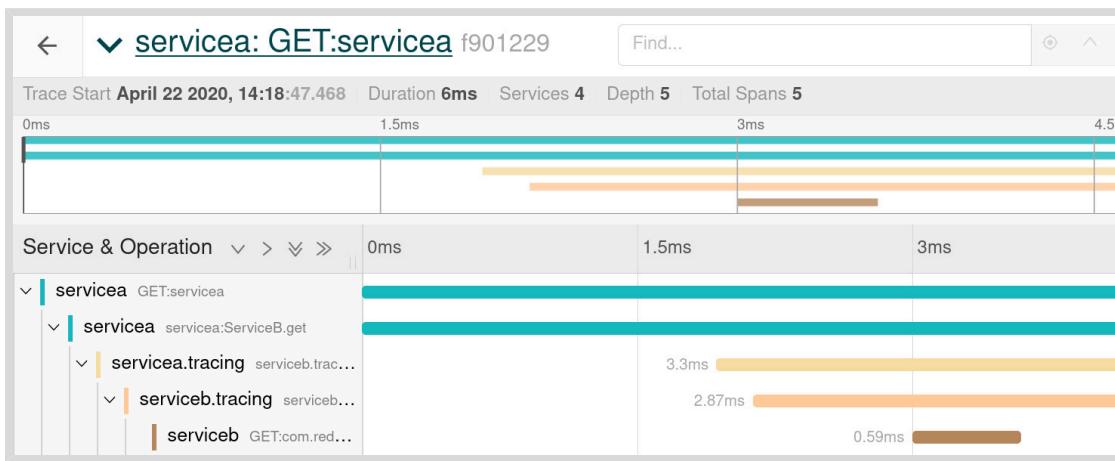
The screenshot shows the Jaeger UI search interface. At the top, there is a navigation bar with tabs for 'Jaeger UI', 'Lookup by Trace ID...', 'Search' (which is active), and 'Logs'. Below the navigation bar is a search form. The 'Search' tab is highlighted in blue. The 'Service' dropdown menu is open, showing a list of services: 'istio-ingressgateway', 'jaeger-query', 'servicea' (which is highlighted with a red box), 'servicea.tracing', 'serviceb', and 'serviceb.tracing'. Below the service dropdown are fields for 'Lookback' (set to 'Last Hour'), 'Min Duration' (with placeholder 'e.g. 1.2s, 100ms, 500us'), 'Max Duration' (with placeholder 'e.g. 1.2s, 100ms, 500us'), and 'Limit Results' (set to '20'). At the bottom of the search form is a large 'Find Traces' button.

### Chapter 3 | Observing a Service Mesh

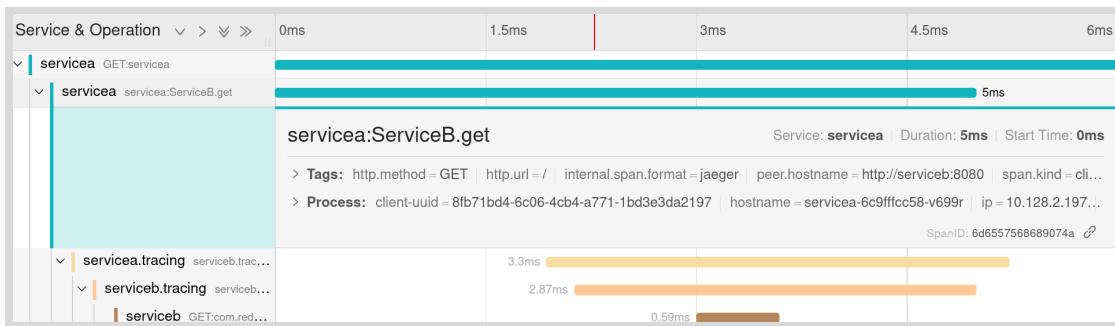
- 9.6. You should see a number of traces displayed, corresponding to the number of requests that you made to the service mesh.



Click any one trace and observe the spans reported by both microservices. Note how the spans from serviceb are shown as child spans of servicea.



You can click each of the spans and note the runtime values, which have been propagated through HTTP headers as the traffic flows from servicea to serviceb.



Expand Tags for the servicea.tracing span to see contextual span information, which was propagated to services.

serviceb.tracing.svc.cluster.local:8080/*		Service: <b>servicea.tracing</b>   Duration: <b>3.3ms</b>   Start Time: <b>1.93ms</b>
<b>Tags</b>		
component	"proxy"	
downstream_cluster	"-"	
guid:x-request-id	"80f3f62a-a4a5-9897-81e5-288992dd63de"	
http.method	"GET"	
http.protocol	"HTTP/1.1"	
http.status_code	"200"	
http.url	"http://serviceb:8080/"	
internal.span.format	"zipkin"	
node_id	"sidecar-10.128.2.197-servicea-6c9fffc58-v699r.tracing-tracing.svc.cluster.local"	
request_size	"0"	
response_flags	"-"	



### Note

You will see extra \*.tracing spans in the Jaeger console. These are propagated by the Envoy proxy as it intercepts traffic bound for the services in the mesh.

- 10. Return to the home directory.

```
[student@workstation observe-jaeger]$ cd
```

## Finish

On the **workstation** machine, use the **lab** command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab observe-jaeger finish
```

This concludes the guided exercise.

# Collecting Service Metrics

## Objectives

After completing this section, you should be able to collect and inspect critical metrics with Prometheus and Grafana.

## Metrics and Service Level Objectives

In any system that has a large number of services, it is important to understand the different types of metrics to gather, and then decide on a process to measure and evaluate their performance. Each service, or a set of services with common business functionality can define their own set of metrics that should be gathered, measured and analyzed.

A common practice is to define a set of *service levels* that act as a sort of contract, or agreement between a service provider and a service consumer. Service levels can be broadly classified into three categories:

### Service Level Indicators (SLI)

An SLI is a carefully defined quantitative measure of some aspect of the level of service that is provided. For example, a common SLI is the **response time**, that is, the time taken by a service to provide a response. Other examples of SLI include **error rate** (percentage of responses that were invalid), and **availability** (percentage of time that the service was in a correctly functional state).

### Service Level Agreements (SLA)

An SLA is an explicit or implicit contract with your users which includes consequences of meeting (or missing) the service level objectives (SLO) for a service. Selecting and publishing an SLA to users sets expectations about how a service will perform. For example, a credit card payment service for an e-commerce website will have an SLA that declares that "All payment requests will be processed in less than 5 seconds."

### Service Level Objectives (SLO)

An SLO is a threshold value, or range of values that is measured by an SLI. For example, an E-commerce website can have an SLO that tries to render a product catalog page in 3 to 5 seconds. Another scenario could be for handling a large number of users, for example "The payment service should be capable of handling 30,000 to 35,000 users concurrently on weekends."

## Selecting Metrics to Measure

You should carefully select a set of metrics for a service that you want to include in your SLI. Selecting too many metrics wastes monitoring cycles and clutters up your dashboards, while choosing too few, or the wrong metrics will impede your analysis and reduce the effectiveness of your response to issues in the field.

Examples of types of systems, and the metrics that are relevant for measuring their performance are as follows:

- **End user facing systems/HTTP web APIs**: Good candidates for SLIs are system uptime (availability), response time (latency), and number of requests served per second (throughput).

- **Big Data/Machine Learning:** SLIs such as data throughput (how many items were processed) and end-to-end latency (how much time to process all the data) are the preferred starting points for measurement.
- **Database/Storage Systems:** These kinds of systems are concerned with latency (how quickly were items written to disk), availability, and durability (no data corruption).

These are good starting points and not a definitive list of indicators. You must analyze your service and determine what metrics to gather, ideally a small set of core metrics are preferred over monitoring a large number of items. Use an iterative approach to add new metrics and learn from incidents in production.

## Service Mesh Metrics (Telemetry)

Red Hat OpenShift Service Mesh gathers detailed metrics (telemetry) for all services within a service mesh. These metrics allow developers to observe, troubleshoot, and optimize the behavior of their applications under load. Developers are able to understand how the services communicate and interact with each other, as well as with the service mesh control plane.

A default installation of Red Hat OpenShift Service Mesh gathers a number service metrics related to error rates, rate of traffic, HTTP status codes of the response, and more. The service mesh also gathers detailed metrics for its control plane. A default set of monitoring dashboards using these metrics is automatically created and provided to developers.

### Metrics from Envoy Proxies

The Envoy proxies provide a rich set of metrics about traffic passing through the proxy, both incoming (ingress) and outgoing (egress). The proxies also provide detailed statistics about the functioning of the proxy itself (health status and configuration).

You can customize the set of Envoy proxy metrics that will be collected for a given service mesh. By default, only a small subset of the Envoy proxy metrics are collected. This avoids overloading the system and reduces the CPU overhead associated with metrics collection.

The *References* section has a number of links that detail the metrics that are available for monitoring the Envoy proxies.

### Metrics from Application Services

Red Hat OpenShift Service Mesh provides a set of application service metrics for observing the performance and state of incoming and outgoing service traffic.

A default installation of Red Hat OpenShift Service Mesh gathers the following service metrics:

- Request Count : The total number of requests sent to a service.
- Request Duration : The time taken for the service to provide a response.
- Request Size : The size of the body in the HTTP request.
- Response Size : The size of the body in the HTTP response.

The *References* section has a number of links that detail the full list of metrics that are available for monitoring the application services.

## Metrics from the Service Mesh Control Plane

Each of the service mesh components (Pilot, Citadel, and Galley) also provide a set of metrics about their health, configuration, and performance.

The *References* section has a number of links that detail the full list of metrics that are available for monitoring the components of the service mesh control plane.

## Introducing Prometheus and Grafana

*Prometheus* is an open-source systems monitoring and alerting toolkit which includes a time-series database for storing metrics. It provides a powerful web based user interface to query and analyze performance trends from the data it collects.

Red Hat OpenShift Service Mesh provides a default Prometheus server instance which gathers metrics data from the Envoy proxies, the services in the service mesh, and the components in the control plane.

*Grafana* is an open-source graphical visualization tool used for creating operational dashboards for software systems.

Red Hat OpenShift Service Mesh provides a default Grafana instance with ready made dashboards for viewing data from the Envoy proxies, the services in the service mesh, and the components in the control plane. The Grafana instance is tightly integrated with the default Prometheus instance in the service mesh installation and uses the data stored in Prometheus to render the graphs in the dashboard.

## Collecting Custom Application Metrics

A default Red Hat OpenShift Service Mesh instance automatically collects several useful metrics for your application. These metrics are useful to get a high-level understanding of the performance of the service mesh and the applications deployed on it.

However, you might sometimes need to gather custom application specific metrics and display them in a Grafana dashboard. For example, in an E-commerce application, you might wish to track how many items of a specific category are sold over a weekend or special holiday sale. Another example is a financial services application that tracks the number of successful and failed transactions of a specific type.

You must include the Prometheus client libraries in your application, and then create these custom metrics. Each metric is categorized into a specific Prometheus metric type. The client libraries will collect all the custom metrics and then send it to Prometheus for storage. The data stored in Prometheus can be visualized using custom Grafana dashboards.

## Prometheus Metric Types

Prometheus supports four different types of metrics:

### Counter

A counter is a cumulative metric that represents a single variable whose value can only increase, or be reset to zero on restart. For example, you can use a counter to represent the number of errors, requests served and tasks completed.

### Gauge

A gauge is a metric that represents a single numerical value, which can be incremented or decremented. For example, you can use a gauge to represent the number of processes, or the number of concurrent users.

## Histogram

A histogram samples values and counts them in configurable buckets. It also provides a sum of all values. Histograms track the number and the sum of the values , allowing you to calculate the average of the values.

For example, you can categorize response times in buckets (range of values) of 200 milliseconds with an upper limit of 1000 milliseconds. Prometheus collects the values and categorizes the values in each of the buckets.

## Summary

Similar to a histogram, a summary samples values. However a summary also calculates configurable values over a sliding time window.

Histograms buckets are categorized on the Prometheus server, while summaries are calculated on the client side (that is, the service exposing the metrics).



### Note

For a more detailed explanation about the histogram and summary metric type, refer to <https://blog.pvincent.io/2017/12/prometheus-blog-series-part-2-metric-types/>.

## Creating Custom Metrics for Quarkus Applications

You can enable custom metrics for your Quarkus application by adding the `quarkus-smallrye-metrics` extension.

The following are the steps to enable custom metrics for Quarkus applications:

- Include the `quarkus-smallrye-metrics` dependency in your application `pom.xml` file for enabling metrics collection.

```
<dependency>
  <groupId>io.quarkus</groupId>
  <artifactId>quarkus-smallrye-metrics</artifactId>
</dependency>
```

- Import the required metrics classes in your application from the `org.eclipse.microprofile.metrics.*` package. This package has all the standard Prometheus metric types that you can use to instrument your custom metrics.
- Add relevant metrics for your application.

Counters can be created by adding the `@Counted` annotation to methods as follows:

```
@Counted(name = "card_transactions", description = "count of credit card
transactions")
public void processCreditCardTransaction() {
...output omitted...
```

Gauges can be created by adding the `@Gauge` annotation to methods:

```
@Gauge(name = "concurrent_users", description = "count of active users")
public void listActiveUsers() {
    ...output omitted...
```

You can add different types of metrics to your application. For the complete list of options, refer to the Microprofile Metrics standard API reference at <https://github.com/eclipse/microprofile-metrics/blob/master/spec/src/main/asciidoc/app-programming-model.adoc>.

- By default, Quarkus makes the metrics available at the /metrics endpoint. This endpoint combines your custom metrics along with other standard metrics for the application, such as garbage collection information, heap size, and other system level metrics

Quarkus makes only the custom metrics available at the /metrics/application endpoint. To see only the system level metrics, access the /metrics/base endpoint.

## Creating Custom Metrics for Node.js Applications

You can add custom metrics to your Node.js application by importing the prom-client package. The steps to add custom metrics to your Node.js applications are:

- Install the prom-client package.

```
[user@demo product]$ npm install --save prom-client
```

- Import the prometheus-client package and initialize it. Add a unique prefix to easily identify the standard Node.js runtime metrics for this application. This is to help narrow down the search in the Prometheus web console.

```
var prometheus = require('prom-client');
const prefix = 'myapp_';
prometheus.collectDefaultMetrics({ prefix });
```



### Note

You can comment out the `prometheus.collectDefaultMetrics()` method if you do not want Node.js runtime system metrics, such as memory usage, garbage collection, CPU usage, and more.

- Add code to create new Prometheus metric types for your application. Use a suitable prefix (usually application name), and description of the custom metric to easily identify this custom metric in the Prometheus web console.

Create a new counter as follows:

```
const transactions = new prometheus.Counter({
    name: 'myapp:card_transactions',
    help: 'count of credit card transactions'
});
```

You can then increment the counter (for example at the start of a function):

```
transactions.inc();
```

Similarly, to add a gauge:

```
const concurrent_users = new prometheus.Gauge({
  name: 'myapp:concurrent_users',
  help: 'No of concurrent users'
});
```

Set the value of the gauge:

```
concurrent_users.set(some_value);
```

4. Add code to create a new HTTP GET endpoint called `/metrics` which will be used by Prometheus to collect metrics for this microservice. This endpoint will then return the metrics by calling the `register` object in the Prometheus client library as follows:

```
app.get('/metrics', function (req, res) {
  res.set('Content-Type', prometheus.register.contentType);
  res.send(prometheus.register.metrics());
})
```

Prometheus client libraries exist for other programming languages. Refer to the Prometheus documentation for more details.

## Enabling Prometheus Metrics Scraping

A default installation of Red Hat OpenShift Service Mesh does not collect metrics from applications unless it is explicitly enabled in the application deployment resource file.

To enable Prometheus to scrape (collect) metrics from your application, add the following annotations to the `spec.template.metadata.annotations` section in the deployment YAML resource file:

```
...output omitted...
labels:
  app: myapp
annotations:
  sidecar.istio.io/inject: "true"
  prometheus.io/scrape: "true"
  prometheus.io/port: "8080"
  prometheus.io/scheme: "http"
...output omitted...
```

Make sure that your `prometheus.io/port` value matches the port number where the `/metrics` endpoint is running.

## Querying Service Mesh Metrics using Prometheus

To view metrics collected from the service mesh using the Prometheus web console, do the following:

1. In the OpenShift web console, navigate to **Networking → Routes** and search for the **prometheus** route, which is the URL listed in the **Location** column.
2. Log in using the same user name and password that you used to access the OpenShift web console. You should see the Prometheus web console home page.
3. In the expression editor, type **istio** and observe the list of metrics that are available (the UI provides auto-completion and prompts you for a list of available metrics). You can query custom metrics by typing the metric name that you declared in your application source code when instrumenting the service for metrics. Once you have selected a metric, click **Execute** to display the metrics collected.
4. Select **insert metric at Cursor**, and observe the full list of available metrics available for querying.

Istio service metrics can be queried using the **istio\_\*** entries.

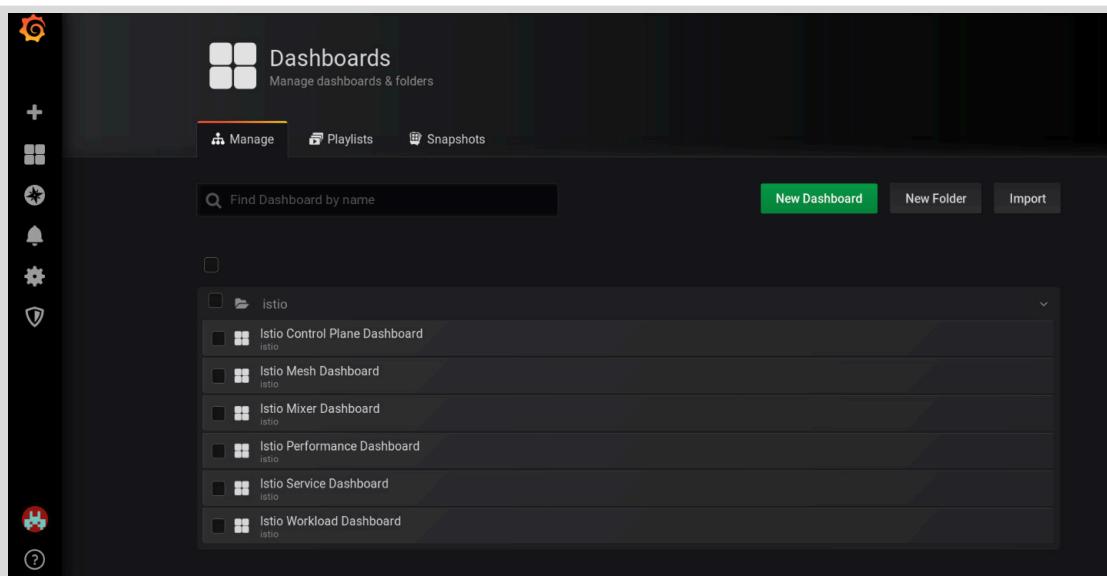
Envoy proxy metrics can be queried using the **envoy\_\*** entries.

Control plane metrics can be queried using the **pilot\_\***, **citadel\_\***, and **galley\_\*** entries.

## Visualizing Service Mesh Metrics using Grafana

To view the metrics dashboard for a service mesh using the Grafana web console, do the following:

1. In the OpenShift web console, navigate to **Networking → Routes** and search for the **grafana** route, which is the URL listed in the **Location** column.
2. Log in using the same user name and password that you used to access the OpenShift web console. You should see the Grafana web console home page.
3. Click the **Dashboards** button in the left side panel (the second button starting from the top). Click **Manage**. Expand the **istio** folder to see a list of available dashboards.



**Figure 3.13: List of Grafana dashboards**

4. Click **Istio Service Dashboard** to view details about your application services.

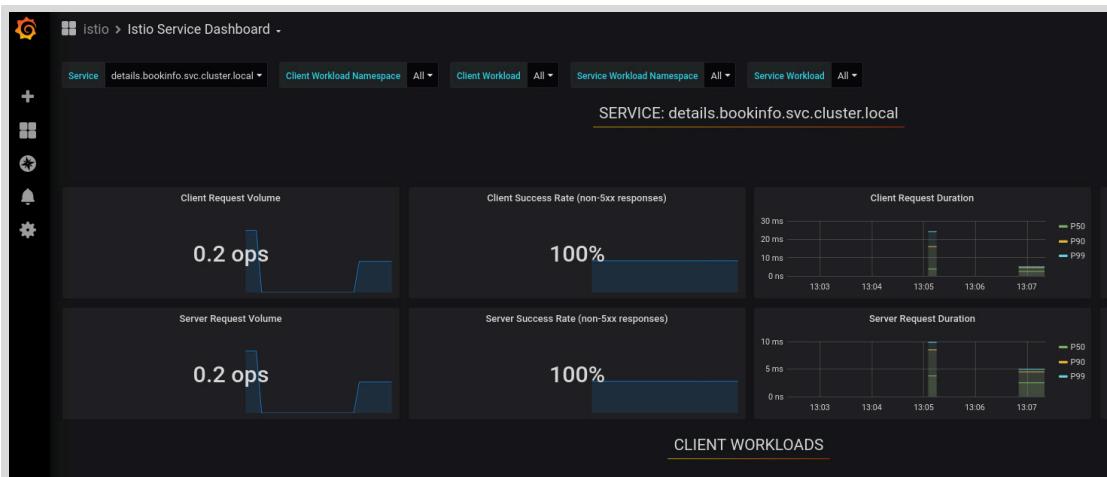


Figure 3.14: Application service dashboard

- Click Istio Mesh Dashboard to view the state of the overall service mesh.

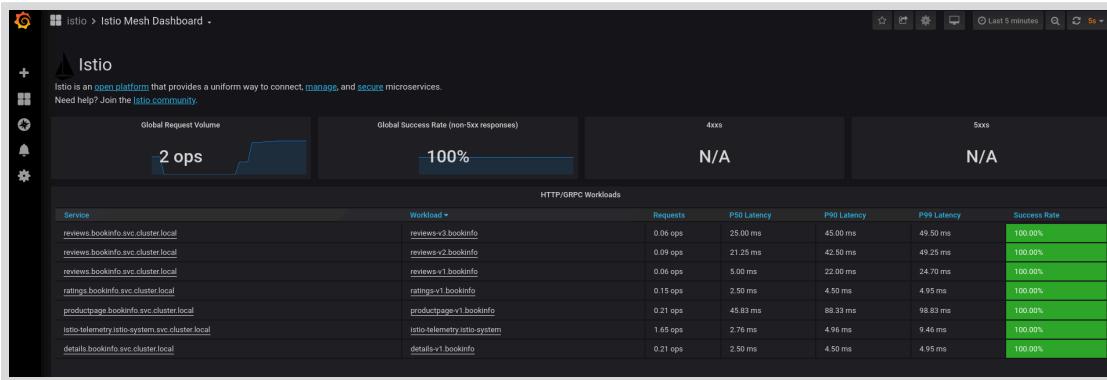


Figure 3.15: Overall Service Mesh dashboard

## Creating Custom Grafana Dashboards

You can create your own custom Grafana dashboards and visualize custom metrics from your application. To create a custom dashboard, do the following:

- Click the plus (+) icon in the left navigation panel in Grafana, and click **Dashboard** to create a new dashboard.
- A dashboard consists of one or more panels. A panel can contain one or more metrics of different graph types (Line Graph, Metered Gauge, Bar Graph, Table, Heatmap, and more). Click **Add Query**.
- You can search for metrics in the query expression editor (Grafana will provide you with auto-completion options) and select an option.

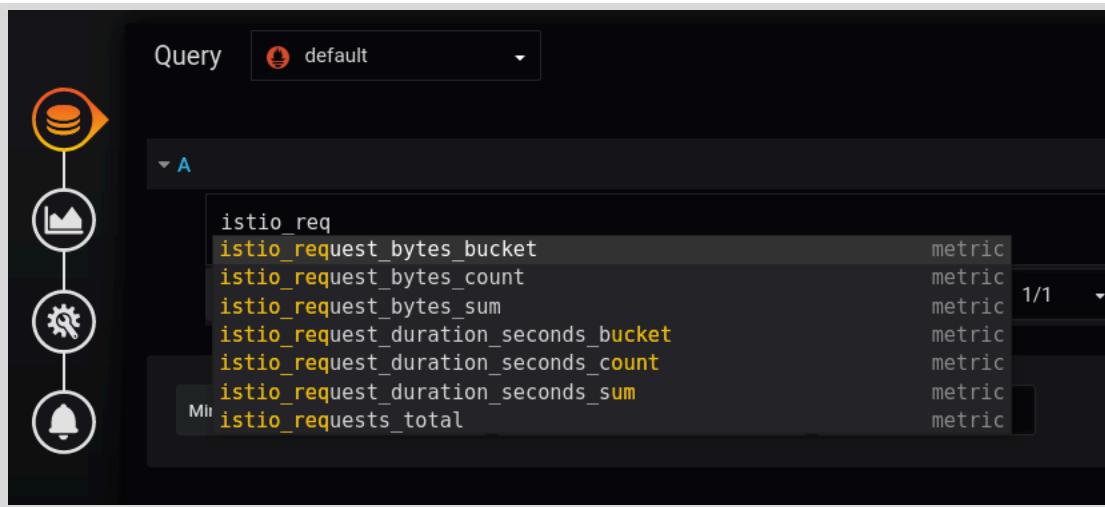


Figure 3.16: Grafana add query

You can click **Add Query** to add more metrics to the panel.

4. Click the graph icon in the left navigation panel to select different types of visual representation for the metrics. Click **Visualization** to select a graph type.

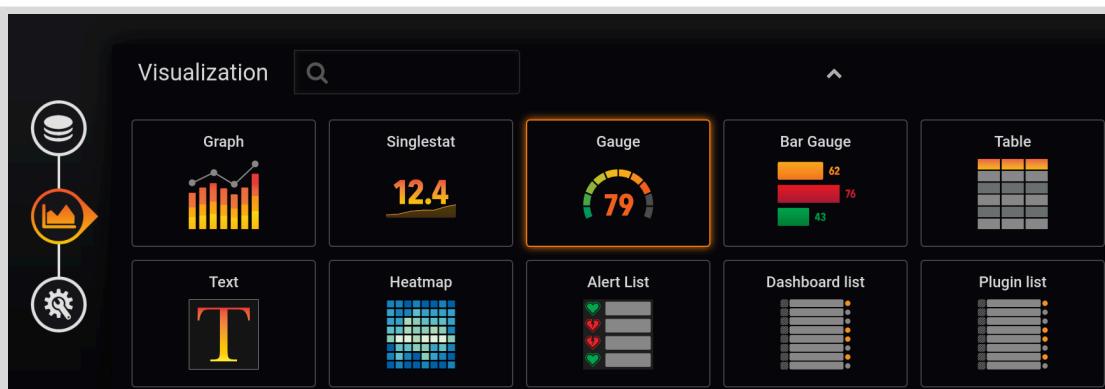


Figure 3.17: Grafana select graph type

Click the gear icon in the left navigation panel to open the **General** page, and provide a suitable name for the panel in the **Title** field.

5. Click the left arrow icon in the top left corner (next to **New dashboard**) to go back to the dashboard page. You should see the panels you added to the dashboard with the selected graph types.
6. Click **Save dashboard** (floppy disk icon) in the top navigation panel to save the dashboard. Provide a suitable name for your dashboard and click **Save**.



## References

### Service Level Objectives

<https://landing.google.com/sre/sre-book/chapters/service-level-objectives/>

### Prometheus

<https://prometheus.io>

### Grafana

<https://grafana.com/>

### Service Mesh Metrics for Envoy proxy, services and Control Plane

<https://archive.istio.io/v1.6/docs/concepts/observability/#metrics>

### Prometheus client library for Node.js

<https://www.npmjs.com/package/prom-client>

### Prometheus client library for Node.js

<https://www.npmjs.com/package/prom-client>

### Using OpenTracing in Quarkus

<https://quarkus.io/guides/opentracing>

### Types of Prometheus metrics

<https://tomgregory.com/the-four-types-of-prometheus-metrics/>

## ► Guided Exercise

# Collecting Service Metrics

In this exercise, you will deploy two microservices on OpenShift Service Mesh, and collect and inspect critical metrics with Prometheus and Grafana.

You will deploy two microservices in this exercise for a fictional online shopping store:

- **product**: written in JavaScript using the Node.js runtime. This service renders product details available for sale in the store.
- **order**: written in Java using the Quarkus framework. This service handles orders placed by customers.

You will do the following in this exercise:

1. Enable standard and custom metrics collection in both microservices. Metrics data is sent to the Prometheus instance running in the service mesh.
2. Build container images locally for both microservices using podman.
3. Push the built container images to the Quay .io public container registry.
4. Deploy both microservices to the service mesh, and view metrics data using the Prometheus and Grafana web console.

## Outcomes

You should be able to deploy applications to OpenShift Service Mesh, and view custom metrics data using Prometheus and Grafana.

## Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- An installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).
- An account with the Quay .io container registry, and podman installed locally on your workstation.

As the **student** user on the **workstation** machine, use the `lab` command to validate the prerequisites for this exercise:

```
[student@workstation ~]$ lab observe-metrics start
```

## Instructions

- 1. If you have not cloned the source code from the D0328-apps GitHub repository in a previous exercise, do so now using the `git clone` command. Inspect the source code for both microservices in the `metrics-ge` folder.

### Chapter 3 | Observing a Service Mesh

Use a text editor like VSCode that supports syntax highlighting for editing JavaScript and Java source files.

- 1.1. Open a new terminal window on your workstation. From the home directory, clone the source code for the microservices from GitHub.

```
[student@workstation ~]$ git clone https://github.com/RedHatTraining/D0328-apps  
...output omitted...  
Cloning into 'D0328-apps'...  
...output omitted...
```

- 1.2. Copy the contents of the /home/student/D0328-apps/metrics-ge folder from your local Git repository to the /home/student/D0328/labs/observe-metrics folder.

```
[student@workstation ~]$ cp -Rv ~/D0328-apps/metrics-ge/* \  
~/D0328/labs/observe-metrics/
```

You should now see two folders called `order` and `product` in the `/home/student/D0328/labs/observe-metrics/` folder.

You should also see shell scripts and service mesh related YAML files in the same folder. These were created by the lab start script.

- 1.3. Review the source code for the `product` microservice in the `/home/student/D0328/labs/observe-metrics/product/server.js` file.

This microservice exposes an HTTP GET endpoint called `/spl50` that renders a 50% discount offer page to customers. For the sake of simplicity, this just renders a simple string that enables us to test invoking the endpoint.

- 1.4. Review the source code for the `order` in the `/home/student/D0328/labs/observe-metrics/order/src/main/java/com/redhat/training/order/OrderService.java` file.

This microservice has two HTTP GET endpoints. The `/order` endpoint handles orders that are placed after a customer views the special offer page (rendered by the `product` microservice). A randomly generated order id is sent to the client as response.

The `/rating` endpoint simulates customers submitting feedback about the order process. For the sake of simplicity, the rating is generated randomly (a number between 1 and 5).



#### Note

Code for communication between the `product` and `order` service is not implemented to keep the code simple. The focus for this exercise is to learn how to generate custom metrics for the microservices.

- 2. Add code to the `product` microservice to enable the collection of custom metrics.

You have been asked to collect the following metrics for this microservice:

1. Response time to render the response for the `/spl50` endpoint. Consistently low response times for a large majority of customers is very important for the store. The operations team wants to track the average response time over a set period of time.

2. Page view count for the /spl50 endpoint. The sales team would like to see data about the number of people who viewed the offer page, and then went on to place the order.
- 2.1. Navigate to the /home/student/D0328/labs/observe-metrics/product folder on the command line terminal. All references to file paths in this step are relative to this folder.

```
[student@workstation ~]$ cd ~/D0328/labs/observe-metrics/product
```

- 2.2. Inspect the package.json file which declares all the NPM packages required for running this microservice.

Install the NPM `prom-client` dependency which provides the Prometheus client library.

```
[student@workstation product]$ npm install --save \
  prom-client@12.0.0
  ...output omitted...
+ prom-client@12.0.0
  ...output omitted...
```

- 2.3. Edit the `server.js` file. The complete source code changes for this file can be copied from the `/home/student/D0328/solutions/observe-metrics/product/server.js` file.

Import the `prometheus-client` package and initialize it. Add a unique prefix called `product_svc` to easily identify the standard Node.js runtime metrics for this application in the Prometheus web console.

```
...output omitted...
const express = require('express');
var prometheus = require('prom-client');
const prefix = 'product_svc_';
prometheus.collectDefaultMetrics({ prefix });
```

- 2.4. Add code to create a new Prometheus gauge type for tracking response time. Note the use of the service name as a prefix to easily identify this custom metric in the Prometheus web console.

```
...output omitted...
app.listen(8080, function () {
  console.log('product-svc started on port 8080');
})

const responseTime = new prometheus.Gauge({
  name: 'product_svc:spl50_response_time',
  help: 'Time take in seconds to render the 50% special offer page'
});
...output omitted...
```

- 2.5. Add code to create a new Prometheus counter type for tracking the page view count.

```

...output omitted...
app.listen(8080, function () {
  console.log('product-svc started on port 8080');
})

const responseTime = new prometheus.Gauge({
  name: 'product_svc:spl50_response_time',
  help: 'Time take in seconds to render the 50% special offer page'
});

const page_views = new prometheus.Counter({
  name: 'product_svc:spl50_page_view_count',
  help: 'No of page views for the 50% special offer page'
});
...output omitted...

```

2.6. Edit the code for the /spl50 route handler.

Start the timer which measures the response time as soon as the function begins to execute. Increment the page view counter.

```

...output omitted...
app.get('/spl50', async function (req, res) {
  responseTime.setToCurrentTime();
  const end = responseTime.startTimer();
  page_views.inc();
...output omitted...

```

2.7. Before sending the response to the client, end the timer which you started at the beginning of the function (after the sleep() call).

```

...output omitted...
await sleep(Math.floor(Math.random() * 200) + 1);
end();
res.send(view_msg);
...output omitted...

```

2.8. Add code to create a new /metrics endpoint which will be used by Prometheus to collect metrics for this microservice.

```

...output omitted...
app.get('/metrics', function (req, res) {
  res.setHeader('Content-Type', 'prometheus.register.contentType');
  res.send(prometheus.register.metrics());
})

```

2.9. Save your changes. To ensure that there are no syntax errors, run the code using the Node.js runtime, and ensure that the microservice starts without any errors.

If there are errors, then compare your changes with the solution files in the /home/student/D0328/solutions/observe-metrics/product folder.

```
[student@workstation product]$ npm install  
...output omitted...  
[student@workstation product]$ node server.js  
product-svc started on port 8080
```

Press Ctrl+C to stop the server.

- 3. Add code to the `order` microservice to enable the collection of custom metrics.

You have been asked to collect the following metrics for this microservice:

1. Response time to process an order.
  2. Count of orders placed after viewing the special offer page. The sales team would like to see data about the number of people who placed an order.
  3. The rate at which orders can be processed. The operations team would like to understand the average rate of orders that can be processed for certain time intervals. This data will be used for planning the scalability and capacity estimation for the system.
  4. Satisfaction rating. The sales team would like to collect the satisfaction rating data provided by customers after they place an order.
- 3.1. Change to the `/home/student/D0328/labs/observe-metrics/order` folder.  
All references to file paths in this step are relative to this folder.

```
[student@workstation product]$ cd ~/D0328/labs/observe-metrics/order
```

- 3.2. Inspect the maven `pom.xml` file which declares the dependencies for this microservice.

Include the `quarkus-smallrye-metrics` dependency for enabling metrics collection. Add this dependency below the `quarkus-smallrye-health` dependency.

You can also copy the code from the solution file at `/home/student/D0328/solutions/observe-metrics/order/pom.xml`.

```
...output omitted...  
<dependency>  
  <groupId>io.quarkus</groupId>  
  <artifactId>quarkus-smallrye-metrics</artifactId>  
</dependency>  
...output omitted...
```

- 3.3. Edit the `src/main/java/com/redhat/training/order/OrderService.java` file. The complete source code changes for this file can be copied from the `/home/student/D0328/solutions/observe-metrics/order/src/main/java/com/redhat/training/order/OrderService.java` file.

Edit the annotations for the `processOrder()` method. Add a counter that tracks the number of orders placed.

```

...output omitted...
@GET
@Path("/order")
@Counted(name = "order_svc:spl50_orders_placed",
    description = "count of spl50 orders placed")
...output omitted...
public String processOrder() {
...output omitted...

```

3.4. Add a timer to track the response time for processing an order.

```

...output omitted...
@Counted(name = "order_svc:spl50_orders_placed", description = "count of spl50
orders placed")
@SimplyTimed(name = "order_svc:spl50_order_process_time",
    description = "A measure of how long it takes to process an order",
    unit = MetricUnits.MILLISECONDS)
...output omitted...

```

3.5. Add a Metered metric to track the rate of order processing.

```

...output omitted...
@Metered(name = "order_svc:orders_processed_rate",
    unit = MetricUnits.MINUTES,
    description = "Rate at which orders are placed",
    absolute = true)
...output omitted...

```

The final `processOrder()` function should look like the following:

```

...output omitted...
@GET
@Path("/order")
@Counted(name = "order_svc:spl50_orders_placed",
    description = "count of spl50 orders placed")
@SimplyTimed(name = "order_svc:spl50_order_process_time",
    description = "A measure of how long it takes to process an order",
    unit = MetricUnits.MILLISECONDS)
@Metered(name = "order_svc:orders_processed_rate",
    unit = MetricUnits.MINUTES,
    description = "Rate at which orders are placed",
    absolute = true)
@Produces(MediaType.TEXT_PLAIN)
public String processOrder() {
...output omitted...

```

3.6. Add a gauge type metric to the `generateRandomRating()` method to capture the rating for the order.

```
...output omitted...
@Gauge(name = "order_svc:spl50_order_process_rating",
unit = MetricUnits.NONE,
description = "Overall customer rating for the order process")
private Integer generateRandomRating() {
...output omitted...
```

- 3.7. Save your changes. To ensure that there are no syntax errors, run `mvn clean package` and ensure that a fat JAR is created in the `target` folder.

```
[student@workstation order]$ mvn clean package
...output omitted...
[INFO] Building order 1.0.0
...output omitted...
...output omitted... Building fat jar: observe-metrics/order/target/order-1.0.0-
runner.jar
[INFO] [io.quarkus.deployment.QuarkusAugmentor] Quarkus augmentation completed in
2440ms
...output omitted...
[INFO] BUILD SUCCESS
...output omitted...
```

- 3.8. Start the microservice and verify that there are no errors.

```
[student@workstation order]$ java -jar target/order-1.0.0-runner.jar
...output omitted... (powered by Quarkus 1.3.2.Final) started in 0.747s.
Listening on: http://0.0.0.0:8080
...output omitted...
```

Verify that there are no errors. If there are errors, compare your changes with the solution files in `/home/student/D0328/solutions/observe-metrics/order` folder. Press `Ctrl+C` to stop the server.

#### ► 4. Build container images for both microservices using podman.

- 4.1. Load your classroom environment configuration.

Run the following command to load the environment variables:

```
[student@workstation order]$ source /usr/local/etc/ocp4.config
```

- 4.2. Briefly review the `Dockerfile` for the product microservice. You will use Red Hat Universal Base Images (UBI) as the base for building your container image. Build the container image using `podman`.

```
[student@workstation order]$ cd ~/D0328/labs/observe-metrics/product
[student@workstation product]$ podman build -t \
quay.io/${RHT_OCP4_QUAY_USER}/ossm-metrics-product:1.0 .
STEP 1: FROM registry.access.redhat.com/ubi8/nodejs-12:latest
...output omitted...
STEP 13: COMMIT quay.io/youruser/ossm-metrics-product:1.0
```

- 4.3. Build the container for the `order` microservice after reviewing the Dockerfile.

```
[student@workstation product]$ cd ~/DO328/labs/observe-metrics/order
[student@workstation order]$ podman build -t \
  quay.io/${RHT_OCP4_QUAY_USER}/ossm-metrics-order:1.0 .
STEP 1: registry.access.redhat.com/ubi8:8.1
...output omitted...
STEP 15: COMMIT quay.io/youruser/ossm-metrics-order:1.0
```

- 4.4. Verify that the container images for `product` and `order` are built successfully.

```
[student@workstation order]$ podman images
REPOSITORY                                     TAG ...output omitted...
quay.io/youruser/ossm-metrics-product          1.0 ...output omitted...
quay.io/youruser/ossm-metrics-order            1.0 ...output omitted...
...output omitted...
```

- ▶ 5. Create new public image repositories in Quay.io to store the newly built container images. Push the container images to Quay.io.
- 5.1. Create two new public container image repositories called `ossm-metrics-product`, and `ossm-metrics-order` in Quay.io. Refer to the instructions in *Appendix B, Creating a Quay account* for creating public container image repositories.



### Warning

If you skip this step and push the container images without creating public repositories, then the `podman push` commands will create private container image repositories by default.

- 5.2. Login to your Quay.io account using `podman`.

```
[student@workstation order]$ podman login -u ${RHT_OCP4_QUAY_USER} quay.io
```

You will be prompted for your Quay.io password.

- 5.3. Push the container image for the `product` microservice to Quay.io.

```
[student@workstation order]$ podman push \
  quay.io/${RHT_OCP4_QUAY_USER}/ossm-metrics-product:1.0
...output omitted...
Writing manifest to image destination
Storing signatures
```

- 5.4. Push the container image for the `order` microservice to Quay.io.

```
[student@workstation order]$ podman push \
  quay.io/${RHT_OCP4_QUAY_USER}/ossm-metrics-order:1.0
...output omitted...
Writing manifest to image destination
Storing signatures
```

- 6. Create the `metrics` project and then add it to the `ServiceMeshMemberRoll` resource.

- 6.1. Log in to OpenShift as the `developer` user.

```
[student@workstation order]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

- 6.2. Create the `metrics` project.

```
[student@workstation order]$ oc new-project metrics
Now using project "metrics" on server
"https://api.cluster.domain.example.com:6443".
...output omitted...
```

- 6.3. Add the `metrics` project to the list of members in the `ServiceMeshMemberRoll` resource.

You can also run the `add-project-to-smmr.sh` script in the `/home/student/D0328/labs/observe-metrics` folder to add the `metrics` project to the list of members in the `ServiceMeshMemberRoll` resource.

```
[student@workstation order]$ cd /home/student/D0328/labs/observe-metrics
[student@workstation observe-metrics]$ oc patch servicemeshmemberroll/default \
-n istio-system --type=merge \
-p '{"spec": {"members": ["metrics"]}}'
servicemeshmemberroll.maistra.io/default patched
```

- 7. Deploy the microservices to OpenShift service mesh.



### Important

To fetch metrics, Prometheus inspects the `/metrics` endpoint of applications annotated with `prometheus.io/scrape: "true"`. A bug is reported because Prometheus only inspects `/metrics` endpoints following the HTTPS protocol. In previous versions of OpenShift Service Mesh, HTTP could also be used to inspect that endpoint.

The lab `observe-metrics start` command that you executed at the beginning of this section contains a workaround that allows you to run the exercise successfully.

The lab `observe-metrics finish` command that you will execute at the end of this section removes the workaround and leaves the OpenShift Service Mesh unchanged.

If you want to know more about the bug, then you can read this Istio GitHub issue [<https://github.com/istio/istio/issues/24075>] or you can follow this Red Hat issue [<https://issues.redhat.com/browse/MAISTRA-2327>].

- 7.1. Edit the `*-deploy.yaml` files in the `/home/student/D0328/labs/observe-metrics` folder which describes the necessary resources to deploy both applications.

The deployment files have the `sidecar.istio.io/inject: "true"` annotation included to inject the Envoy proxy after deployment.

- 7.2. Edit the `/home/student/D0328/labs/observe-metrics/product-deploy.yaml` file. Edit the `spec.template.spec.containers.image` attribute and add the Quay.io URL of the container image you created in a previous step.

```
...output omitted...
spec:
  containers:
    - name: product
      image: quay.io/youruser/ossm-metrics-product:1.0
      imagePullPolicy: IfNotPresent
...output omitted...
```

Add annotations to allow the Prometheus instance to collect metrics from this microservice. Add the following annotations below the `sidecar.istio.io/inject: "true"` annotation.

You can copy these annotations from the `/home/student/D0328/solutions/observe-metrics/product-deploy.yaml` file.

```
...output omitted...
labels:
  app: product
  version: v1
annotations:
  sidecar.istio.io/inject: "true"
  prometheus.io/scrape: "true"
  prometheus.io/port: "8080"
  prometheus.io/scheme: "http"
...output omitted...
```

- 7.3. Edit the `/home/student/D0328/labs/observe-metrics/order-deploy.yaml` file. Add the Quay.io URL of the container image for `order`.

```
...output omitted...
spec:
  containers:
    - name: order
      image: quay.io/youruser/ossm-metrics-order:1.0
      imagePullPolicy: IfNotPresent
...output omitted...
```

Add annotations to allow the Prometheus instance to collect metrics from this microservice. Add the following annotations below the `sidecar.istio.io/inject: "true"` annotation.

You can also copy these annotations from the `/home/student/D0328/solutions/observe-metrics/order-deploy.yaml` file.

```
...output omitted...
labels:
  app: order
  version: v1
annotations:
  sidecar.istio.io/inject: "true"
  prometheus.io/scrape: "true"
  prometheus.io/port: "8080"
  prometheus.io/scheme: "http"
...output omitted...
```

- 7.4. Run the `oc create` command to deploy the applications.

```
[student@workstation observe-metrics]$ oc create -f product-deploy.yaml
deployment.apps/product created
service/product created
[student@workstation observe-metrics]$ oc create -f order-deploy.yaml
deployment.apps/order created
service/order created
```

- 7.5. Run the `oc get pods` command and verify that both microservices are deployed and in Running state.

```
[student@workstation observe-metrics]$ oc get pods
NAME           READY   STATUS    RESTARTS   AGE
order-6c89b48d88-b5tqk   2/2     Running   2          1h
product-69dd4f647f-jxwmp 2/2     Running   2          1h
```

- 7.6. Inspect the `/home/student/D0328/labs/observe-metrics/gateway.yaml` file which describes the ingress gateway for traffic entering the mesh.

From the command line terminal, use the `oc create` command to create the ingress gateway.

```
[student@workstation observe-metrics]$ oc create -f gateway.yaml
gateway.networking.istio.io/observe-metrics-gateway created
```

- 7.7. Create a `VirtualService` to redirect the ingress traffic to the `product` or `order` service based on the URL.

Examine the `virtual-service.yaml` file which routes the ingress traffic to both services,

Use the `oc create` command to create the virtual service.

```
[student@workstation observe-metrics]$ oc create -f virtual-service.yaml
virtualservice.networking.istio.io/observe-metrics-vs created
```

## ► 8. Test the microservices.

- 8.1. Run the `oc get route` command to get the URL of the Istio gateway.

You can also cut and paste the full command from the `get-ingress-gateway-url.sh` file.

Export the ingress gateway URL to an environment variable called GATEWAY\_URL.

```
[student@workstation observe-metrics]$ GATEWAY_URL=$( \
  oc get route istio-ingressgateway -n istio-system \
  -o template --template '{{ "http://" }}{{ .spec.host }}')
```

- 8.2. Execute the curl command in combination with the GATEWAY\_URL variable to access the application.

View the 50% special offer page.

```
[student@workstation observe-metrics]$ curl ${GATEWAY_URL}/spl50
50% off on purchase of 100 or more items!
Hurry! Limited stocks...
```

- 8.3. Place an order using the order service.

```
[student@workstation observe-metrics]$ curl ${GATEWAY_URL}/order
Thank you for your order! Your order id is 4789
```

The order id is randomly generated and may be different in your case.

- 8.4. Invoke the /rating endpoint for the order service.

```
[student@workstation observe-metrics]$ curl ${GATEWAY_URL}/rating
You rated the order process 3 stars. Thank you for your feedback!
```

The rating score is randomly generated and may be different in your case.

## ► 9. Query metrics generated by the microservices using the Prometheus web console.

- 9.1. Run the oc get route command to gather the Prometheus web console URL. You can also copy the commands from the get-prometheus-url.sh file.

```
[student@workstation observe-metrics]$ PROM_URL=$( \
  oc get route prometheus -n istio-system \
  -o template --template '{{ "https://" }}{{ .spec.host }}')
```

- 9.2. Use the Firefox web browser to access the Prometheus web console.

```
[student@workstation observe-metrics]$ firefox ${PROM_URL} &
```

- 9.3. Click Log in with OpenShift.

Log in using your developer user account. Your user name is the RHT\_OCP4\_DEV\_USER variable in the /usr/local/etc/ocp4.config classroom configuration file. Your password is the RHT\_OCP4\_DEV\_PASSWORD variable in the same file.

If you are prompted with a page asking you to authorize service account access to your account. Click **Allow selected permissions** to bring up the Prometheus web console.

- 9.4. Click **Status → Targets** to confirm that metrics are being collected from the order and product services.

The screenshot shows the Prometheus web interface. In the top navigation bar, there are tabs for 'Prometheus', 'Alerts', 'Graph', 'Status', and 'Help'. The 'Status' tab has a dropdown menu open, showing options like 'Runtime & Build Information', 'Command-Line Flags', 'Configuration', 'Rules', and 'Targets'. The 'Targets' option is highlighted with a red box. Below the navigation bar, there is a search bar labeled 'Expression (press Shift+Enter for help)', a button labeled 'Execute', and tabs for 'Graph' and 'Console'. Under the 'Graph' tab, there is a 'Moment' selector. The main content area shows a table with one row, labeled 'no data'. At the bottom left, there is a blue button labeled 'Add Graph'.

You should see the entry for both services in the **kubernetes-pods** section. You can identify the services by their labels in the **Labels** column.

kubernetes-pods (4/4 up) <a href="#">show less</a>			
Endpoint	State	Labels	
<a href="http://10.128.0.12:14269/metrics">http://10.128.0.12:14269/metrics</a>	UP	<code>app="jaeger" app_kubernetes_io_component="all-in-one" app_kubernetes_io_instance="jaeger" app_kubernetes_io_managed_by="jaeger-operator" app_kubernetes_io_name="jaeger" app_kubernetes_io_part_of="jaeger" instance="10.128.0.12:14269" job="kubernetes-pods" namespace="istio-system" pod_name="jaeger-99cd7c9bf-phxr" pod_template_hash="99cd7c9bf"</code>	
<a href="http://10.128.0.30:8080/metrics">http://10.128.0.30:8080/metrics</a>	UP	<code>app="product" instance="10.128.0.30:8080" job="kubernetes-pods" namespace="metrics" pod_name="product-69dd4f647f-jkwmp" pod_template_hash="69dd4f647f" version="v1"</code>	
<a href="http://10.128.0.36:8080/metrics">http://10.128.0.36:8080/metrics</a>	UP	<code>app="order" instance="10.128.0.36:8080" job="kubernetes-pods" namespace="metrics" pod_name="order-6c89b48d88-b5tak" pod_template_hash="6c89b48d88" version="v1"</code>	
<a href="http://10.128.0.81:9090/metrics">http://10.128.0.81:9090/metrics</a>	UP	<code>app="kiali" instance="10.128.0.81:9090" job="kubernetes-pods" namespace="istio-system" pod_name="kiali-c954d57f7-lfmna" pod_template_hash="c954d57f7" version="1.0.12"</code>	



### Note

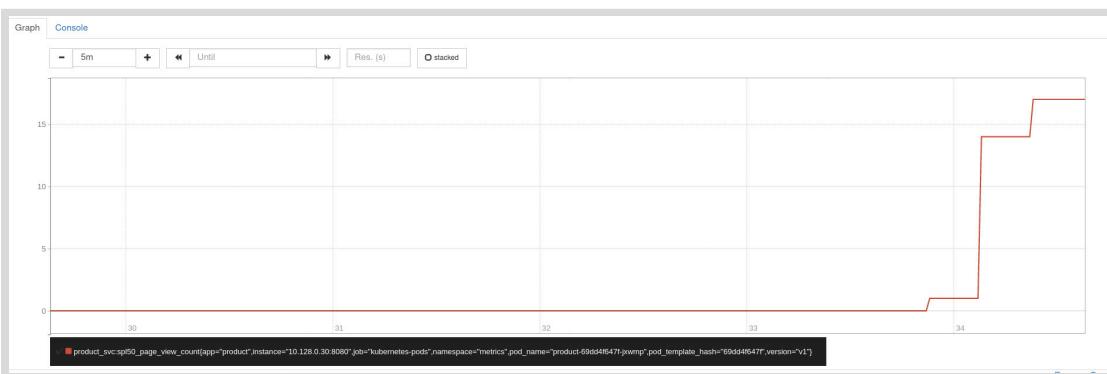
If you cannot see your services in the **Targets** page, then ensure that you added `prometheus.io/*` annotations to the deployment YAML files for the services.

- Click **Graph** in the top navigation bar in the Prometheus web console. Click the **Graph** tab. An expression editor is available at the top of the page for queries using the PromQL query language.

- 9.6. Start by typing `product_svc:sp150` to see the metrics gathered for the product service. Recall that you had provided this string as a prefix for all metrics created for the product service. The expression editor should provide autocompleted options based on the metrics it has gathered.

The screenshot shows the Prometheus web interface. At the top, there are tabs for 'Prometheus', 'Alerts', 'Graph', 'Status ▾', and 'Help'. Below the tabs, there is a checkbox for 'Enable query history' which is unchecked. The main area contains an input field with the text 'product\_svc:sp150'. A dropdown menu is open over this field, showing two options: 'product\_svc:sp150\_page\_view\_count' and 'product\_svc:sp150\_response\_time'. Below the input field are buttons for 'Graph' and 'Console', and a time range selector with '1h' selected. To the right of the time range are buttons for 'Res. (s)' and 'stacked'. At the bottom left is a blue 'Add Graph' button.

Select `product_svc:sp150_page_view_count` in the expression editor, and click **Execute**. You should see a graph for the page view count metric.



Next, select `product_svc:sp150_response_time` in the expression editor, and click **Execute**. You should see a graph for the response time metric.

- 9.7. Start by typing `application_order_svc` in the expression editor to view the metrics for the `order` service. You should be presented with a list of custom, and other standard metrics that were collected from the service.

The screenshot shows the Prometheus web interface. At the top, there are navigation links: Prometheus, Alerts, Graph, Status ▾, and Help. Below the navigation bar, there is a checkbox labeled "Enable query history". The main area has a search bar containing the text "application\_order\_svc". Below the search bar, a list of metrics is displayed, starting with "application\_order\_svc\_orders\_processed\_rate\_fifteen\_min\_rate\_per\_second" and continuing with several other metrics related to the application\_order\_svc service.

Select a metric in the expression editor, and click **Execute** to see a graph for the corresponding metric.



### Note

If you do not see any metric data, then use the `curl` command from previous steps to invoke the `/spl50`, `/order`, and `/rating` endpoints a few times. You may have to wait for a few seconds until Prometheus scrapes the metrics from the service and displays the data in the graph.

## ► 10. Visualize default metrics for the service mesh using the Grafana web console.

- 10.1. Run the `oc get route` command to gather the Grafana web console URL. You can also copy the commands from the `get-grafana-url.sh` file.

```
[student@workstation observe-metrics]$ GRAFANA_URL=$( \
  oc get route grafana -n istio-system \
  -o template --template '{{ "https://" }}{{ .spec.host }}')
```

- 10.2. Use the Firefox web browser to access the Grafana web console.

```
[student@workstation observe-metrics]$ firefox ${GRAFANA_URL} &
```

- 10.3. Click **Log in with OpenShift**.

Log in using your developer user account. Your user name is the `RHT_OCP4_DEV_USER` variable in the `/usr/local/etc/ocp4.config` classroom configuration file. Your password is the `RHT_OCP4_DEV_PASSWORD` variable in the same file.

If you are prompted with a page asking you to authorize service account access to your account, then you must click **Allow selected permissions** to bring up the Grafana web console.

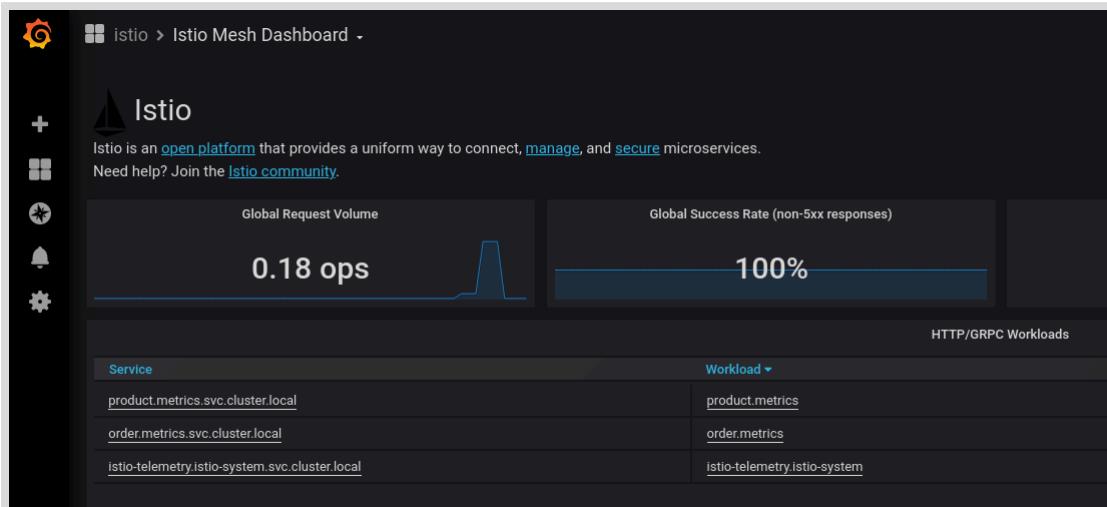
- 10.4. Grafana is already configured to use Prometheus as a data source. The envoy proxy sidecars are configured to automatically send metrics to Prometheus. This data is

### Chapter 3 | Observing a Service Mesh

used to populate a set of pre-created dashboards related to various aspects of the service mesh.

Click the **Dashboards** button in the left side panel (the second button starting from the top). Click **Manage**.

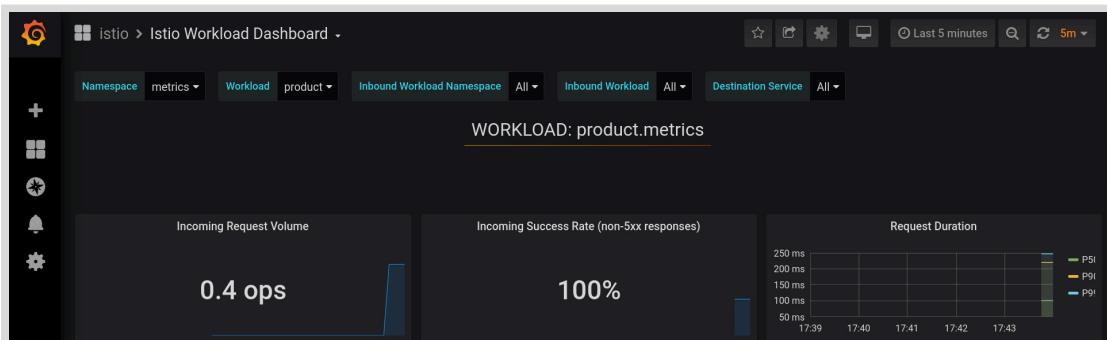
The service mesh dashboards are grouped together under the **istio** folder. Expand the **istio** folder, and select the **Istio Mesh Dashboard** to view high-level statistics about the overall service mesh.



#### Note

If you do not see any metric data, then use the `curl` command from previous steps to invoke endpoints from the `product`, and `order` services a few times. You might have to wait for a few seconds until Prometheus scrapes the metrics from the service and displays the data in the graph. Adjust the refresh interval (refresh icon in the top right corner) to a higher value like `5m`.

- 10.5. Go back to the Dashboards page. Click **Istio Workload Dashboard**, which is under the **istio** folder, to view details about the `product` and `order` services. You are provided with options to filter data by namespace and workload. Select the `metrics` namespace, and then select `product` or `order` to view the statistics for the corresponding service.

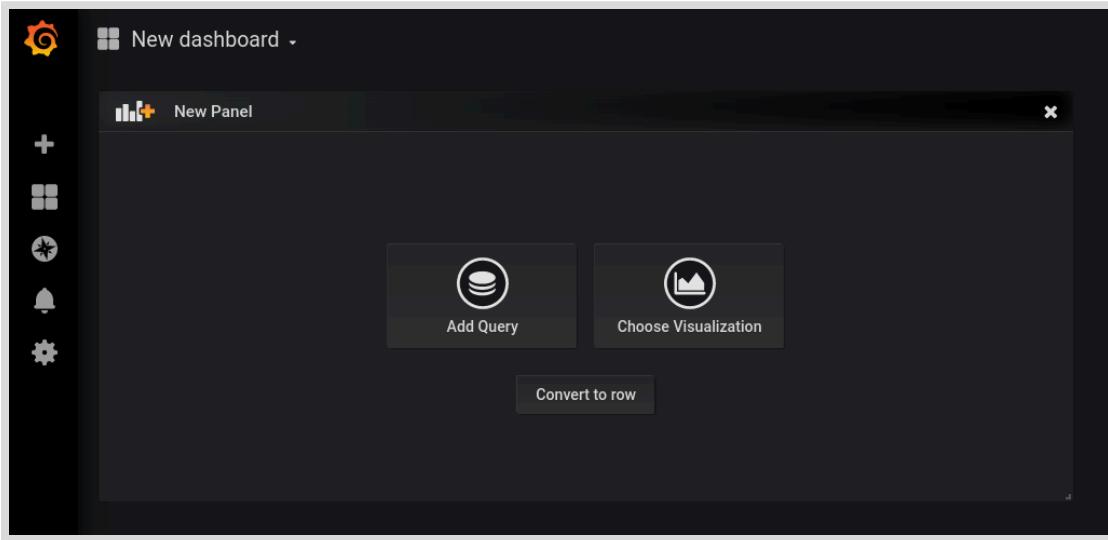


Optional: Briefly select and view other provided dashboards under the **istio** folder.

- 11. Create a custom dashboard for the shopping store. Populate it with the custom metrics gathered from the `product` and `order` services.

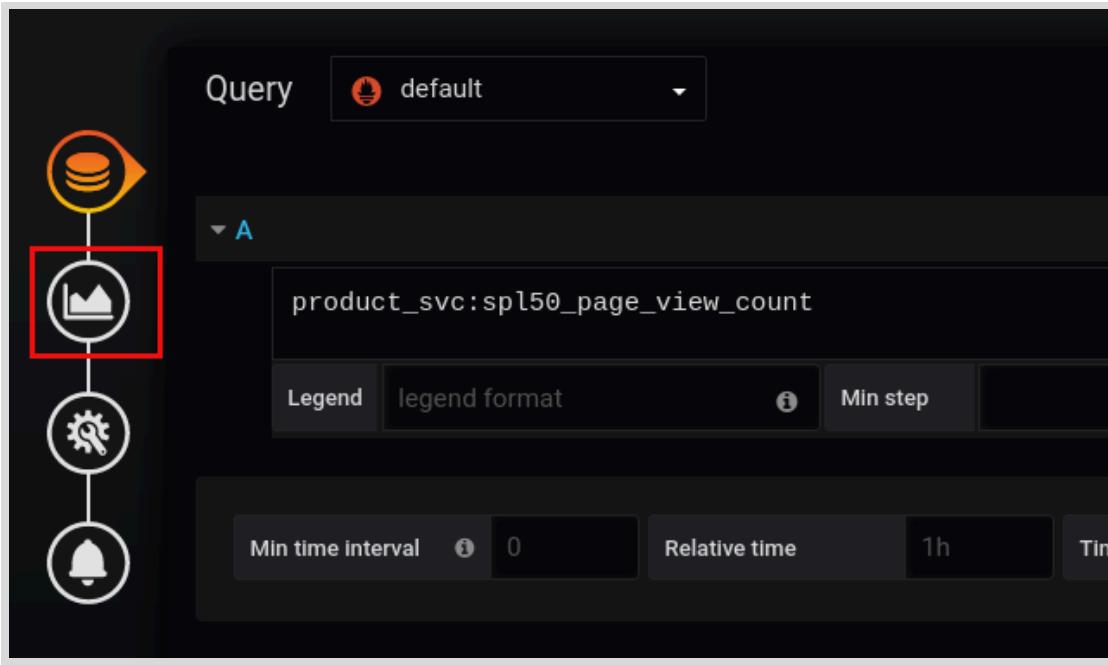
- 11.1. Click the plus (+) icon in the left navigation menu of Grafana web console to open the **Create** menu. Select **Dashboard** to create a new dashboard.

You will see a panel added to the dashboard called **New Panel**.

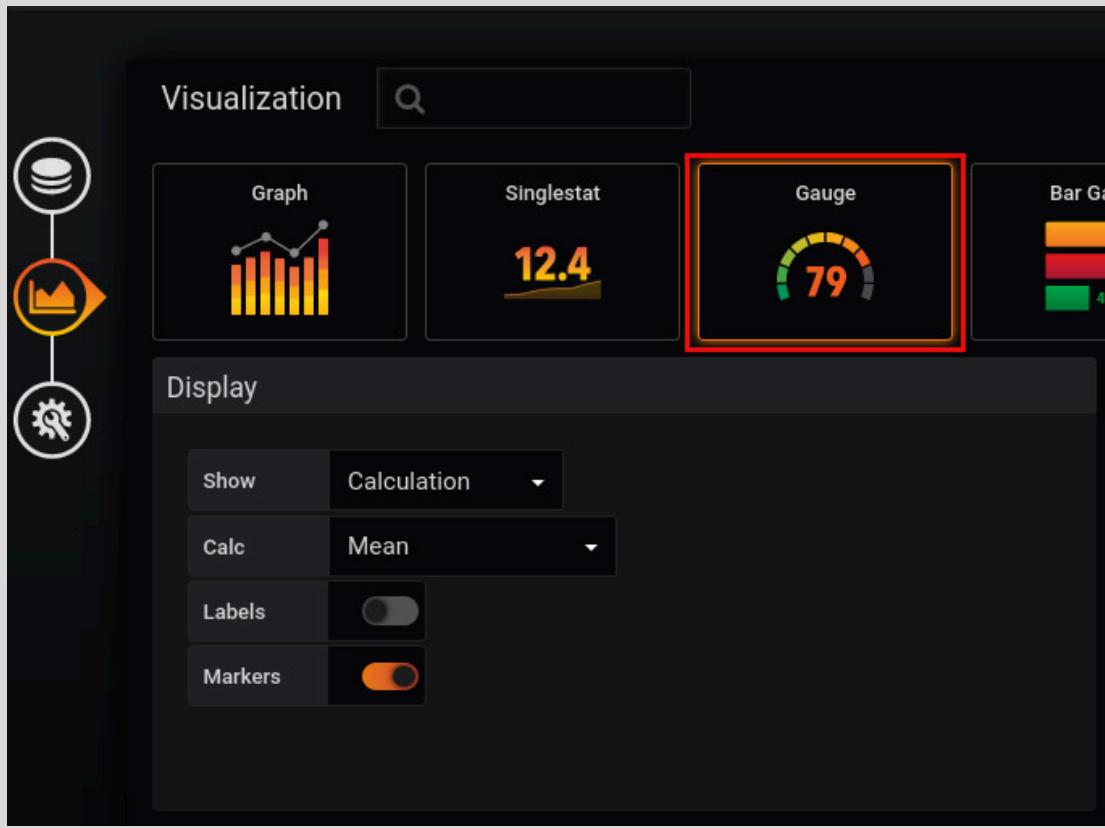


- 11.2. Click **Add Query** in the **New Panel** panel.

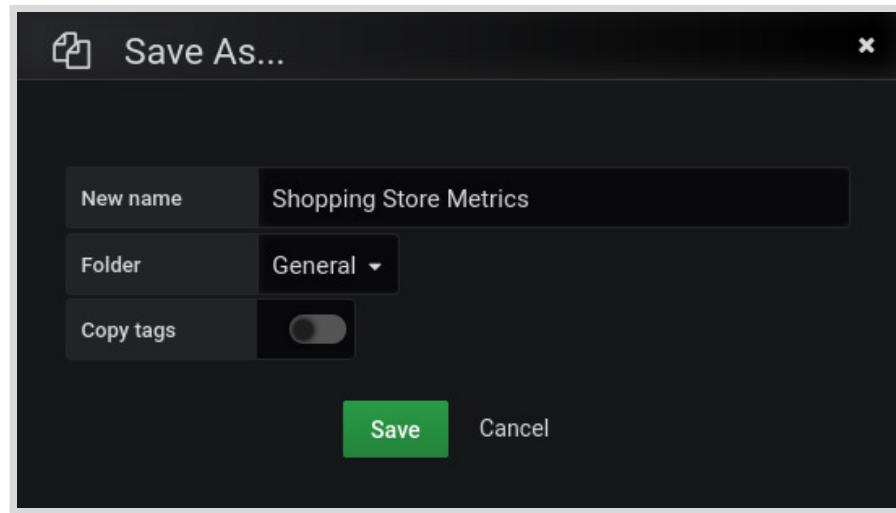
In the query expression editor named **A** (next to the **Metrics** label), type `product_svc:spl50_page_view_count`. Click the graph icon in the left menu (to the left of the **Query** window) to select how you want to visualize the metric.



- 11.3. In the **Visualization** panel, expand the **Visualization** selection, and select **Gauge**.



- 11.4. Click **General** (gear icon below **Visualize** icon in the left menu).  
Enter **Product Page View Count** as the **Title**.  
Click the left arrow icon (top left corner to the left of **New dashboard**) to go back to the dashboard page. You will add a panel with a metric from the **order** service to this dashboard in the next step. Your dashboard should now show the page view count metric from the product service.
- 11.5. Click **Add panel** (graph icon with yellow plus in top right) to add another panel for displaying metrics from the **order** service.  
Click **Add Query** in the **New Panel**, and type **orders\_placed**. Prometheus will auto-complete a long metric name ending with **orders\_placed\_total**. Select the option.  
Click **Visualization** in the left menu, and select the **Graph** option.  
Click **General** in the left panel, and change the **Title** field to **Total Orders Placed**. Click the left arrow icon in the top left corner to go back to the **New dashboard** page.
- 11.6. Your new dashboard should now show one metric each from both services. You can add more panels and add custom metrics from your services using the same steps outlined previously.  
Click the **Save dashboard** icon to save your new dashboard. Enter **Shopping Store Metrics** in the **Save As** dialog.



Your final Grafana dashboard should look like the following.



- ▶ 12. Return to the home directory.

```
[student@workstation observe-metrics]$ cd
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab observe-metrics finish
```

This concludes the guided exercise.

# Observing Service Interactions with Kiali

## Objectives

After completing this section, you should be able to monitor and visualize service interactions with Kiali.

## Introducing Kiali

Kiali is a web based console for viewing the topology of a service mesh. In a microservices architecture, a large number of discrete services will be interacting with each other in various complex ways to achieve business goals. Kiali helps you to understand the structure of your service mesh and how traffic flows between services in the mesh. Kiali also provides intuitive dashboards with dynamic animation to understand the end-to-end flow of requests as it traverses the service mesh.

Kiali provides an interactive graphical view of the services in your service mesh in real time. It provides visibility into features like circuit breakers, request rates, latency, and traffic flows. Kiali also provides the ability to validate your service mesh configuration. You can configure gateways, destination rules, virtual services, mesh policies and visually verify the impact of these changes using Kiali.

A default installation of Red Hat OpenShift Service Mesh includes a fully configured ready to use instance of Kiali.

## Viewing Service Mesh Interactions with Kiali

The Kiali console has different views that provide insights into service mesh components from various perspectives, such as applications, services, versions, configuration health status, and more. The following are the steps to use Kiali:

1. In the OpenShift web console, navigate to **Networking → Routes** and search for the **kiali** route, which is the URL listed in the **Location** column.
2. Log in using the same user name and password that you used to access the OpenShift web console. You should see the Kiali web console home page, which shows the OpenShift projects that are managed by the service mesh, and the count and overall health status of the services in them.
3. Click **Applications** in the left menu to see the list of services and their overall health status. If you have several namespaces, then click the **Namespace** button to include applications from different namespaces.

The screenshot shows the 'Applications' section of the Istio Control Plane interface. The left sidebar has 'Graph' selected. The main area shows a table with columns: App Name, Namespace, Labels, Health, and Details. The namespace is set to 'observe-kiali'. The table contains four rows:

- czech (NS: observe-kiali, app:czech version:v1) - Healthy
- english (NS: observe-kiali, app:english version:v1v2) - Healthy
- greet-api (NS: observe-kiali, app:greet-api version:v1) - Healthy
- spanish (NS: observe-kiali, app:spanish version:v1) - Healthy

Figure 3.30: Service health status in a project

- Click Graph in the left menu to see a dynamic, real-time, animated representation of your service mesh. In the Graph page, you can view the topology of your service mesh in terms of services, workloads, and versions.

Select App graph (next to Namespace) to view the topology in terms of the services and the application containers to which traffic is being sent. This view aggregates all versions of an application into a single node on the graph. This view does not show the different versions of an application container that are deployed to the mesh.

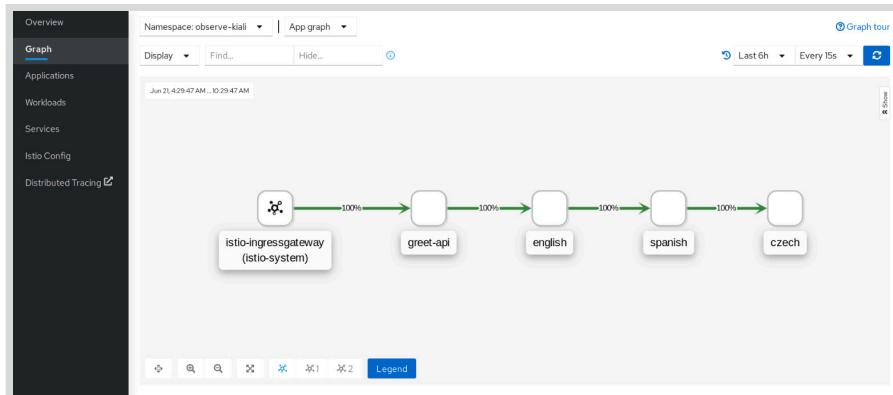


Figure 3.31: App graph view

- Select Service graph to view the topology in terms of only the services in the mesh. This view shows a node for each service in your mesh, but excludes all applications and their versions from the graph.

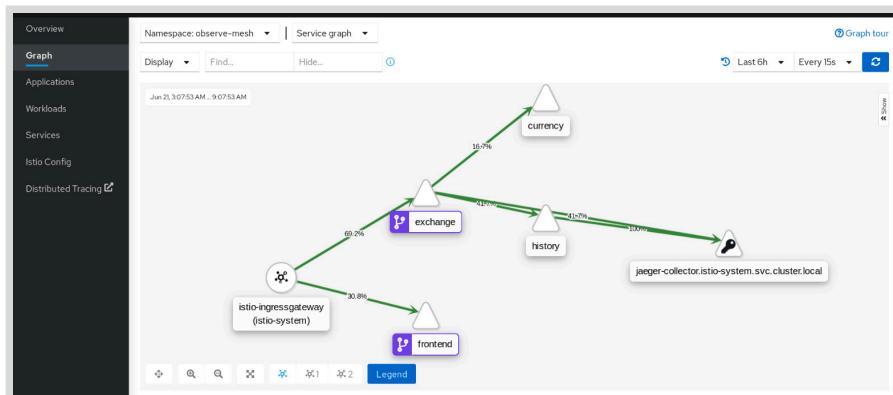
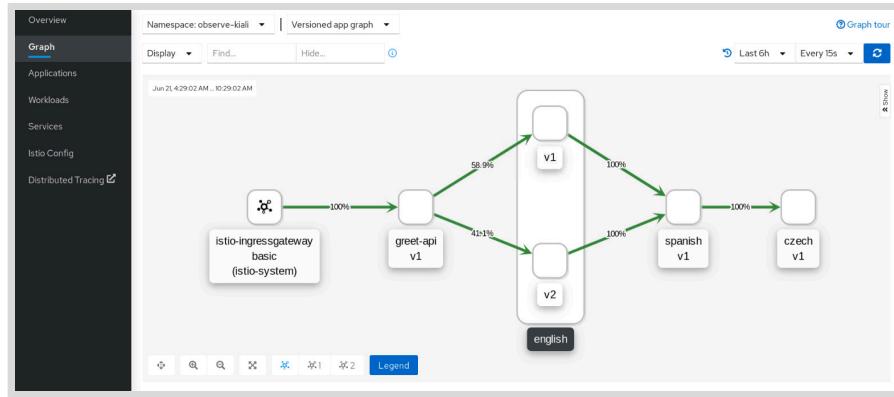


Figure 3.32: Service graph view

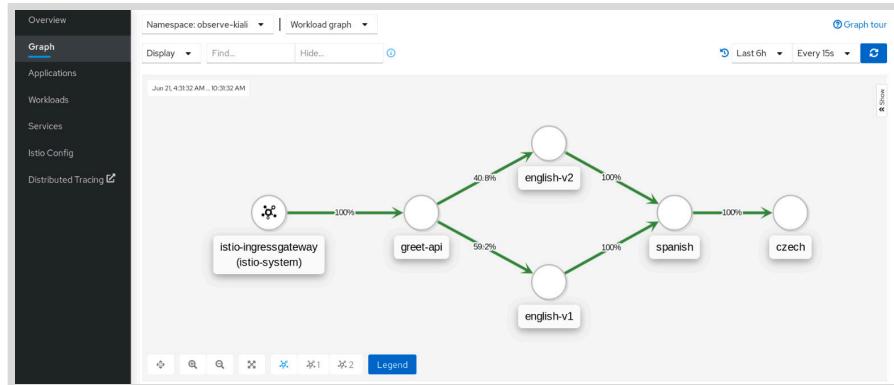
- Select Versioned app graph to view the topology in terms of the services and the different versions of application containers to which traffic is being sent. This view shows a

node in the graph for each version of an application, but all versions of a particular application are grouped together. Using this view, you can easily identify the amount of traffic that is being sent to specific versions of your application. This is useful to verify dark launches, A/B testing and deployments involving multiple versions of applications.



**Figure 3.33: Versioned app graph view**

7. Select **Workload graph** to view a simplified view of the service mesh topology without any grouping.



**Figure 3.34: Workload graph view**



### Note

Click the blue question mark icon next to the **Hide** text input field to understand the function of the various drop-down boxes, buttons and options available in the **Graph** page. You can also click the **Legend** button at the bottom of the **Graph** page to get details about the various colored icons in the graphs.



## References

For more information about Kiali, refer to the *Kiali* chapter in the *Red Hat OpenShift Service Mesh Guide* at

[https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.4/html-single/service\\_mesh/index#ossm-kiali](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.4/html-single/service_mesh/index#ossm-kiali)

### Kiali

<https://kiali.io/>

### Visualizing your Service Mesh

<https://archive.istio.io/v1.4/docs/tasks/observability/kiali/>

## ► Guided Exercise

# Observing Service Interactions with Kiali

In this exercise, you will deploy an application consisting of four microservices and visualize the service interaction and traffic flow using Kiali.

The application consists of four microservices:

- The first three microservices are `czech`, `english` and `spanish`, which are simple microservices that greet the user in Czech, English and Spanish respectively.
- `greet-api`: An API gateway, which acts as the entry point for the application. The API gateway calls the individual language services in different ways depending on the request.

## Outcomes

You can visualize traffic flow and inter-service communication using Kiali.

## Before You Begin

To perform this exercise, ensure you have:

- A configured and running OpenShift cluster.
- An installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (`/usr/local/bin/oc`).

On the `workstation` machine, use the `lab` command to prepare your system for this exercise.

```
[student@workstation ~]$ lab observe-kiali start
```

The `lab` command deploys the `czech`, `english`, `spanish`, and `greet-api` services into your Red Hat OpenShift cluster. The source code is in the Git repository at <https://github.com/RedHatTraining/DO328-apps> in the `kiali-ge` folder.

You can examine the full deployment file in the `~/DO328/labs/observe-kiali/app-deployment.yaml` file. In the `app-deployment.yaml` file, note that a gateway and a virtual service is created which exposes the following endpoints:

- `/greet`: The API gateway calls each of the individual language services in alphabetical order:  
*czech → english → spanish.*
- `/chained`: The API gateway calls only the `english` service. The `english` service in turn calls another service to form a chain as follows:  
*english → spanish → czech.*

## Instructions

- 1. Log in to OpenShift and verify that the four microservices are deployed.
- 1.1. Run the following command to load the environment variables created in the first guided exercise:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

- 1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

- 1.3. Set the current project to observe-kiali:

```
[student@workstation ~]$ oc project observe-kiali
Now using project "observe-kiali" on server ...output omitted...
```

- 1.4. Verify that there are four pods in Running state:

```
[student@workstation ~]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
czech-84c5754796-cpqfq   2/2     Running   0          49s
english-v1-684884c897-qk7j2   2/2     Running   0          49s
greet-api-7fb89fdc45-f7gs6   2/2     Running   0          49s
spanish-f8848fc89-c9slw    2/2     Running   0          49s
```

- 2. Log in to Kiali and verify that the four microservices are in a healthy state.

- 2.1. Run the `oc get route` command to gather the Kiali web console URL. You can also copy the commands from the `get-kiali-url.sh` file in the `/home/student/D0328/labs/observe-kiali` folder..

```
[student@workstation ~]$ KIALI_URL=$(oc get route kiali \
-n istio-system -o jsonpath='{.spec.host}')
```

- 2.2. Access the Kiali web console using the `firefox` browser on your workstation.



### Warning

The lab start script updates the `ServiceMeshMemberRoll` resource of the service mesh control plane. This will cause the Kiali pod to be redeployed after some time. Check the status of the Kiali pod by running `oc get pods -n istio-system`, and proceed after you see it in `Running` state.

If the Kiali pod is restarted after you have logged into Kiali, or if you see errors in the Kiali console, verify the Kiali pod status and log in again.

```
[student@workstation observe-metrics]$ firefox ${KIALI_URL} &
```

2.3. Click **Log in with OpenShift**.

Log in using your developer user account. Your user name is the RHT\_OCP4\_DEV\_USER variable in the /usr/local/etc/ocp4.config classroom configuration file. Your password is the RHT\_OCP4\_DEV\_PASSWORD variable in the same file.

If you are prompted with a page asking you to authorize service account access to your account, then click **Allow selected permissions** to bring up the **Overview** page of the Kiali web console.

2.4. Click the green tick icon in the **observe-kiali** namespace to view the **Applications** page.

The screenshot shows the Kiali web interface with the 'Overview' tab selected. On the left, a sidebar lists 'Overview' (selected), 'Graph', 'Applications', 'Workloads', 'Services', 'Istio Config', and 'Distributed Tracing'. At the top, there are dropdowns for 'Namespace' (set to 'Namespace') and 'Filter by Namespace', and a search bar for 'Name'. Below these are two cards: 'istio-system' (3 Labels, Istio Config, 7 Applications, green checkmark) and 'observe-kiali' (2 Labels, Istio Config, 4 Applications, green checkmark). A red box highlights the number '4' next to the green checkmark for the 'observe-kiali' card.

Verify that all four microservices are healthy.

The screenshot shows the Kiali 'Applications' page for the 'observe-kiali' namespace. The sidebar on the left shows 'Overview' (selected), 'Graph', 'Applications' (selected), 'Workloads', 'Services', 'Istio Config', and 'Distributed Tracing'. The main area has a 'Namespace: observe-kiali' dropdown and a 'Filter by App Name' input. Under 'Active Filters', 'Health' is selected. The table lists four applications: 'czech' (Namespace: observe-kiali, Labels: app:czech version:v1, Health: green checkmark), 'english' (Namespace: observe-kiali, Labels: app:english version:v1, Health: green checkmark), 'greet-api' (Namespace: observe-kiali, Labels: app:greet-api version:v1, Health: green checkmark), and 'spanish' (Namespace: observe-kiali, Labels: app:spanish version:v1, Health: green checkmark).

► 3. Invoke the `/greet` endpoint, and visualize the traffic flow in Kiali.

3.1. Set up Kiali for traffic visualization.

Click **Graph** in the left navigation panel. Because there is no traffic being sent to the microservices, the **Graph** page will be empty.

Click **Display**, and select the **Requests Percentage** option to enable Kiali to show you the percentage of requests sent to different versions of a microservice.

Select the **Traffic Animation** option to enable Kiali to show you an animated version of the traffic flow as requests come in to the service mesh.

The screenshot shows the Kiali interface with the 'Graph' tab selected. On the left, a sidebar lists 'Overview', 'Graph' (selected), 'Applications', 'Workloads', 'Services', 'Istio Config', and 'Distributed Tracing'. The main area is titled 'Empty Graph' with the message: 'There is currently no graph available for namespace observe-kiali. This could either mean there is no service mesh available for this namespace or the service mesh has yet to see request traffic. You can enable 'Unused nodes' to display service mesh nodes that have yet to see any request traffic.' Below this message is a blue button labeled 'Display unused nodes'. On the right, there is a list of display options under 'Display': 'Show Edge Labels' (radio button), 'No Edge Labels', 'Requests Per Second', 'Requests Percentage' (radio button, highlighted with a red box), 'Response Time' (radio button), 'Show' (checkbox checked), 'Compress Hidden' (checkbox checked), 'Node Names' (checkbox checked), 'Operation Nodes' (checkbox checked), 'Service Nodes' (checkbox checked), 'Traffic Animation' (checkbox checked, highlighted with a red box), 'Unused Nodes' (checkbox), 'Show Badges' (checkbox checked), 'Circuit Breakers' (checkbox checked), 'Missing Sidecars' (checkbox checked), 'Virtual Services' (checkbox checked), and 'Security' (checkbox).

- 3.2. Run the `oc get route` command to get the URL of the istio gateway.

You can also cut and paste the full command from the `get-ingress-gateway-url.sh` file in the `/home/student/D0328/labs/observe-kiali` folder.

Export the ingress gateway URL to an environment variable called `GATEWAY_URL`.

```
[student@workstation ~]$ GATEWAY_URL=$(oc get route istio-ingressgateway -n
istio-system \
-o jsonpath='{.spec.host}' )
```

- 3.3. Use the `curl` command to keep sending continuous requests to the `/greet` endpoint. This command will not return to the prompt, and will continue to run unless you explicitly stop it with `Ctrl+C`.

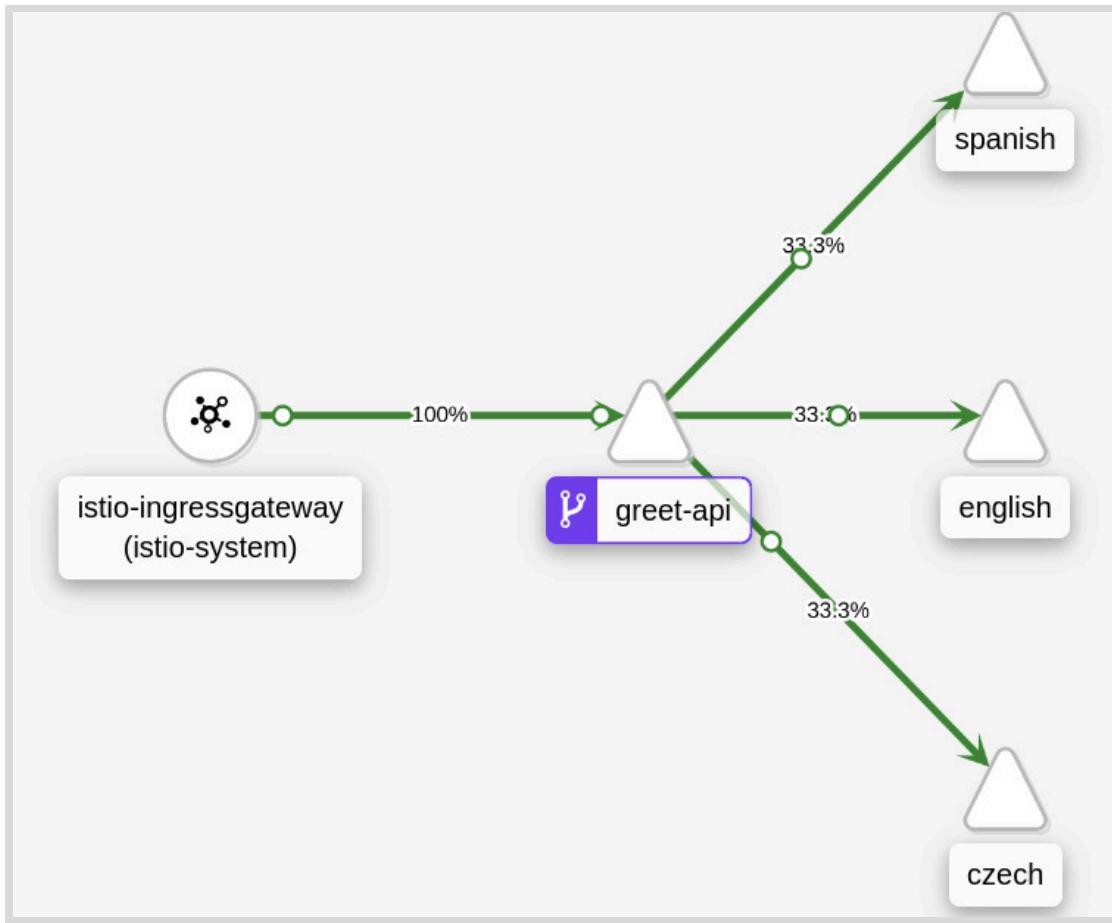
You can also run the `invoke-greet.sh` script in the `/home/student/D0328/labs/observe-kiali` folder

```
[student@workstation observe-metrics]$ while true; \
do curl ${GATEWAY_URL}/greet; \
sleep 3;done
Ahoj světe! | Hello World! | Hola Mundo!
Ahoj světe! | Hello World! | Hola Mundo!
...output omitted...
```

- 3.4. Switch to the Kiali **Graph** page, and observe the traffic animation. You might have to wait for a few seconds while Kiali captures data from the Envoy proxies and renders the animation.

By default, Kiali displays a graph with the services and their versions (**Versioned app graph**).

Click **Versioned app graph** and select the **Service graph** option to display a more compact graph with only the services in the application.

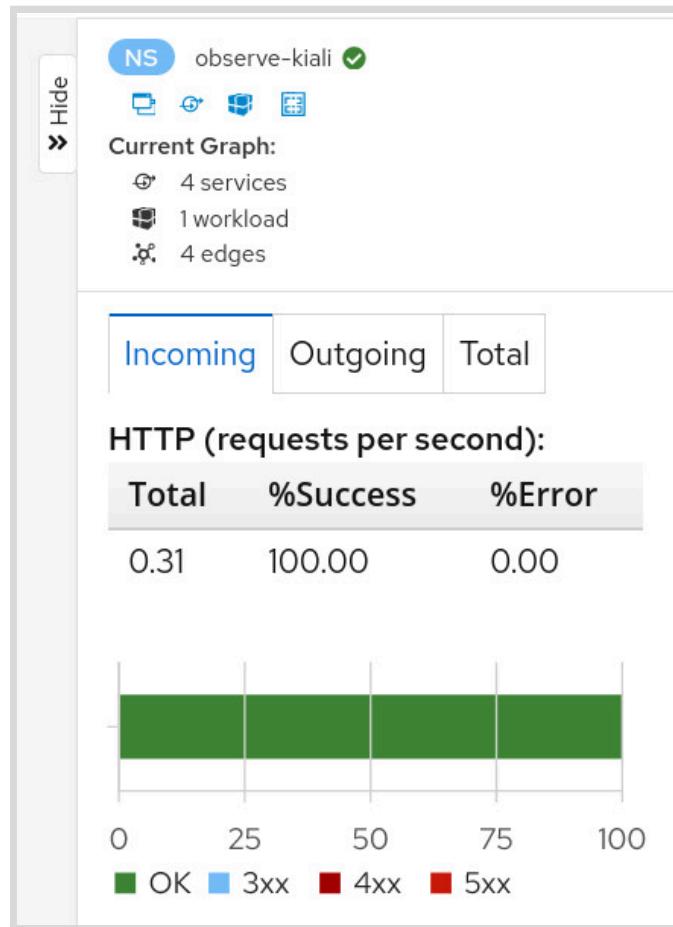


Note how the **greet -api** calls the individual services. You should see the percentage of responses being equally split between the three language services at this point.

A side panel to the right of the graph shows more details about the overall service mesh. You can click the services in the graph, and the side panel will show details of

the selected service. Clicking anywhere other than the displayed services switches back to the overall service mesh view.

You can click the **Hide** or **Show** button on the side panel to hide or show the side panel respectively.



- 3.5. Press **Ctrl+C** to stop the curl command in the command line terminal window where you were invoking the `/greet` endpoint.

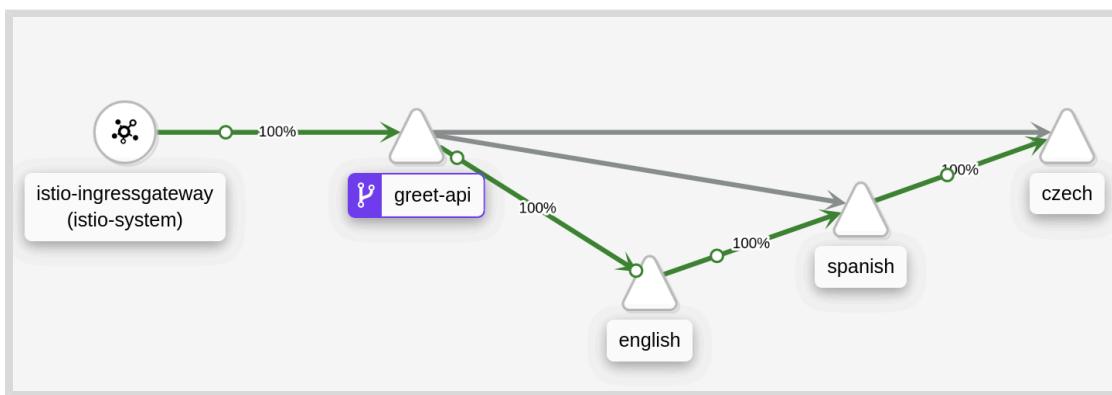
▶ **4.** Invoke the `/chained` end point, and visualize the traffic flow in Kiali.

- 4.1. Use the `curl` command to keep sending continuous requests to the `/chained` endpoint. Observe that the language services are now called in a different order.

You can also run the `invoke-chained.sh` script in the `/home/student/D0328/labs/observe-kiali` folder

```
[student@workstation observe-metrics]$ while true; \
do curl ${GATEWAY_URL}/chained; \
sleep 3;done
Hello World! -> Hola Mundo! -> Ahoj světe!
Hello World! -> Hola Mundo! -> Ahoj světe!
...output omitted...
```

- 4.2. Switch to the Kiali **Graph** page, and observe the traffic animation. You might have to wait for a few seconds while Kiali captures data from the Envoy proxies and renders the animation.



Note how the **greet-api** only calls the **english** service, which calls the other languages in a chain.

Do not interrupt the command line terminal where you are sending traffic to the / chained endpoint. Leave it running. You will need this for subsequent steps in this exercise.

► 5. Deploy version 2 of the **english** microservice and view the updated traffic flow in Kiali.

- 5.1. From a new command line terminal, run the `oc create` command to deploy version 2 of the **english** microservice. This new version prints a more informal greeting. The deployment resource is provided in the `english-v2-deploy.yaml` file in the / `home/student/D0328/labs/observe-kiali` folder.

```
[student@workstation ~]$ cd ~/D0328/labs/observe-kiali
[student@workstation observe-kiali]$ oc create -f english-v2-deploy.yaml
deployment.apps/english-v2 created
```

- 5.2. Run the `oc get pods` command and verify that version 2 of the **english** microservice is deployed and in **Running** state.

```
[student@workstation observe-jaeger]$ oc get pods
NAME          READY   STATUS    RESTARTS   AGE
czech-84c5754796-cpqfq   2/2     Running   0          10m
english-v1-684884c897-qk7j2 2/2     Running   0          10m
english-v2-f696b69db-s285s 2/2     Running   0          27s
greet-api-7fb89fdc45-f7gs6 2/2     Running   0          10m
spanish-f8848fc89-c9slw   2/2     Running   0          10m
```

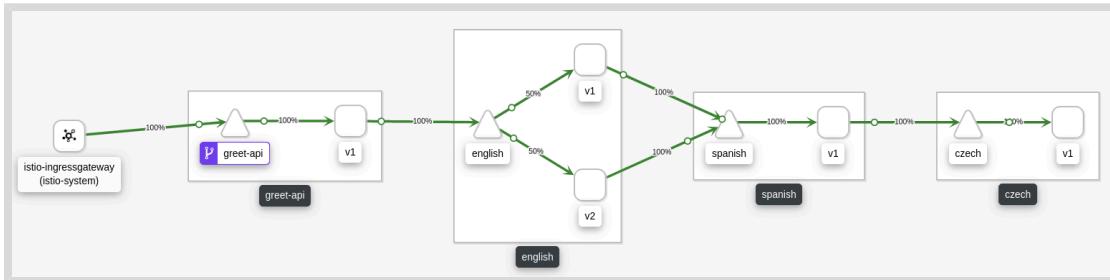
- 5.3. Switch to the command line terminal window running the `curl` command. After a while, you should see the output change to:

```
Hello World! -> Hola Mundo! -> Ahoj světe!
Hello World! -> Hola Mundo! -> Ahoj světe!
Hello World! -> Hola Mundo! -> Ahoj světe!
...output omitted...
Howdy! This mesh ain't big enough for both of us. -> Hola Mundo! -> Ahoj světe!
Hello World! -> Hola Mundo! -> Ahoj světe!
```

```
Howdy! This mesh ain't big enough for both of us. -> Hola Mundo! -> Ahoj světe!
Hello World! -> Hola Mundo! -> Ahoj světe!
...output omitted...
```

Traffic for the **english** service is split equally (load balanced) between both versions.

- 5.4. Switch to the Kiali **Graph** page, and observe the traffic animation. You might have to wait for a few seconds while Kiali captures data from the Envoy proxies and renders the animation.
- Click **Service graph** and select **Versioned app graph**. This will change the graph to display versions of services.



### Note

Your graph might not look exactly like the above. Graph nodes from previous scenarios might still be visible, but grayed out in the graph.

Note how Kiali shows the request percentage split equally between version 1 and version 2 of the **english** microservice.

- 6. Redirect all traffic bound for the **english** microservice to version 2 of the service. View the updated traffic flow in Kiali.
- 6.1. From a new command line terminal, run the `oc create` command to deploy version 2 of the **english** microservice. This new version prints a more informal greeting. The deployment resource is provided in the `english-v2-all.yaml` file in the `/home/student/D0328/labs/observe-kiali` folder.



### Note

Do not worry about the details in the YAML resource file. You will learn more about traffic shaping and load balancing in subsequent chapters.

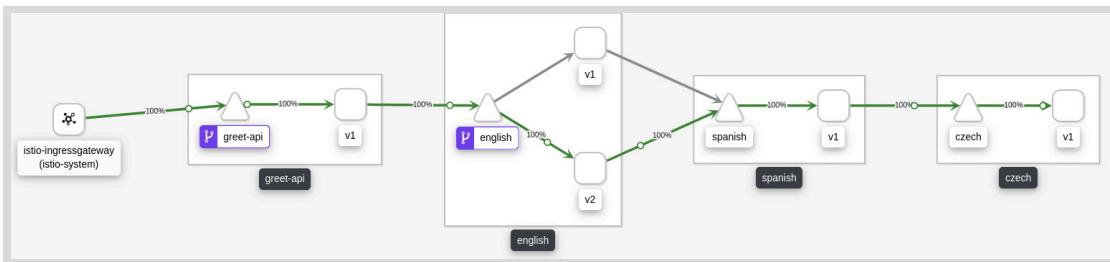
```
[student@workstation observe-kiali]$ oc create -f english-v2-all.yaml
destinationrule.networking.istio.io/english created
virtualservice.networking.istio.io/english-v2-all created
```

- 6.2. Switch to the command line terminal window running the `curl` command. After a while, you should see the output change to:

```
Hello World! -> Hola Mundo! -> Ahoj světe!
Howdy! This mesh ain't big enough for both of us. -> Hola Mundo! -> Ahoj světe!
Hello World! -> Hola Mundo! -> Ahoj světe!
...output omitted...
Howdy! This mesh ain't big enough for both of us. -> Hola Mundo! -> Ahoj světe!
Howdy! This mesh ain't big enough for both of us. -> Hola Mundo! -> Ahoj světe!
Howdy! This mesh ain't big enough for both of us. -> Hola Mundo! -> Ahoj světe!
Howdy! This mesh ain't big enough for both of us. -> Hola Mundo! -> Ahoj světe!
...output omitted...
```

All traffic for the `english` service is sent to version 2.

- 6.3. Switch to the Kiali **Graph** page, and observe the traffic animation. You might have to wait for a few seconds while Kiali captures data from the Envoy proxies and renders the animation.



Note how Kiali shows 100% of traffic being sent to version 2 of the `english` microservice.

- 6.4. Press `Ctrl+C` to stop the curl command in the command line terminal window where you were invoking the `/chained` endpoint.

▶ 7. Return to the home directory.

```
[student@workstation observe-kiali]$ cd
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab observe-kiali finish
```

This concludes the guided exercise.

## ► Lab

# Observing an OpenShift Service Mesh

### Performance Checklist

In this lab, you will troubleshoot performance issues with an application using distributed tracing, and enable metrics collection for the application.

### Outcomes

You should be able to:

- Identify and fix performance issues with an application deployed on Red Hat OpenShift Service Mesh.
- Enable distributed tracing for a Quarkus based microservice and visualize the traces using Jaeger.
- Enable custom application metrics for a Quarkus based microservice and create a custom dashboard for visualizing the collected metrics.
- Visualize communication between services in the application using Kiali.

### Before You Begin

To perform this lab, ensure you have:

- A configured and running OpenShift cluster.
- An installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift client (oc), OpenJDK 1.8, and podman installed on workstation.

You will be using an application that simulates an online currency exchange for this lab. The application has four microservices:

- **currencies**: Written in Python using the Flask framework. It provides a REST API, which returns a list of all currencies supported by the exchange.
- **history**: Written in JavaScript using the Node.js runtime. It provides a REST API, which returns historical data of exchange rates between currencies.
- **frontend**: Written using HTML, JavaScript, and CSS using the React.js library. It provides a web user interface for users of the currency exchange application.
- **exchange**: Written in Java using the Quarkus framework. It acts as an API gateway and communicates with the currencies and history microservices. It acts as a single point of communication for the frontend microservice.

The source code for the four microservices are available in the `exchange-traced` folder in the GitHub repository at <https://github.com/RedHatTraining/DO328-apps>.

On the `workstation` machine, use the `lab` command to prepare your system for this exercise.

```
[student@workstation ~]$ lab observe-mesh start
```

The `lab observe-mesh start` command will create a new project called `observe-mesh` owned by the developer (the value of the `$RHT_OCP4_DEV_USER` environment variable in your `/usr/local/etc/ocp4.config` file) user. It will deploy an initial version of the four microservices in this project.

You can examine the template that deploys the microservices in the `~/DO328/labs/observe-mesh/exchange-app-template.yaml` file.

## Instructions

1. Log in to OpenShift as the developer user, and inspect the deployed applications. Verify that the four microservices are deployed and running.  
Do not forget to load the environment variables from the `/usr/local/etc/ocp4.config` file in your command line terminal.
2. Identify the gateway URL for the service mesh. The currency exchange application is available at the URL `/frontend` relative to the gateway URL.  
Explore the currency exchange application by clicking on the **Historical Data**, and **Exchange** menu options in the left navigation panel.  
You can ignore the **News** menu option because it requires communicating with an external service, which is not deployed in this lab.  
Note that fetching the historical data of currency rates in the **Historical Data** page is very slow. It takes more than 5 seconds to fetch the data.
3. Visualize the service mesh communication using the Kiali web console. View the traces and spans generated by the currency exchange application using the Jaeger web console.  
Identify the microservice that is causing the slow response time in the **Historical Data** page. From the traces and spans in the Jaeger console, you can identify the function name that is causing the slowdown.  
Although distributed tracing was enabled for the services that you originally deployed, the source code of the problematic microservice that is available in this lab does not include tracing instrumentation. Therefore, to keep distributed tracing active after fixing the slowdown problem, you will add tracing instrumentation when you make changes to the source code of the problematic microservice. You will clone the source code of this microservice from GitHub and add tracing code in a subsequent step of the lab.



### Warning

The lab start script updates the `ServiceMeshMemberRoll` resource of the service mesh control plane. This will cause the Kiali pod to be redeployed after some time. Check the status of the Kiali pod by running `oc get pods -n istio-system`, and proceed after you see it in `Running` state.

If the Kiali pod is restarted after you have logged into Kiali, or if you see errors in the Kiali console, verify the Kiali pod status and log in again.

4. Clone the source code for the traced currency exchange application from the GitHub repository at <https://github.com/RedHatTraining/DO328-apps>. The application code is located in the `exchange-traced` directory. Correct the source code of the microservice you identified in the previous step to eliminate the performance issue.  
Use a text editor like **VSCodium**, which supports syntax highlighting for editing source files.

**5.** Enable distributed tracing for the problematic microservice.

The distributed tracing properties for the problematic microservice must be configured as follows:

- The service name for identifying traces and spans in Jaeger must be named `exchange`.
- Enable Jaeger to collect all sample traces from all requests to the service.
- The URL of the Jaeger collector is `http://jaeger-collector.istio-system.svc:14268/api/traces`.
- Enable propagation of all `x-b3-*` HTTP headers, and log span information for all incoming and outgoing requests to and from this service.

**6.** You have been instructed by the operations team to add custom metrics to the problematic microservice, which will keep track of its performance in future deployments.

Add the following custom metrics to the problematic microservice:

- A timer that tracks how long (in milliseconds) the `getHistoricalData()` function takes to execute. Provide a unique name for this metric called `exchange_svc:history_fetch_time`.
- The rate of requests (per minute) served by the `getHistoricalData()` function. This will provide information for capacity planning in the future. Provide a unique name for this metric called `exchange_svc:history_fetch_rate`.

**7.** Rebuild the container image for the problematic microservice. Fully complete Dockerfiles are provided to you for all four microservices in their respective folders.

Create a new container image repository in Quay.io called `ossm-microservice-traced`. Replace `microservice` with the name of the problematic microservice.

Push the newly built container image with a tag named `1.0` to the `ossm-microservice-traced` image repository.

**8.** Edit the deployment resource for the `exchange` service.

Replace the container image for the problematic microservice with your newly built container image.

Enable metrics collection for the problematic microservice by adding the correct annotations.

**9.** Test the application with the updated `exchange` microservice. Verify that the performance issues identified earlier are no longer present in the **Historical Data** page.

**10.** Create a custom dashboard in Grafana for the custom application metrics you added in a previous step.

**11.** Return to the home directory.

## Evaluation

Grade your work by running the `lab observe-mesh grade` command from your `workstation` machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab observe-mesh grade
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab observe-mesh finish
```

This concludes the lab.

## ► Solution

# Observing an OpenShift Service Mesh

### Performance Checklist

In this lab, you will troubleshoot performance issues with an application using distributed tracing, and enable metrics collection for the application.

### Outcomes

You should be able to:

- Identify and fix performance issues with an application deployed on Red Hat OpenShift Service Mesh.
- Enable distributed tracing for a Quarkus based microservice and visualize the traces using Jaeger.
- Enable custom application metrics for a Quarkus based microservice and create a custom dashboard for visualizing the collected metrics.
- Visualize communication between services in the application using Kiali.

### Before You Begin

To perform this lab, ensure you have:

- A configured and running OpenShift cluster.
- An installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift client (oc), OpenJDK 1.8, and podman installed on workstation.

You will be using an application that simulates an online currency exchange for this lab. The application has four microservices:

- **currencies**: Written in Python using the Flask framework. It provides a REST API, which returns a list of all currencies supported by the exchange.
- **history**: Written in JavaScript using the Node.js runtime. It provides a REST API, which returns historical data of exchange rates between currencies.
- **frontend**: Written using HTML, JavaScript, and CSS using the React.js library. It provides a web user interface for users of the currency exchange application.
- **exchange**: Written in Java using the Quarkus framework. It acts as an API gateway and communicates with the currencies and history microservices. It acts as a single point of communication for the frontend microservice.

The source code for the four microservices are available in the `exchange-traced` folder in the GitHub repository at <https://github.com/RedHatTraining/DO328-apps>.

On the `workstation` machine, use the `lab` command to prepare your system for this exercise.

```
[student@workstation ~]$ lab observe-mesh start
```

The `lab observe-mesh start` command will create a new project called `observe-mesh` owned by the developer (the value of the `$RHT_OCP4_DEV_USER` environment variable in your `/usr/local/etc/ocp4.config` file) user. It will deploy an initial version of the four microservices in this project.

You can examine the template that deploys the microservices in the `~/D0328/labs/observe-mesh/exchange-app-template.yaml` file.

## Instructions

1. Log in to OpenShift as the developer user, and inspect the deployed applications. Verify that the four microservices are deployed and running.  
Do not forget to load the environment variables from the `/usr/local/etc/ocp4.config` file in your command line terminal.
  - 1.1. Run the following command to load the environment variables created in the first guided exercise:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

- 1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

- 1.3. Set the current project to `observe-mesh`:

```
[student@workstation ~]$ oc project observe-mesh
Now using project "observe-mesh" on server ...output omitted...
```

- 1.4. Verify that there are four pods in Running state:

```
[student@workstation ~]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
currency-cc8566cdd-fc4qx   2/2     Running   0          13m
exchange-8cf576667-9z7h5   2/2     Running   0          13m
frontend-7846899665-8bpwr  2/2     Running   0          13m
history-db65bfb86-rwmdr   2/2     Running   0          13m
```

2. Identify the gateway URL for the service mesh. The currency exchange application is available at the URL `/frontend` relative to the gateway URL.  
Explore the currency exchange application by clicking on the **Historical Data**, and **Exchange** menu options in the left navigation panel.  
You can ignore the **News** menu option because it requires communicating with an external service, which is not deployed in this lab.  
Note that fetching the historical data of currency rates in the **Historical Data** page is very slow. It takes more than 5 seconds to fetch the data.

- 2.1. Run the `oc get route` command to gather the service mesh gateway URL.

```
[student@workstation ~]$ GW_URL=$( \
  oc get route istio-ingressgateway -n istio-system \
  -o template --template '{{ "http://" }}{{ .spec.host }}')
```

- 2.2. Access the currency exchange application using the **firefox** browser on your workstation.

```
[student@workstation ~]$ firefox ${GW_URL}/frontend &
```

- 2.3. Click **Historical Data** in the left navigation panel. Select a source and target currency and click **Submit** to see historical exchange data.

Note the slow response after you click **Submit** to fetch historical data.

- 2.4. Click **Exchange** in the left navigation panel. Enter an amount, select the source and target currency and click **Submit**.

3. Visualize the service mesh communication using the Kiali web console. View the traces and spans generated by the currency exchange application using the Jaeger web console.

Identify the microservice that is causing the slow response time in the **Historical Data** page. From the traces and spans in the Jaeger console, you can identify the function name that is causing the slowdown.

Although distributed tracing was enabled for the services that you originally deployed, the source code of the problematic microservice that is available in this lab does not include tracing instrumentation. Therefore, to keep distributed tracing active after fixing the slowdown problem, you will add tracing instrumentation when you make changes to the source code of the problematic microservice. You will clone the source code of this microservice from GitHub and add tracing code in a subsequent step of the lab.

**Warning**

The lab start script updates the `ServiceMeshMemberRoll` resource of the service mesh control plane. This will cause the Kiali pod to be redeployed after some time. Check the status of the Kiali pod by running `oc get pods -n istio-system`, and proceed after you see it in `Running` state.

If the Kiali pod is restarted after you have logged into Kiali, or if you see errors in the Kiali console, verify the Kiali pod status and log in again.

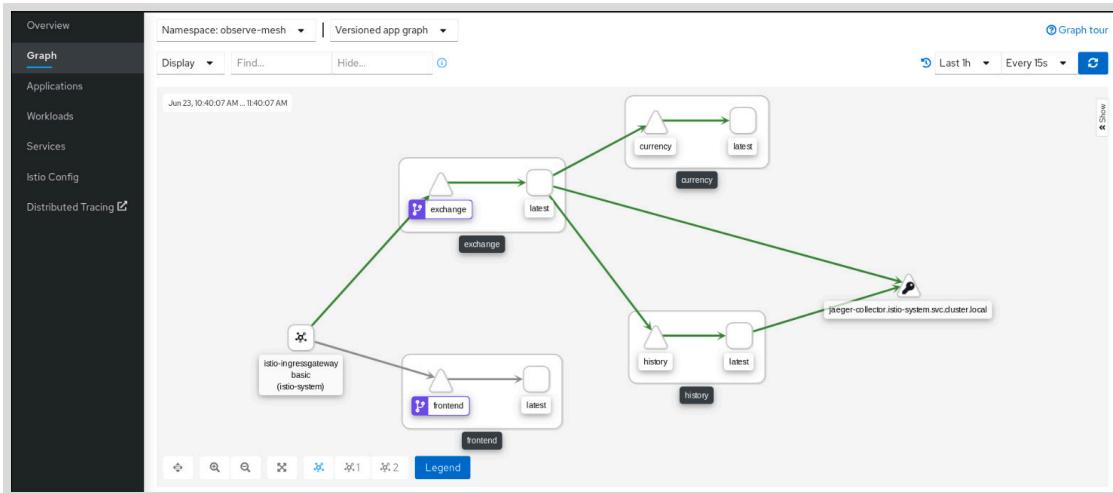
- Run the `oc get route` command to gather the Kiali web console URL.

```
[student@workstation ~]$ KIALI_URL=$(oc get route kiali -n istio-system \
-o template --template '{{ "https://" }}{{ .spec.host }}')
```

- Access the Kiali web console using the `firefox` browser on your workstation. Log in using your OpenShift developer user account.

```
[student@workstation ~]$ firefox ${KIALI_URL} &
```

- Click **Graph** in the left navigation panel, and select the `observe-mesh` namespace to view the service mesh graph. Click **Last 1m** and then select **Last 1h** to see the traffic that you generated in the previous step. Your graph could look different than the one shown below.

**Note**

You will not see the `currency` microservice sending traces to the `jaeger-collector` because, the `currency` service is written in Python and does not yet support sending traces to jaeger over TCP. Instead the microservice sends trace information using UDP datagrams to the `jaeger-agent` service, which forwards it to the jaeger backend. Kiali cannot capture this UDP traffic to render the graphs.

You will see traces from the `currency` microservice in the Jaeger web console and verify this in the next step.

**Chapter 3 |** Observing a Service Mesh

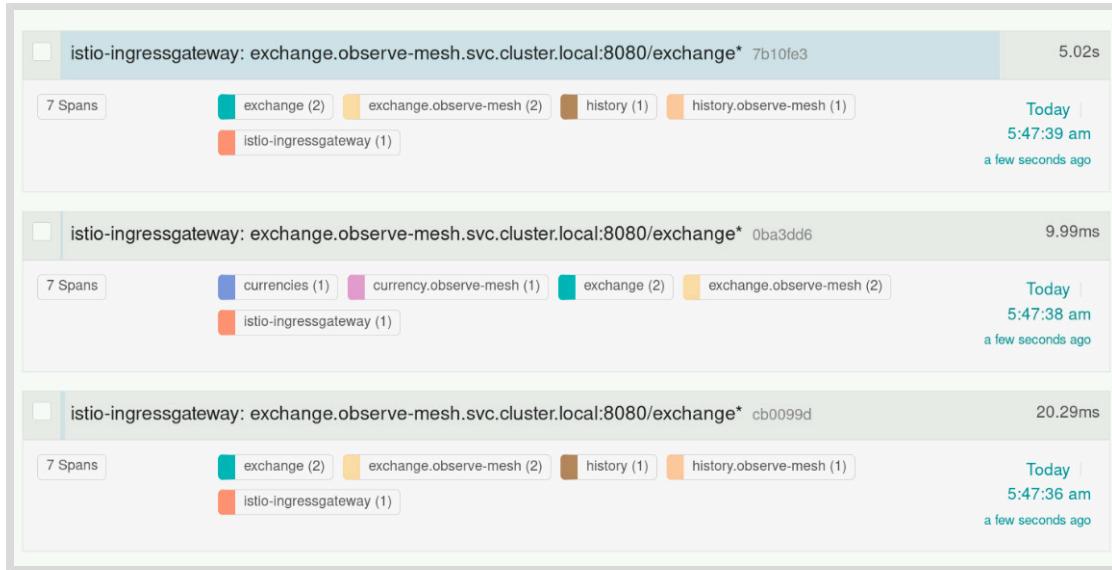
- 3.4. Run the `oc get route` command to gather the Jaeger web console URL.

```
[student@workstation ~]$ JAEGER_URL=$(oc get route jaeger -n istio-system \
-o template --template '{{ "https://" }}{{ .spec.host }}')
```

- 3.5. Use the Firefox browser to access the Jaeger web console and log in using your OpenShift developer user account.

```
[student@workstation ~]$ firefox ${JAEGER_URL} &
```

- 3.6. In the Jaeger web console, select the `istio-ingressgateway` service in the search panel on the left of the page. Click **Find Traces**. You will see a list of traces for the currency exchange application.

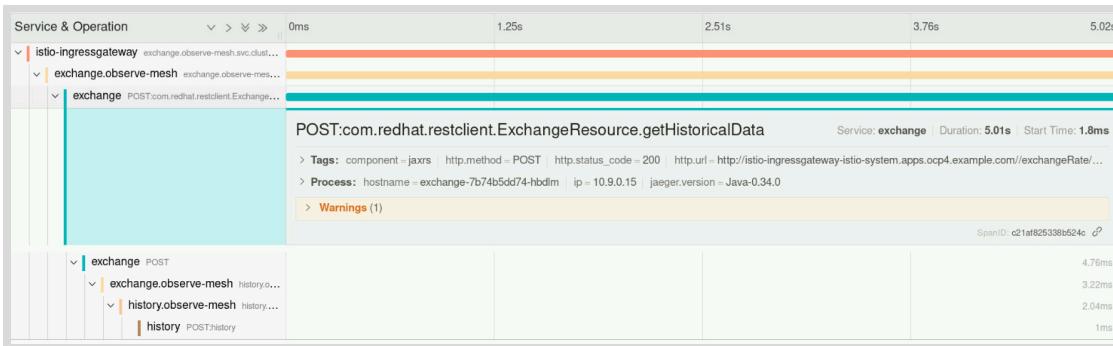


- 3.7. Click any trace that is greater than 5 seconds. These traces are generated by the functionality in the **Historical Data** page of the currency exchange application.

Note the hierarchy of service calls for this trace. The front end calls the `exchange` service, which then calls the `history` service to fetch historical data.



- 3.8. To identify the method causing the bottleneck, click the span corresponding to the `exchange` service. This span has the longest execution time (> 5 seconds on average).



There seems to be an issue in the `getHistoricalData` function of the `com.redhat.restclient.ExchangeResource` class in the `exchange` service. The class name and function is displayed as the title of the span (the text following `POST:`).

- Clone the source code for the traced currency exchange application from the GitHub repository at <https://github.com/RedHatTraining/DO328-apps>. The application code is located in the `exchange-traced` directory. Correct the source code of the microservice you identified in the previous step to eliminate the performance issue.

Use a text editor like `VSCodium`, which supports syntax highlighting for editing source files.

- If you have not cloned the source code from the `D0328-apps` GitHub repository in a previous exercise, then do so now using the `git clone` command.

```
[student@workstation ~]$ git clone https://github.com/RedHatTraining/D0328-apps
...output omitted...
Cloning into 'D0328-apps'...
...output omitted...
```

- Copy the contents of the `/home/student/D0328-apps/exchange-traced` folder from your local Git repository to the `/home/student/D0328/labs/observe-mesh` folder.

```
[student@workstation ~]$ cp -Rv ~/D0328-apps/exchange-traced \
~/D0328/labs/observe-mesh/
...output omitted...
'/home/student/D0328-apps/exchange-traced/frontend/README.md' -> '/home/student/
D0328/labs/observe-mesh/exchange-traced/frontend/README.md'
'/home/student/D0328-apps/exchange-traced/frontend/package.json' -> '/home/
student/D0328/labs/observe-mesh/exchange-traced/frontend/package.json'
'/home/student/D0328-apps/exchange-traced/frontend/yarn.lock' -> '/home/student/
D0328/labs/observe-mesh/exchange-traced/frontend/yarn.lock'
```

- Fix the issue in the source code for the `exchange` microservice. Edit the `/home/student/D0328/labs/observe-mesh/exchange-traced/exchange/src/main/java/com/redhat/restclient/ExchangeResource.java` file.

Note the hard coded `Thread.sleep(5000)` try-catch block in the `getHistoricalData()` method. This was added to simulate slow processing (for example, due to an inefficient algorithm, a slow database query, or high latency due to invoking external services).

Remove the try-catch block that was causing the slowdown.

- Enable distributed tracing for the problematic microservice.

The distributed tracing properties for the problematic microservice must be configured as follows:

- The service name for identifying traces and spans in Jaeger must be named exchange.
- Enable Jaeger to collect all sample traces from all requests to the service.
- The URL of the Jaeger collector is `http://jaeger-collector.istio-system.svc:14268/api/traces`.
- Enable propagation of all `x-b3-*` HTTP headers, and log span information for all incoming and outgoing requests to and from this service.

#### 5.1. Enable distributed tracing for the exchange microservice.

Edit the `/home/student/D0328/labs/observe-mesh/exchange-traced/exchange/pom.xml` file and add the `quarkus-smallrye-opentracing` dependency.

```
<dependency>
  <groupId>io.quarkus</groupId>
  <artifactId>quarkus-smallrye-opentracing</artifactId>
</dependency>
```

#### 5.2. Edit the `/home/student/D0328/labs/observe-mesh/exchange-traced/exchange/src/main/resources/application.properties` file and add the Jaeger related properties.

```
quarkus.jaeger.service-name=exchange
quarkus.jaeger.sampler-type=const
quarkus.jaeger.sampler-param=1
quarkus.jaeger.endpoint=http://jaeger-collector.istio-system.svc:14268/api/traces
quarkus.jaeger.propagation=b3
quarkus.jaeger.reporter-log-spans=true
```

#### 6. You have been instructed by the operations team to add custom metrics to the problematic microservice, which will keep track of its performance in future deployments.

Add the following custom metrics to the problematic microservice:

- A timer that tracks how long (in milliseconds) the `getHistoricalData()` function takes to execute. Provide a unique name for this metric called `exchange_svc:history_fetch_time`.
- The rate of requests (per minute) served by the `getHistoricalData()` function. This will provide information for capacity planning in the future. Provide a unique name for this metric called `exchange_svc:history_fetch_rate`.

#### 6.1. Edit the `/home/student/D0328/labs/observe-mesh/exchange-traced/exchange/pom.xml` file and add the `quarkus-smallrye-metrics` dependency.

```
<dependency>
  <groupId>io.quarkus</groupId>
  <artifactId>quarkus-smallrye-metrics</artifactId>
</dependency>
```

- 6.2. Edit the source code for the `getHistoricalData()` function in the `/home/student/D0328/labs/observe-mesh/exchange-traced/exchange/src/main/java/com/redhat/restclient/ExchangeResource.java` file.

Import the required metrics classes from the OpenTracing API.

Add the following import statements at the top of the file.

```
...output omitted...
import org.eclipse.microprofile.metrics.MetricUnits;
import org.eclipse.microprofile.metrics.annotation.SimplyTimed;
import org.eclipse.microprofile.metrics.annotation.Metered;
...output omitted...
```

Add the following annotations to the `getHistoricalData()` function (below the `@Path("/historicalData")` line) to enable custom metrics.

```
@SimplyTimed(name = "exchange_svc:history_fetch_time",
    description = "A measure of how long it takes to fetch history data",
    unit = MetricUnits.MILLISECONDS)
@Metered(name = "exchange_svc:history_fetch_rate",
    unit = MetricUnits.MINUTES,
    description = "Rate at which historical data is fetched (minutes)",
    absolute = true)
```

7. Rebuild the container image for the problematic microservice. Fully complete Dockerfiles are provided to you for all four microservices in their respective folders.

Create a new container image repository in Quay.io called `ossm-microservice-traced`. Replace `microservice` with the name of the problematic microservice.

Push the newly built container image with a tag named `1.0` to the `ossm-microservice-traced` image repository.

- 7.1. Create a new public container image repository called `ossm-exchange-traced` in Quay.io. To create a public container image repository, refer to instructions in the *Appendix: Creating a Quay Account*.



### Warning

If you skip this step and push the container images without creating public repositories, the `podman push` commands will create private container image repositories by default.

- 7.2. To ensure that there are no syntax errors, run `mvn clean package` and ensure that a fat JAR is created in the `target` folder.

```
[student@workstation ~]$ cd \
~/D0328/labs/observe-mesh/exchange-traced/exchange
[student@workstation exchange]$ mvn clean package
...output omitted...
[INFO] BUILD SUCCESS
...output omitted...
```

- 7.3. Review the Dockerfile for the exchange microservice. You will use Red Hat Universal Base Images (UBI) as the base for building your container image. Do not make any changes to it.

Build the container image using podman.

```
[student@workstation exchange]$ podman build -t \
quay.io/${RHT_OCP4_QUAY_USER}/ossm-exchange-traced:1.0 .
STEP 1: FROM registry.access.redhat.com/ubi8:8.1
...output omitted...
STEP 15: COMMIT quay.io/youruser/ossm-exchange-traced:1.0
```

- 7.4. Log in to your Quay.io account using podman.

```
[student@workstation exchange]$ podman login -u ${RHT_OCP4_QUAY_USER} quay.io
```

You will be prompted for your Quay.io password.

- 7.5. Push the updated container image for the exchange microservice to Quay.io.

```
[student@workstation exchange]$ podman push \
quay.io/${RHT_OCP4_QUAY_USER}/ossm-exchange-traced:1.0
...output omitted...
Writing manifest to image destination
Storing signatures
```

8. Edit the deployment resource for the exchange service.

Replace the container image for the problematic microservice with your newly built container image.

Enable metrics collection for the problematic microservice by adding the correct annotations.

- 8.1. Edit the deployment resource for the exchange microservice.

You can also apply the solution file /home/student/D0328/solutions/observe-mesh/exchange-deployment.yaml. Remember to include your Quay user in the image attribute.

```
[student@workstation exchange]$ oc edit deployment exchange
```

Edit the spec.template.spec.containers.image attribute for the exchange deployment, and add the Quay.io URL of the container image for the exchange deployment.

```
...output omitted...
spec:
  containers:
    - image: quay.io/youruser/ossm-exchange-traced:1.0
      imagePullPolicy: Always
      name: exchange
  ...output omitted...
```

- 8.2. Add annotations to allow the Prometheus instance to collect metrics from the exchange microservice. Add the following annotations below the sidecar.istio.io/inject: "true" annotation for the exchange microservice.

```
...output omitted...
template:
metadata
  annotations:
    sidecar.istio.io/inject: "true"
    prometheus.io/scrape: "true"
    prometheus.io/port: "8080"
    prometheus.io/scheme: "http"
...output omitted...
```

Save your changes. OpenShift will detect the changed deployment, and delete the old pod. It will create a new pod for the exchange microservice.

- 8.3. Verify that the four microservices are ready and running using the `oc get pods` command.

```
[student@workstation exchange]$ oc get pods
NAME           READY   STATUS    RESTARTS   AGE
currency-699d4dd98d-rzlvx   2/2     Running   0          20m
exchange-5454495f78-47457   2/2     Running   0          40s
frontend-5b78fc6bb5-ztdvq   2/2     Running   0          20m
history-8c875469d-csfsv    2/2     Running   0          20m
```

9. Test the application with the updated exchange microservice. Verify that the performance issues identified earlier are no longer present in the **Historical Data** page.
  - 9.1. Access the currency exchange application at the URL `GW_URL/frontend`. Click **Historical Data**, and verify that the response time is much improved (the spinner icon after you click **Submit** should disappear quickly).
  - 9.2. You will see span information from the exchange microservice. Access the Jaeger console and verify that there is no longer a 5 second pause in the span details for the historical data page.
10. Create a custom dashboard in Grafana for the custom application metrics you added in a previous step.
  - 10.1. Run the `oc get route` command to gather the Grafana web console URL.

```
[student@workstation exchange]$ GRAFANA_URL=$( \
  oc get route grafana -n istio-system \
  -o template --template '{{ "https://" }}{{ .spec.host }}')
```

- 10.2. Use the Firefox web browser to access the Grafana web console. Log in using your developer user account.

```
[student@workstation exchange]$ firefox ${GRAFANA_URL} &
```

- 10.3. Click the plus (+) icon in the left navigation menu of Grafana web console to open the **Create** menu. Select **Dashboard** to create a new dashboard.
- 10.4. Click **Add Query** in the **New Panel** panel.

In the query expression editor named **A** (next to the **Metrics** label), type `history_fetch_time` and select the first auto completed option (ends with `elapsed`). Click the graph icon in the left menu (to the left of the **Query** window) to select how you want to visualize the metric.

In the **Visualization** panel, expand the **Visualization** selection, and select **Graph**.

- 10.5. Click **General** (gear icon below **Visualize** icon in the left menu).

Enter **Historical Data Fetch Time** as the **Title**.

Click the left arrow icon (top left corner to the left of **New dashboard**) to go back to the dashboard page.

- 10.6. Click **Add panel** (graph icon with yellow plus in top right) to add another panel.

Click **Add Query** in the **New Panel**, and type `history_fetch_rate`. Prometheus will auto-complete and provide you with 5 options. Select the option ending with `fetch_rate_total`.

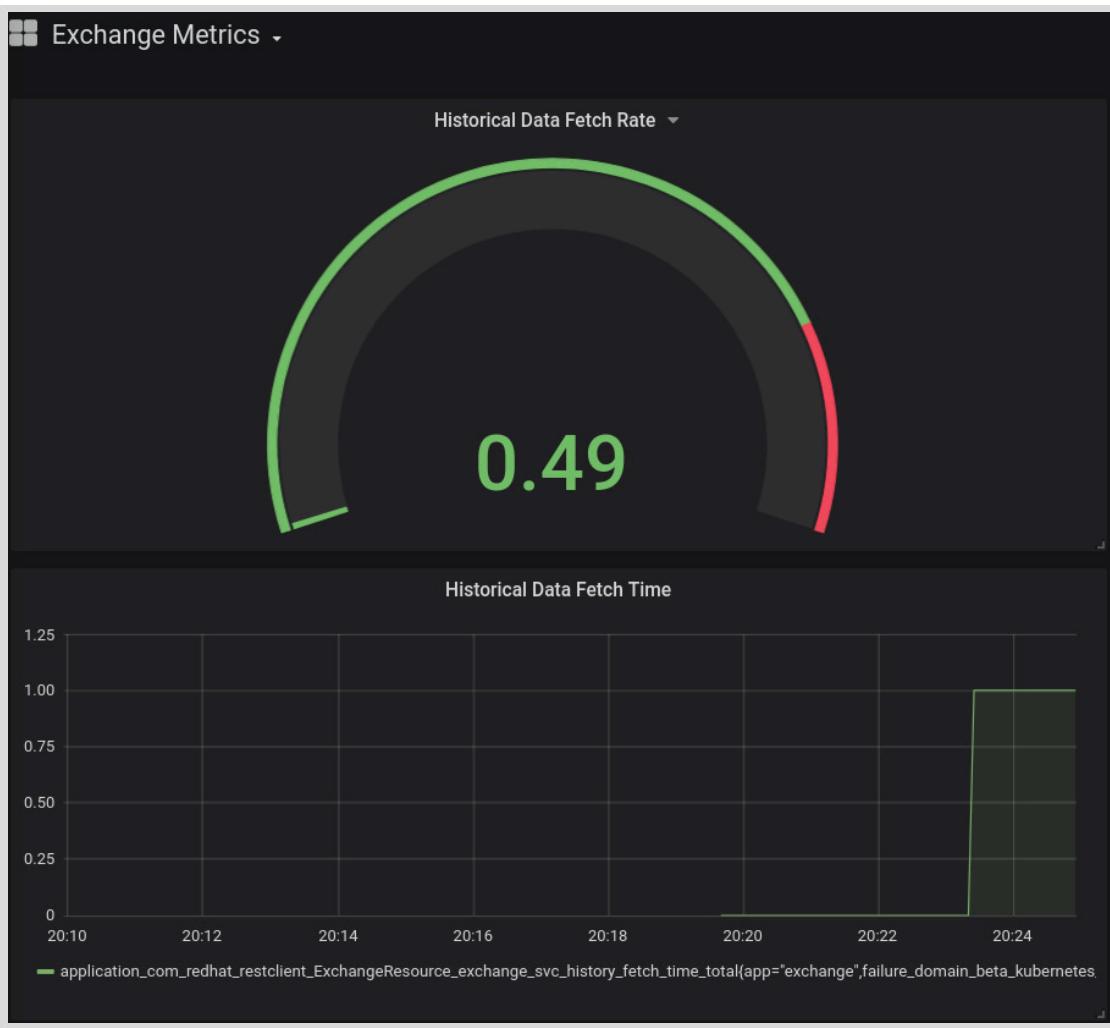
Click **Visualization** in the left menu, and select the **Gauge** option.

Click **General** in the left panel, and change the **Title** field to **Historical Data Fetch Rate**. Click the left arrow icon in the top left corner to go back to the **New dashboard** page.

- 10.7. Your new dashboard should now show both metrics from the **exchange** service.

Click the **Save dashboard** icon to save your new dashboard. Enter **Exchange Metrics** in the **Save As** dialog.

Your final Grafana dashboard should look like the following.



11. Return to the home directory.

```
[student@workstation exchange]$ cd
```

## Evaluation

Grade your work by running the `lab observe-mesh grade` command from your workstation machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab observe-mesh grade
```

## Finish

On the workstation machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab observe-mesh finish
```

This concludes the lab.

# Summary

---

In this chapter, you learned:

- Distributed tracing helps you identify performance issues in microservices based applications. You need to instrument your applications with Jaeger and OpenTracing libraries to enable distributed tracing.
- You can use Prometheus libraries to instrument your applications for generating custom application metrics. You can use Grafana to generate custom dashboards for your application metrics.
- Kiali can be used to visualize the communication between services in your service mesh.

## Chapter 4

# Controlling Service Traffic

### Goal

Manage and route traffic with Red Hat OpenShift Service Mesh

### Objectives

- Manage and route traffic with Red Hat OpenShift Service Mesh.
- Route traffic to services in a mesh, based on request headers.
- Control egress traffic to access external services.

### Sections

- Managing Service Connections with Envoy (and Guided Exercise)
- Routing Traffic Based on Request Headers (and Guided Exercise)
- Accessing External Services (and Guided Exercise)

### Lab

Controlling Service Traffic

# Managing Service Connections with Envoy

---

## Objectives

After completing this section, you should be able to manage and route traffic with Red Hat OpenShift Service Mesh.

## Explaining Traffic Management

*Traffic management*, in the context of cloud-native microservices, is the process of monitoring and controlling the external and internal network communications of an application.

As cloud-native applications evolve and grow, the number of microservices increases, which makes it more difficult to manage and observe the network connections. In addition to an increasing number of services to manage, the reliability of microservice applications is dependent on a reliable network. For these reasons, developers need a way to improve reliability, security, and observability of the network connections.

Projects that are not using Service Mesh usually use libraries embedded in the source code of the application.

OpenShift Service Mesh abstracts network communications, allowing you to manage them using Kubernetes custom resources. With OpenShift Service Mesh, you control the flow of traffic and API calls of your applications.

## Describing the Sidecar Pattern

Cloud applications usually require functionalities outside of the application domain, such as monitoring, logging, and authentication.

The *sidecar pattern* is an architectural pattern where a main process (the main application) segregates non-business related functionalities to an auxiliary process (the sidecar).

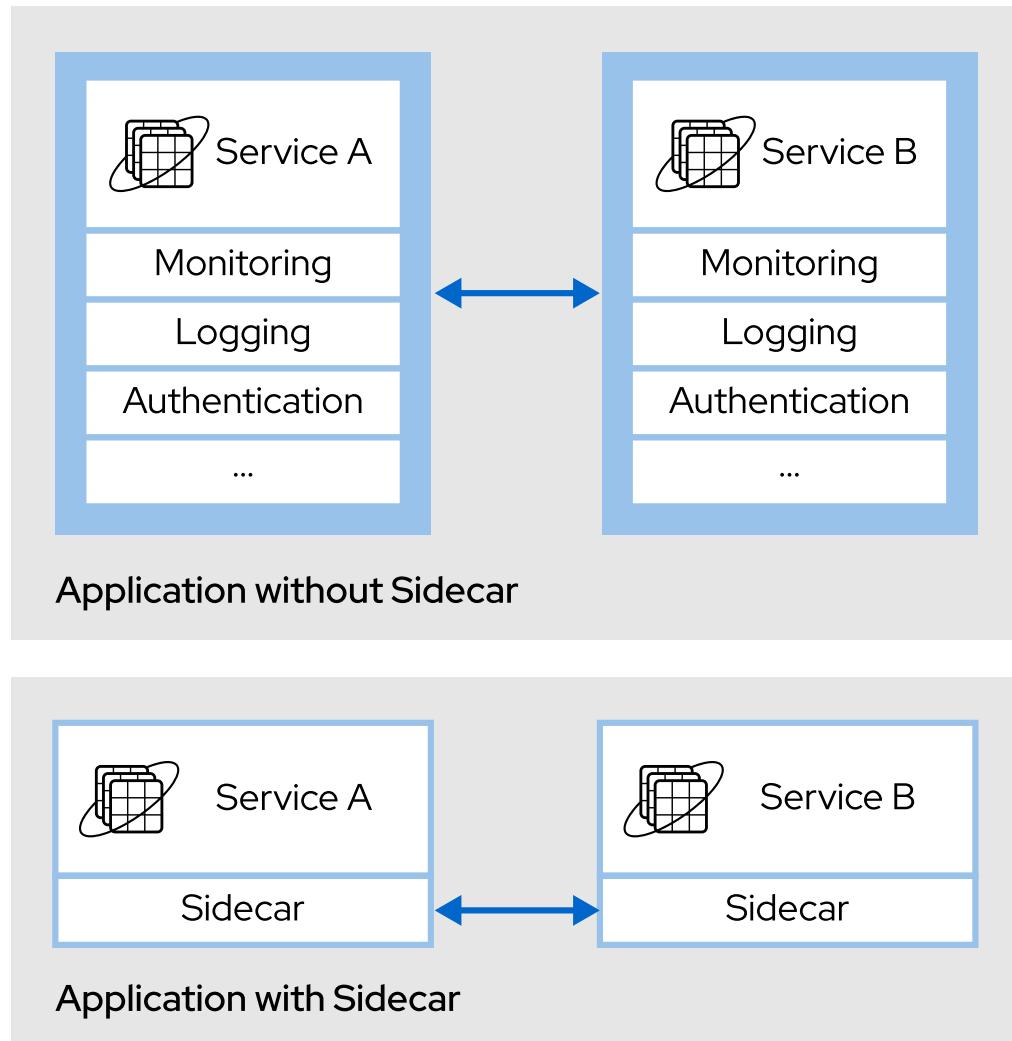


Figure 4.1: The sidecar pattern

Applying the sidecar pattern minimizes coupling between the application and the underlying infrastructure and reduces the complexity of the main application.

OpenShift Service Mesh and the Istio project are good examples of implementing the sidecar pattern at a network level.

## The Sidecar Pattern and OpenShift Service Mesh

On Service Mesh enabled services, an Envoy proxy instance is injected into the application pod using the sidecar pattern. After the Envoy sidecar is injected, it takes control of all of the network communications for the pod.

OpenShift Service Mesh does not automatically inject the sidecar into every pod. You must explicitly specify the pods that you want Service Mesh to manage by adding annotations to the deployment configuration. This manual approach ensures that the automatic sidecar injection does not interfere with other Red Hat OpenShift features.

**Note**

The default configuration in the upstream Istio version uses automatic sidecar injection at a namespace level.

## Injecting the Envoy Sidecar Automatically

To automatically inject the Envoy sidecar into a service, you must specify the `sidecar.istio.io/inject` annotation with the value set to "true" in the Deployment resource.

Example of automatic sidecar injection:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: history
spec:
  replicas: 1
  template:
    metadata:
      labels:
        app: history
    annotations:
      sidecar.istio.io/inject: "true"
  spec:
    containers:
      - name: history
        image: quay.io/redhattraining/ossm-history:1.0
        ports:
          - containerPort: 8080
```

## Distinguishing Ingress and Egress Traffic

In the context of a Service Mesh, we can distinguish two types of network traffic:

### **Ingress**

Incoming traffic from sources external to the cluster, as well as calls originating from other services within the cluster.

### **Egress**

Outgoing traffic to sources outside the cluster, as well as calls to services within the cluster.

The default installation of OpenShift Service Mesh provides an instance of `istio-ingressgateway` and an instance of `istio-egressgateway` to manage the ingress and egress traffic in a Service Mesh. Both gateways can be customized to suit the needs of your applications.

## Understanding the Gateway Custom Resource

A `gateway` is a custom resource that operates as a load balancer at the edge of the Service Mesh, managing ingress or egress connections. Gateway configurations are applied to Envoy proxies running at the edge of the Service Mesh.

In a default installation of OpenShift Service Mesh, a gateway instance called `istio-ingressgateway` manages ingress connections and a gateway instance called `istio-egressgateway` manages egress connections.

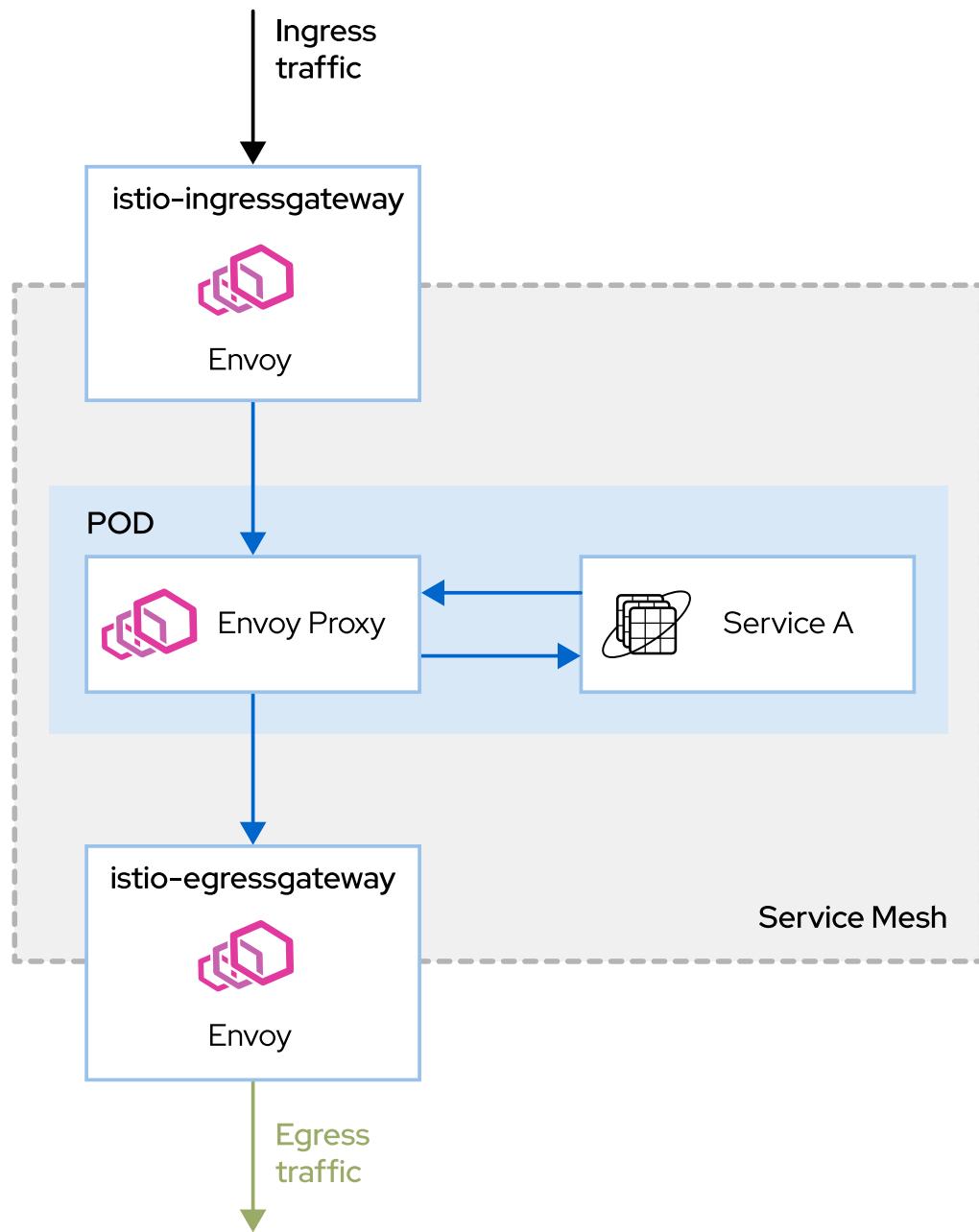


Figure 4.2: Ingress and egress gateways

The Open Systems Interconnection (OSI) model is a conceptual model that splits networking systems into seven abstraction layers. It provides a standard to describe how applications communicate over the network.

A gateway follows the OSI model, letting you configure Layer 4, Layer 5, and Layer 6 load balancing properties, and also delegates application-layer traffic routing (Layer 7) to virtual

services. This way of splitting the configuration between different and specialized components gives you more control and flexibility over the communications of your application.

Example of ingress gateway:

```
apiVersion: networking.istio.io/v1beta1
kind: Gateway
metadata:
  name: exchange-gw
spec:
  selector:
    istio: ingressgateway
  servers:
    - port:
        number: 80
        name: http
        protocol: HTTP
    hosts:
      - "exchange.example.com"
```

The preceding setup configures the `ingressgateway` to expose the combination of virtual hostname/DNS `exchange.example.com` protocol HTTP and port 80. This means that all HTTP traffic for that hostname/DNS is allowed to enter the mesh.

## Describing the VirtualService Custom Resource

A *virtual service* is a Kubernetes custom resource, which allows you to configure how the requests to services in the Service Mesh are routed.

A virtual service is composed of a list of routing rules that are evaluated in order, from top to bottom. Each routing rule consists of a traffic destination and zero or more match conditions that, if met, direct traffic to the destination defined by the rule.

`Istiod` translates the `VirtualService` custom resources to Envoy configuration, thereby propagating it to the data plane. In the absence of virtual services, Envoy distributes traffic between all service instances using a round-robin algorithm.

Example of a virtual service:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: exchange-vs ①
spec:
  hosts: ②
    - exchange
  http: ③
    - match: ④
      - headers:
          end-user:
            exact: test
    route:
      - destination:
          host: reviews
          subset: v2
```

```
- route: ⑤
  - destination:
    host: exchange
    subset: v1
```

- ① Virtual service name.
- ② List of destinations to which these routing rules apply.
- ③ List of routing rules to apply to HTTP/1.1, HTTP2, and gRPC traffic.
- ④ Rule with a match condition.
- ⑤ Default no condition rule. All traffic will be routed to the specified destination if no previous conditions are met.

The preceding example redirects all requests containing the header `end-user` and the value `test` from the `exchange` service to the subset `v2`. In any other case, the match condition is not fired so the traffic is redirected to the default destination.

## Combining Gateways and Virtual Services

To make gateways and virtual services work together, you must bind them using the `gateways` field for the virtual service. As a result, the traffic managed by the gateways listed in the `gateways` field is checked against the routing rules defined in the virtual service.

Example of virtual service bound to a gateway:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: exchange-vs
spec:
  hosts:
    - exchange
  gateways:
    - exchange-gw
  http:
    - match:
        - headers:
            end-user:
              exact: test
      route:
        - destination:
            host: reviews
            subset: v2
    - route:
        - destination:
            host: exchange
            subset: v1
```

In the preceding example the `exchange-gw` gateway is bound to the `exchange-vs` virtual service.

## Ingress flow with OpenShift Service Mesh

In a default OpenShift Service Mesh installation, an OpenShift route is assigned to the Istio ingress gateway (`istio-ingressgateway`), which is the resource in charge of managing the routing inside the mesh. All ingress traffic originating from outside the service mesh flows through this gateway into the service mesh.

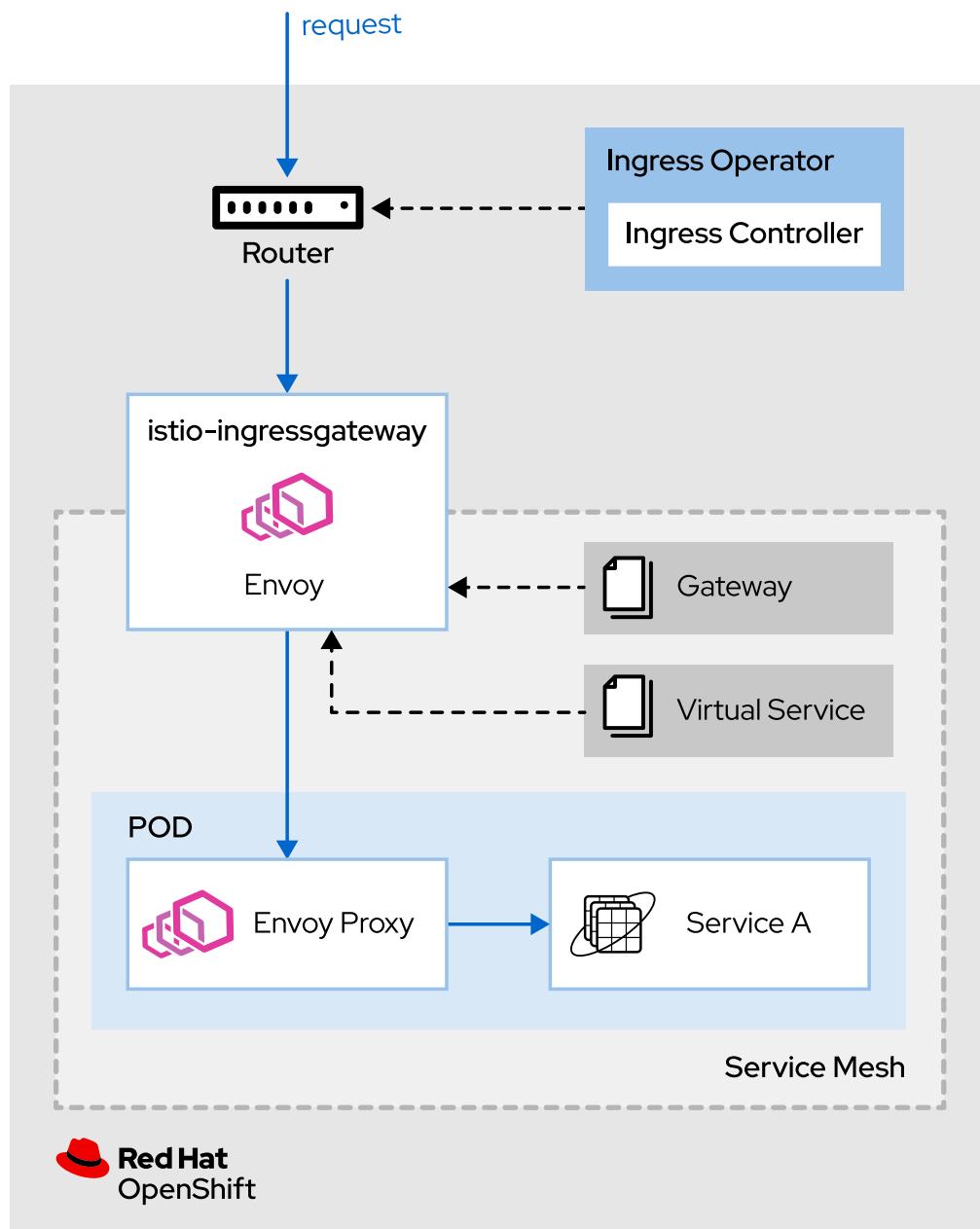


Figure 4.3: Ingress request flow in Red Hat OpenShift Service Mesh

The ingress request flow is as follows:

1. A external request enters the cluster.

2. A router instance checks the routing rules implemented by the ingress controller. If a match is found, the request is sent to the ingress gateway service pod (`istio-ingressgateway`).
3. The ingress gateway service pod evaluates the request against the `Gateway` configurations to check if the request matches with any configuration. If a match is found, the request is allowed to enter the mesh.
4. The ingress gateway service pod evaluates the `VirtualService` rules to find the application service pod in charge of processing the request.
5. If a `VirtualService` rule is matched, the ingress gateway service pod sends the request to the designated pod to process the request.



## References

### Traffic management with Istio

<https://archive.istio.io/v1.6/docs/concepts/traffic-management/>

### Automatic sidecar injection in Istio

<https://archive.istio.io/v1.6/docs/setup/additional-setup/sidecar-injection/#automatic-sidecar-injection>

For more information, refer to the *Configuring traffic management* section in the *OpenShift Container Platform Service Mesh* documentation at

[https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.7/html-single/service\\_mesh/index](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.7/html-single/service_mesh/index)

### Decyphering the OSI model of networking

<https://www.redhat.com/sysadmin/osi-model-bean-dip>



## References

For more information, refer to the *Red Hat OpenShift Service Mesh's sidecar injection* section in the *OpenShift Container Platform Service Mesh* documentation at

[https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.4/html-single/service\\_mesh/index](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.4/html-single/service_mesh/index)

## ► Guided Exercise

# Exposing a Service

In this exercise, you will deploy and expose an application in Red Hat OpenShift Service Mesh.

### Outcomes

You should be able to deploy applications to OpenShift Service Mesh and allow clients outside the service mesh to invoke them.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the student user on the workstation machine, use the `lab` command to validate the prerequisites for this exercise:

```
[student@workstation ~]$ lab traffic-deploy start
```

### Instructions

► 1. Log in to the OpenShift cluster.

- 1.1. Source the classroom configuration file that is accessible at /usr/local/etc/ocp4.config.

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

- 1.2. Log in to OpenShift as the developer user.

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

► 2. Create the hello project and then add it to the ServiceMeshMemberRoll resource.

- 2.1. The required YAML files and scripts for this guided exercise are located in /home/student/D0328/labs/traffic-deploy. Change to that directory using the `cd` command.

```
[student@workstation ~]$ cd /home/student/D0328/labs/traffic-deploy
```

## 2.2. Create the hello project.

```
[student@workstation traffic-deploy]$ oc new-project hello
Now using project "hello" on server
"https://api.cluster.domain.example.com:6443".
...output omitted...
```

- 2.3. Add the hello project to the list of members in the `ServiceMeshMemberRoll` resource. The `ServiceMeshMemberRoll` is available in the `istio-system` project. Use the `add-project-to-smmr.sh` script to add the hello project to the list of members in the `ServiceMeshMemberRoll` resource.

```
[student@workstation traffic-deploy]$ sh add-project-to-smmr.sh
servicemeshmemberroll.maistra.io/default patched
```

## ▶ 3. Deploy a simple Vert.X application.

This application exposes a single GET endpoint that returns `Hello World!` for every request.

The source code is in the Git repository at <https://github.com/RedHatTraining/D0328-apps/> in the `maven-simplest` directory.

- 3.1. Examine the `application.yaml` file, which describes the necessary resources to deploy the application.

The deployment resource contains the `sidecar.istio.io/inject: "true"` annotation to inject the Envoy proxy.

- 3.2. Run the `oc create -f application.yaml` command to deploy the application.

The `create` command creates a deployment and a service for the application (both named `hello`).

```
[student@workstation traffic-deploy]$ oc create -f application.yaml
deployment.apps/hello created
service/hello created
```

At this point the Vert.X application is only accessible from inside the mesh.

## ▶ 4. Create an ingress gateway to allow ingress traffic to the mesh.

- 4.1. Examine the `gateway.yaml` file, which describes the traffic allowed to enter the mesh.

```
apiVersion: networking.istio.io/v1beta1
kind: Gateway
metadata:
  name: hello-gateway①
spec:
  selector:
    istio: ingressgateway②
  servers:
    - port: ③
      number: 80
      name: http
```

```
protocol: HTTP
hosts: ④
  - "*"
```

- ① Name assigned to the gateway configuration.
- ② Indicates to which proxy gateway implementations the rules apply. In this case, it is the ingress gateway Envoy proxy.
- ③ Port and protocol where the gateway is listening for incoming connections.
- ④ Hosts exposed by this gateway; the "\*" means that this field is not used to filter the incoming traffic.

Use the `oc create` command to create the ingress gateway configuration.

```
[student@workstation traffic-deploy]$ oc create -f gateway.yaml
gateway.networking.istio.io/hello-gateway created
```

#### ▶ 5. Create a VirtualService to redirect the ingress traffic to the Vert.x application.

- 5.1. Examine the `virtual-service.yaml` file, which links the ingress traffic with the deployed Vert.X application.

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: hello-vs①
spec:
  hosts:
    - "*"
  gateways:
    - hello-gateway②
  http: ③
    - route: ④
      - destination:
          host: hello⑤
          port: ⑥
            name: http-8080
            number: 8080
```

- ① Name assigned to the virtual service configuration.
- ② List of gateways that should apply the routes. This virtual service is applied to the traffic configured by the `hello-gateway` gateway.
- ③ List of route rules for HTTP traffic.
- ④ Default route, as no match conditions are defined. This route redirects all traffic to the specified destination.
- ⑤ Destination rule which sends the traffic to the `hello` service.
- ⑥ Destination rule which sends the traffic to the port `http-8080` of the `hello` service.

Use the `oc create` command to create a virtual service.

```
[student@workstation traffic-deploy]$ oc create -f virtual-service.yaml
virtualservice.networking.istio.io/hello-vs created
```

► 6. Test the application.

- 6.1. Examine the `get-ingress-gateway-url.sh` script, which uses the `oc` command to gather the Istio ingress gateway URL.

Export the ingress gateway URL to an environment variable called `GATEWAY_URL`.

```
[student@workstation traffic-deploy]$ GATEWAY_URL=$(sh get-ingress-gateway-url.sh)
```

- 6.2. Execute the `curl` command in combination with the `GATEWAY_URL` variable to confirm the access to the application from the terminal.

```
[student@workstation traffic-deploy]$ curl ${GATEWAY_URL}
Hello World!
```

► 7. Visualize the ingress traffic with Kiali

- 7.1. Examine the `get-kiali-url.sh` script, which uses the `oc` command to gather the Kiali URL.

Export the Kiali URL to an environment variable called `KIALI_URL`.

```
[student@workstation traffic-deploy]$ KIALI_URL=$(sh get-kiali-url.sh)
```

- 7.2. Open the `KIALI_URL` URL in a browser to access Kiali.

```
[student@workstation traffic-deploy]$ firefox ${KIALI_URL} &
```

- 7.3. Log in as the `developer` user.

- 7.4. Click **Graph** in the sidebar to visualize the traffic.

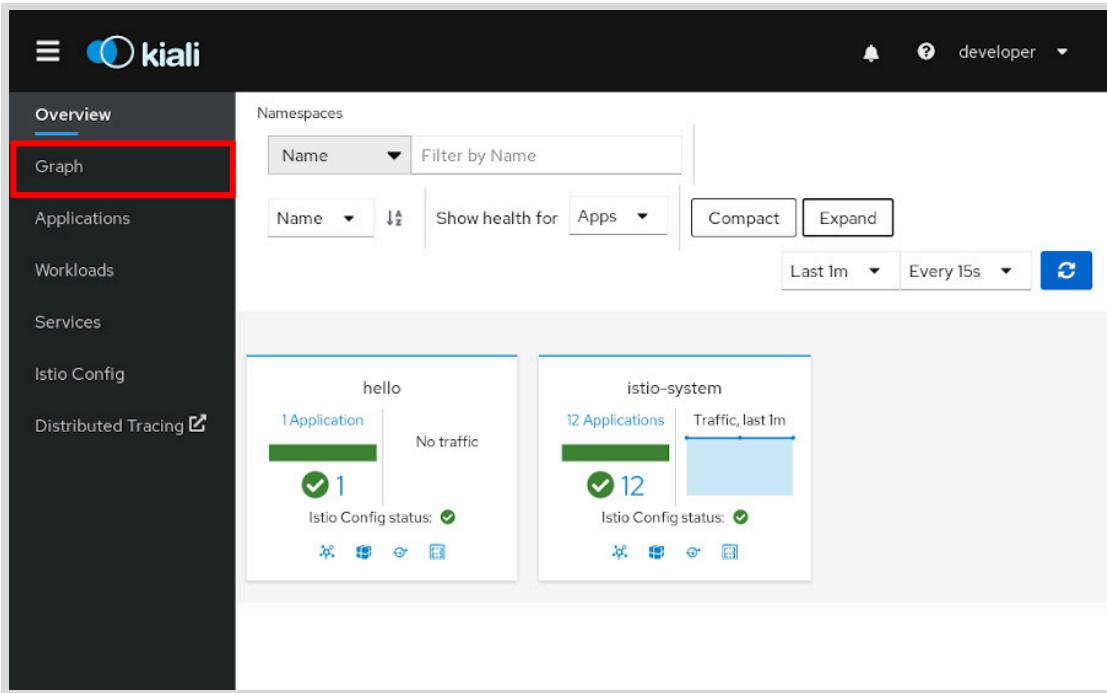


Figure 4.4: Kiali dashboard

7.5. From the Graph page, select the hello namespace.

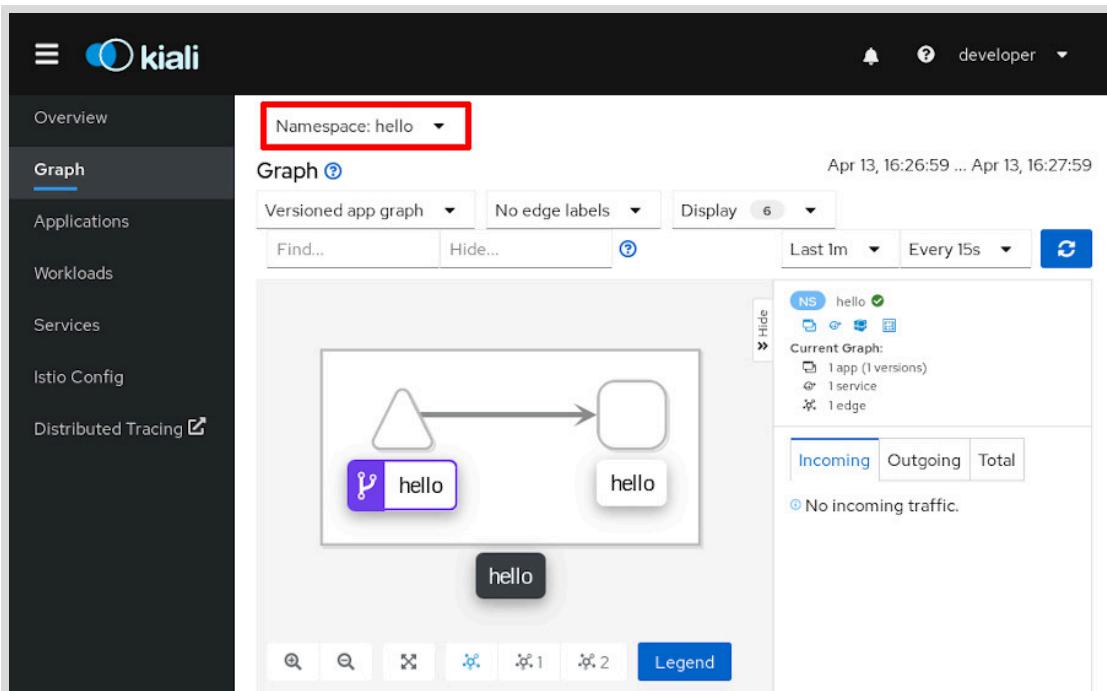


Figure 4.5: Graph representation of the hello application

7.6. Click the Display → Traffic Animation option to add motion to the graphics.

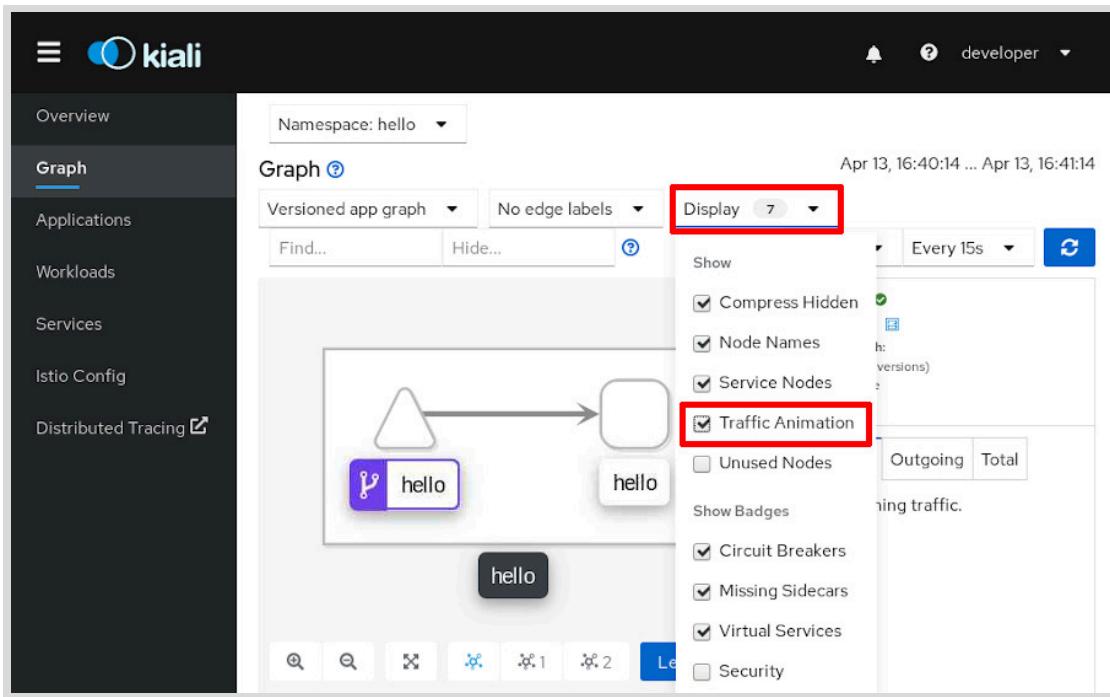


Figure 4.6: Adding animation to the Kiali graphics

- 7.7. Run the `curl ${GATEWAY_URL}` command multiple times in the background.

```
[student@workstation traffic-deploy]$ while true; \
do curl -o /dev/null -s ${GATEWAY_URL}; \
sleep 2; done
```

- 7.8. Observe the Kiali console to see how the traffic flows into the application. You might have to wait for a few seconds before you can see the changes on the Graph page in Kiali

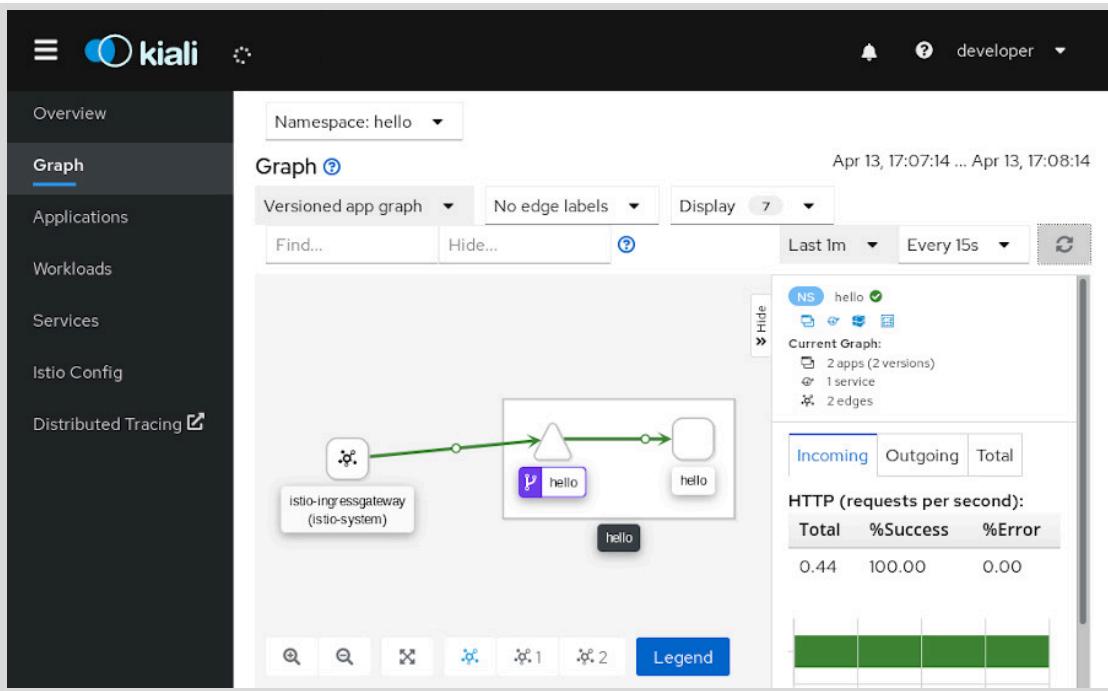


Figure 4.7: Traffic flow

7.9. Press **Ctrl+C** in the terminal to stop the `curl` command.

```
sleep 2; done
^C
[student@workstation traffic-deploy]$
```

► 8. Return to the home directory.

```
[student@workstation traffic-deploy]$ cd
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab traffic-deploy finish
```

This concludes the guided exercise.

# Routing Traffic Based on Request Headers

---

## Objectives

After completing this section, you should be able to route traffic to services in a mesh, based on request headers.

## Describing Destination Rules

*Destination rules* are custom resources that define policies that apply to the traffic of a service. Using those traffic policies, you can configure the load balancing behavior to distribute traffic between the instances of a service.

Virtual services route traffic to a specific destination, and destination rules operate in the traffic routed to that destination.

The policies defined in destination rules are applied after the routing rules in the virtual services are evaluated. With destination rules you can define load balancing, connection limits, and outlier detection policies.

## Load Balancing Traffic

With destination rules, you can specify the strategy used to distribute traffic between the instances of a service.

### Round-robin

Requests are sent to each service instance in turn.

### Random

Requests are sent to the service instances randomly.

### Weighted

Requests are sent to the service instances according to a specific weight (percentage).

### Least request

Requests are sent to the least busy service instances.



### Note

When no balancing option is specified, OpenShift Service Mesh uses the round-robin strategy.

Example of a destination rule that uses random load balancing strategy:

```
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: my-destination-rule ①
spec:
  host: my-svc ②
```

```
trafficPolicy: ③  

  loadBalancer:  

    simple: RANDOM ④
```

- ①** Name of the destination rule.
- ②** Service affected by the defined policies.
- ③** Traffic policy defined for the my-svc service.
- ④** Random load balancing strategy for the traffic sent to the my-svc service.

## Splitting Services into Subsets

A service can have variants of the application running concurrently with destination rules. You can group those variants into subsets using Kubernetes tags.

When you have subsets, destination rules allow you to define a global traffic policy for the service and override the policy on the subsets.

Example of destination rule with subsets and policy overrides:

```
apiVersion: networking.istio.io/v1beta1  

kind: DestinationRule  

metadata:  

  name: my-destination-rule  

spec:  

  host: my-svc  

  trafficPolicy: ①  

    loadBalancer:  

      simple: RANDOM  

  subsets: ②  

    - name: v1 ③  

      labels: ④  

      version: v1  

    - name: v2  

      labels:  

      version: v2  

  trafficPolicy: ⑤  

    loadBalancer:  

      simple: ROUND_ROBIN
```

- ①** Traffic policy defined at a service level.
- ②** List of subsets defined for the service.
- ③** Name of the subset.
- ④** List of label tags used to select the service instances belonging to the subset.
- ⑤** Traffic policy set at the subset level, overriding the policy set at the service level.

## Routing Traffic

OpenShift Service Mesh traffic management relies on virtual services and destination rules. After combining these custom resources, you can perform A/B testing or route traffic to a specific version of a service.

Route traffic based on request headers with the following steps:

- Deploy different services or different versions of the same service.
- Create destination rules to split the service into subsets.
- Create a virtual service to check the request headers and route the request to a destination service or to a subset.

## Creating Routing Rules

A virtual service is a compilation of conditions and actions that you can use to route HTTP, TCP, and unterminated TLS traffic to a desired destination.

Virtual services in combination with destination rules allow you to route traffic based on request headers. The following conditions and actions are involved:

### **HTTPRoute**

Conditions and actions defined for HTTP/1.1, HTTP2, and gRPC traffic.

### **HTTPMatchRequest**

List of match conditions to meet in order to execute the action defined by the rule.

### **HTTPRouteDestination**

Action that routes the traffic to a desired destination.

### **StringMatch**

Rule to compare a string against a value. The available options to do the comparison are: `exact`, `prefix`, and `regex`.

### **Destination**

Destination for traffic that matches specified conditions.

Example of a virtual service with routing based on request headers:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: my-virtual-service
spec:
  hosts:
    - "*"
  http: ①
    - match: ②
      - headers: ③
        end-user: ④
          exact: redhatter ⑤
      route: ⑥
        - destination: ⑦
          host: my-svc
          subset: v2
```

```

- route: ⑧
  - destination:
    host: my-svc
    subset: v1
  
```

- ① List of `HTTPRoute` conditions and actions.
- ② List of `HTTPMatchRequest` conditions and actions.
- ③ Header rule.
- ④ Name of the HTTP header to check.
- ⑤ `StringMatch` rule for the HTTP header. The match condition is activated when the request has an HTTP header called `end-user` with the value `redhatter`.
- ⑥ `HTTPRouteDestination`. When the match condition is activated, the request is redirected to this route.
- ⑦ `Destination`. When the headers condition is satisfied, the traffic is redirected to the `v2` subset of the `my-svc` service.
- ⑧ Default route. Without a previous matching, the traffic is routed to this destination.

The previous example routes all the traffic that has the HTTP header `end-user`, with a value of `redhatter`, to the subset `v2` of the `my-svc` service. When the HTTP header does not match the defined values, the traffic goes to the subset `v1` of the `my-svc` service.

Redirecting traffic to an endpoint based on the presence of a specific HTTP header is often used for A/B testing and for HTTP authorization.



## References

### Destination Rule reference

<https://istio.io/v1.6/docs/reference/config/networking/destination-rule/>  
in Istio documentation.

### Virtual Service reference

<https://istio.io/v1.6/docs/reference/config/networking/virtual-service/>  
in Istio documentation.

## ► Guided Exercise

# Routing Traffic Based on Request Headers

In this exercise, you will route traffic to services in Red Hat OpenShift Service Mesh based on request headers.

### Outcomes

You should be able to create subsets of a service, and route traffic to services in a mesh, based on request headers.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the `student` user on the `workstation` machine, use the `lab` command to validate the prerequisites for this exercise:

```
[student@workstation ~]$ lab traffic-route start
```

### Instructions

► 1. Log in to the OpenShift cluster.

- 1.1. Source the classroom configuration file that is accessible at `/usr/local/etc/ocp4.config`.

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

- 1.2. Log in to OpenShift as the `developer` user.

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

► 2. Create the `headers` project, and then add it to the `ServiceMeshMemberRoll` resource.

- 2.1. The required YAML files and scripts for this guided exercise are located in the `/home/student/D0328/labs/traffic-route` directory. Change to this directory using the `cd` command.

```
[student@workstation ~]$ cd /home/student/D0328/labs/traffic-route
```

- 2.2. Create the `headers` project.

```
[student@workstation traffic-route]$ oc new-project headers
Now using project "headers" on server
"https://api.cluster.domain.example.com:6443".
...output omitted...
```

- 2.3. Add the `headers` project to the list of members in the `ServiceMeshMemberRoll` resource. The `ServiceMeshMemberRoll` is available in the `istio-system` project.

Use the `add-project-to-smmr.sh` script to add the `headers` project to the list of members in the `ServiceMeshMemberRoll` resource.

```
[student@workstation traffic-route]$ sh add-project-to-smmr.sh
servicemeshmemberroll.maistra.io/default patched
```

- 3. Deploy a simple Vert.X application with two versions of the same service, and with `/headers` as the URI prefix. This application exposes a single GET endpoint that returns:

- Hello World! on version v1.
- Hello Red Hat! on version v2.

The source code is in the Git repository at <https://github.com/RedHatTraining/D0328-apps/> in the `maven-simplest` and `maven-simplest-v2` directories.

- 3.1. Examine the `application.yaml` file, which describes the necessary resources to deploy the application. This file defines two different deploys of an application, a service, a virtual service, and a gateway.

Run the `oc apply -f application.yaml` command to deploy the application.

```
[student@workstation traffic-route]$ oc apply -f application.yaml
deployment.apps/headers-v1 created
deployment.apps/headers-v2 created
service/headers created
gateway.networking.istio.io/headers-gateway created
virtualservice.networking.istio.io/headers-vs created
```

Now the Vert.X application is deployed in the service mesh and is accessible from outside the mesh.

- 3.2. Examine the `get-ingress-gateway-url.sh` script, which uses the `oc` command to gather the Istio ingress gateway URL.

Export the ingress gateway URL to an environment variable called `GATEWAY_URL`.

```
[student@workstation traffic-route]$ GATEWAY_URL=$(sh get-ingress-gateway-url.sh)
```

- 3.3. Execute the `curl` command several times, in combination with the `GATEWAY_URL` variable, to confirm access to the application from the terminal.

```
[student@workstation traffic-route]$ while true; \
  do curl -s ${GATEWAY_URL}; \
  sleep 1; done
Hello World!
Hello Red Hat!
Hello Red Hat!
Hello World!
...output omitted...
```

When you have variants of a service without destination rules defined, Kubernetes balances the traffic between service instances randomly.

- 3.4. Press **Ctrl+C** in the terminal to stop the `curl` command.

```
...output omitted...
Hello World!
^C
[student@workstation traffic-route]$
```

- ▶ 4. Route all traffic to the v1 subset of the application.

- 4.1. Examine the `destination-rule.yaml` file, which defines the subsets of the Vert.X application.

```
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: headers
spec:
  host: headers①
  subsets:
    - name: v1②
      labels:
        version: v1③
    - name: v2
      labels:
        version: v2
```

- ① Service affected by the defined policies.
- ② Name assigned to the subset.
- ③ Labels used to make the subset grouping.

The `destination-rule.yaml` file defines two subsets for the `headers` service:

- A subset called `v1` grouping all the application instances that have the `version: v1` flag.
- A subset called `v2` grouping all the application instances that have the `version: v2` flag.

Use the `oc create` command to create a destination rule.

```
[student@workstation traffic-route]$ oc create -f destination-rule.yaml
destinationrule.networking.istio.io/headers created
```

- 4.2. Examine the `virtual-service-subset-v1.yaml` file, which uses destination rules subsets to route traffic.

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: headers-vs
spec:
  hosts:
    - "*"
  gateways:
    - headers-gateway
  http:
    - match:
        - uri: ①
          prefix: /headers
      route: ②
        - destination:
            host: headers ③
            subset: v1 ④
```

- ① Rule to accept only traffic with the `/headers` prefix in the URI.
- ② Route assigned to all ingress traffic with the `/headers` prefix in the URI.
- ③ Destination service.
- ④ Destination service subset.

The virtual service defined in `virtual-service-subset-v1.yaml` redirects all the ingress traffic for `/headers` to the subset `v1` of the `headers` service.

Use the `oc apply` command to update the `headers-vs` virtual service with the new configuration.

```
[student@workstation traffic-route]$ oc apply -f virtual-service-subset-v1.yaml
virtualservice.networking.istio.io/headers-vs configured
```

- 4.3. Execute the `curl` command several times, in combination with the `GATEWAY_URL` variable, to confirm the routing of all traffic to the `v1` subset.

```
[student@workstation traffic-route]$ while true; \
do curl -s ${GATEWAY_URL}; \
sleep 1; done
Hello World!
Hello World!
Hello World!
Hello World!
...output omitted...
```

- 4.4. Press **Ctrl+C** in the terminal to stop the `curl` command.

```
...output omitted...
Hello World!
^C
[student@workstation traffic-route]$
```

► 5. Route traffic based on headers.

- 5.1. Examine the `virtual-service-with-header-subsets.yaml` file, which uses destination rules subsets in combination with header rules to route traffic.

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: headers-vs
spec:
  hosts:
    - "*"
  gateways:
    - headers-gateway
  http:
    - match: ①
      - uri:
          prefix: /headers
        headers:
          end-user:
            exact: redhatter
    route:
      - destination: ②
        host: headers
        subset: v2
    - match:
      - uri:
          prefix: /headers
    route: ③
      - destination:
          host: headers
          subset: v1
```

- ① Match condition for HTTP traffic. This rule is activated when the request URI has the `/headers` prefix, and an HTTP header called `end-user` with `redhatter` as value.
- ② Route destination assigned to the match condition. When the match condition is activated, the request is redirected to the `v2` subset of the `headers` service.
- ③ When no previous match conditions are activated for traffic to `/headers`, the request is redirected to the `v1` subset of the `headers` service.

Use the `oc apply` command to update the `headers-vs` virtual service with the new configuration.

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```
[student@workstation traffic-route]$ oc apply \
-f virtual-service-with-header-subsets.yaml
virtualservice.networking.istio.io/headers-vs configured
```

- 5.2. Execute the `curl` command in combination with the `GATEWAY_URL` variable.

```
[student@workstation traffic-route]$ curl ${GATEWAY_URL}
Hello World!
```

Without specifying any extra HTTP headers, the request is redirected to the v1 subset, returning Hello World!

- 5.3. Execute the `curl` command in combination with the `GATEWAY_URL` variable and send the end-user HTTP header.

```
[student@workstation traffic-route]$ curl -H "end-user: redhatter" ${GATEWAY_URL}
Hello Red Hat!
```

When the `end-user: redhatter` HTTP header is added to the request, the service mesh redirects the request to the v2 subset.

► **6.** Visualize traffic routing with Kiali.

- 6.1. Examine the `get-kiali-url.sh` script, which uses the `oc` command to gather the Kiali URL.

Export the Kiali URL to an environment variable called `KIALI_URL`.

```
[student@workstation traffic-route]$ KIALI_URL=$(sh get-kiali-url.sh)
```

- 6.2. Execute the `firefox` command in combination with the `KIALI_URL` variable to access Kiali.

```
[student@workstation traffic-deploy]$ firefox ${KIALI_URL}&
```

- 6.3. Log in as the developer user.

- 6.4. Click **Graph** to visualize the traffic.

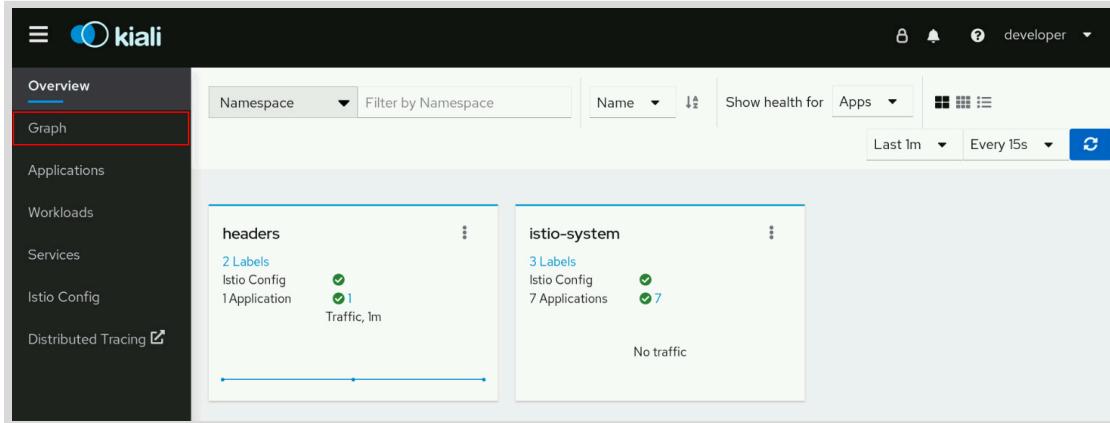


Figure 4.8: Kiali dashboard

- 6.5. On the **Graph** page, select the headers namespace.

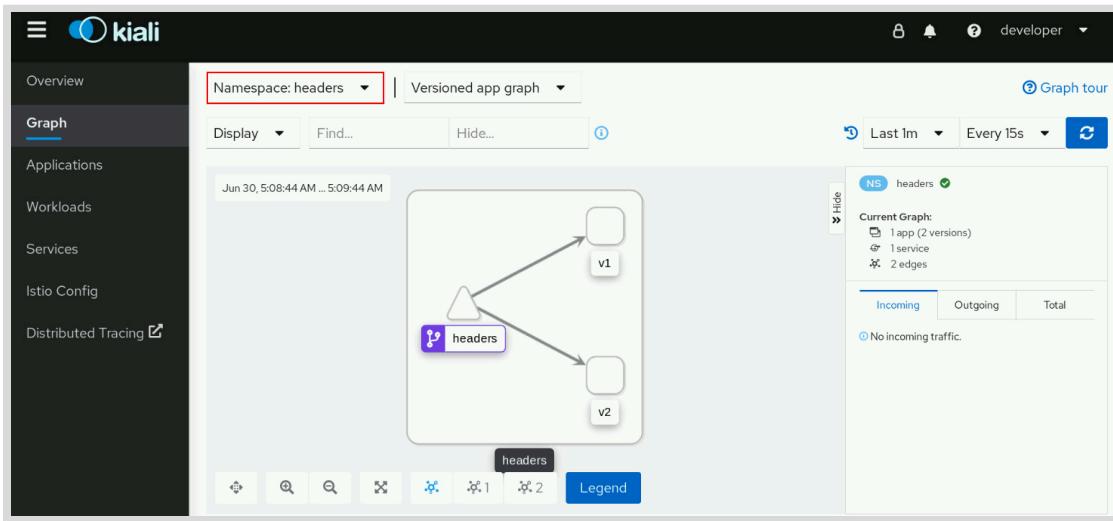


Figure 4.9: Graph representation of the headers application

- 6.6. Click the **Display** → **Traffic Animation** option to add motion to the graphics.

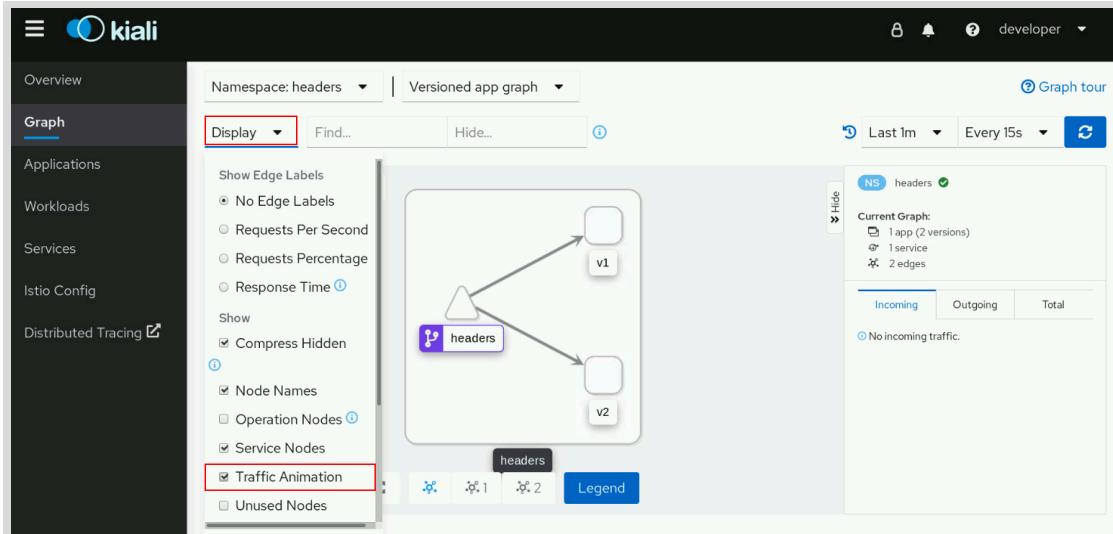


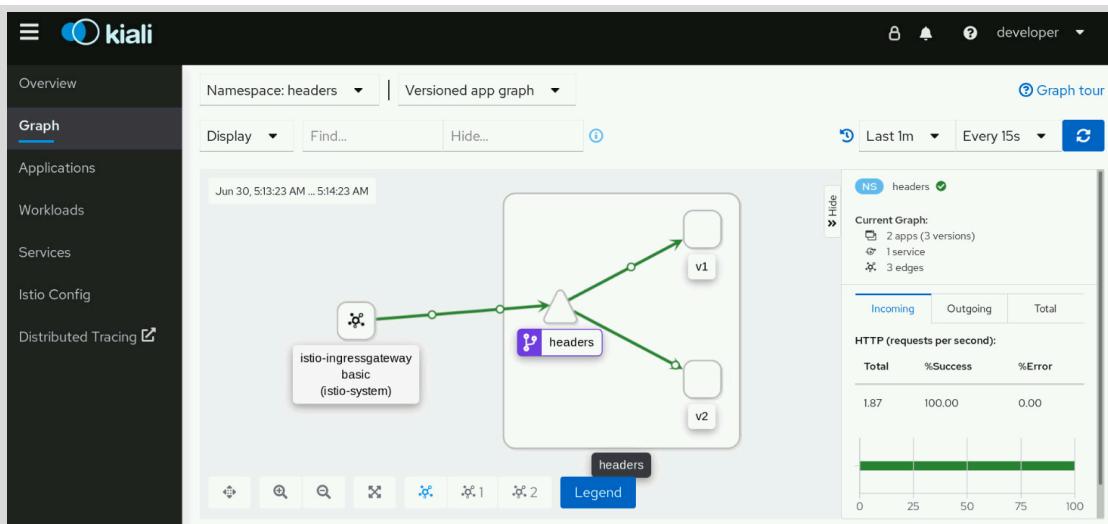
Figure 4.10: Adding animation to the Kiali graphics

- 6.7. Examine the `traffic-simulator.sh` script. This script simulates traffic to the deployed application, making curl calls to the ingress URL.

Run the `traffic-simulator.sh` script to generate some traffic.

```
[student@workstation traffic-deploy]$ sh traffic-simulator.sh
```

- 6.8. Observe the Kiali console to see how the traffic flows into the application to the two service subsets. You may have to wait for a few seconds until you can see the changes in the Graph page in Kiali.



**Figure 4.11: Routed traffic flow**

6.9. Press **Ctrl+C** in the terminal to stop the `traffic-simulator.sh` script.

```
[student@workstation traffic-route]$ sh traffic-simulator.sh  
^C
```

▶ 7. Return to the home directory.

```
[student@workstation traffic-route]$ cd
```

## Finish

On the **workstation** machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab traffic-route finish
```

This concludes the guided exercise.

# Accessing External Services

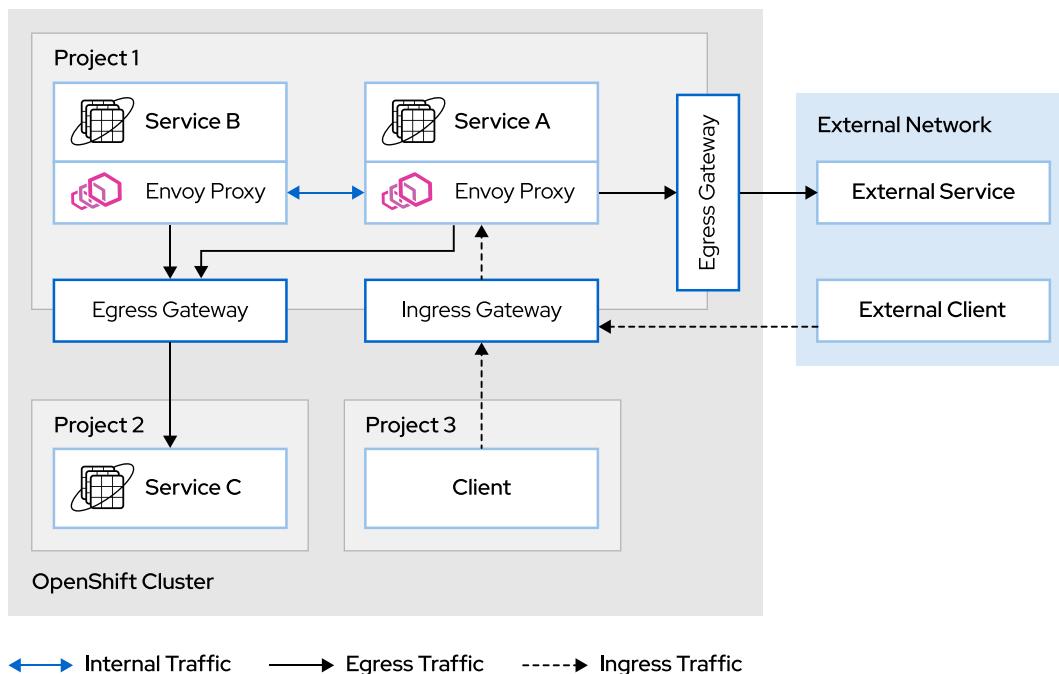
## Objectives

After completing this section, you should be able to control egress traffic to access external services.

## Managing and Routing Egress Traffic in OpenShift Service Mesh

Preceding sections introduced the capabilities of RHOPC Service Mesh to route between services inside the mesh.

It is common, however, for applications deployed in an OpenShift project to require access to services in different projects, or even outside the OpenShift cluster. This section describes how OpenShift Service Mesh enables the management and routing of service requests outside the mesh. Traffic originating from services inside the mesh and targeting external services is called *egress traffic*.



**Figure 4.12: Ingress and egress traffic in Red Hat OpenShift Service Mesh**

There are two elements related to egress traffic in OpenShift Service Mesh. The Istio control plane includes egress gateways, configuring these gateways to allow all egress traffic, or to restrict egress traffic to registered services. `ServiceEntry` resources register external services that are requested by internal services.

## Configuring Egress Traffic Configuration in Istio

By default, OpenShift Service Mesh allows all egress traffic. If a service invokes another service not managed by OpenShift Service Mesh, the Envoy proxy redirects the requests to the default Istio gateway. By default, this egress gateway forwards the requests to the external network, allowing all external requests to be serviced.

This setup allows all services in the mesh to reach any external service without restrictions. In some cases, it is beneficial to restrict the external services allowed to a specific list of approved services. The `spec.proxy.networking.trafficControl.outbound.policy` configuration value in the `ServiceMeshControlPlane` resource controls this behavior.

The default value for this entry is `ALLOW_ANY`. This value instructs Istio to allow all egress traffic regardless of the destination. If this configuration holds the value `REGISTRY_ONLY`, the gateway only forwards requests to services explicitly registered.

## Registering External Services

The `REGISTRY_ONLY` configuration value restricts traffic to registered external services only. To register external services, create a `ServiceEntry` resource associated to the external service, as follows:

```
[user@host ~]$ oc create -f - <<'EOF'
apiVersion: networking.istio.io/v1beta1
kind: ServiceEntry
metadata:
  name: my-external-service ①
spec:
  hosts:
  - example.external.com ②
  ports:
  - number: 80
    name: http
    protocol: HTTP
  resolution: DNS ③
  location: MESH_EXTERNAL④
EOF
```

- ① Give each service a meaningful name for easy identification.
- ② The hostname where the external service is exposed.
- ③ The actual IP of the service must be resolved via DNS by the proxy.
- ④ `MESH_EXTERNAL` indicates that the service is external to the mesh.

This `ServiceEntry` configures Istio to allow egress traffic to `example.external.com:80` from any service in the mesh.

## Enabling Direct Access to External Services

Sometimes, it is necessary to access external services bypassing the Envoy proxy, such as for extreme performance requirements or strict immutability of the requests. You can configure Istio to create a denylist or allowlist of IP ranges for the proxy to intercept. The Envoy proxy intercepts all IPs belonging to any range in the

`spec.proxy.networking.trafficControl.outbound.includedIPRanges` configuration entry. Istio traffic management policies handle all requests to those IPs. The Envoy proxy *does not* intercept any request targeting an IP belonging to a range in the `spec.proxy.networking.trafficControl.outbound.excludedIPRanges` configuration entry. Those requests bypass Istio policies and monitoring.

To update the configuration, edit the `ServiceMeshControlPlane` resource or use an `oc patch` command similar to:

```
[user@host ~]$ oc patch smcp basic --type merge -n istio-system \
-p '{"spec":{"proxy":{"networking":{"trafficControl":{"outbound": {"includedIPRanges":["10.0.0.1/24"]}}}}}'
```

Note that this configuration is global for the whole Istio installation, and affects all traffic in all meshes managed by Istio. To apply this same behavior for specific pods, add the `traffic.sidecar.istio.io/excludeOutboundPorts` or `traffic.sidecar.istio.io/includeOutboundIPRanges` annotations in the Pod resource.

```
kind: Pod
apiVersion: v1
metadata:
  name: application_pod
  annotations:
    sidecar.istio.io/inject: 'false'
    traffic.sidecar.istio.io/includeOutboundIPRanges: '10.0.0.1/24'
    ...output omitted...
  namespace: application_project
  ...output omitted...
```



## References

### Accessing External Services

<https://istio.io/v1.6/docs/tasks/traffic-management/egress/egress-control/>  
in Istio documentation.

### Annotations Reference

<https://istio.io/v1.6/docs/reference/config/annotations/>  
in Istio documentation

## ► Guided Exercise

# Accessing External Services

In this exercise, you will connect an application with OpenShift with an external service, deployed in a namespace not managed by Istio. Those same steps are also valid for connecting with a service deployed outside the OpenShift cluster.

## Outcomes

You should be able to enable egress connections from the mesh, either globally for all services or for a single external service.

## Before You Begin

As the student user on the workstation machine, use the `lab` command to prepare your system for this exercise.

This command deploys the Financial application and the News service in two separate projects in the Red Hat OpenShift cluster. The command also includes the Financial application into the Red Hat OpenShift Service Mesh.

```
[student@workstation ~]$ lab traffic-external start
```

## Instructions

- 1. Review the installed applications and acknowledge the correct functioning.

- 1.1. Log in to the Red Hat OpenShift cluster using the developer account.

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
[student@workstation ~]$ oc login \
-u ${RHT_OCP4_DEV_USER} -p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

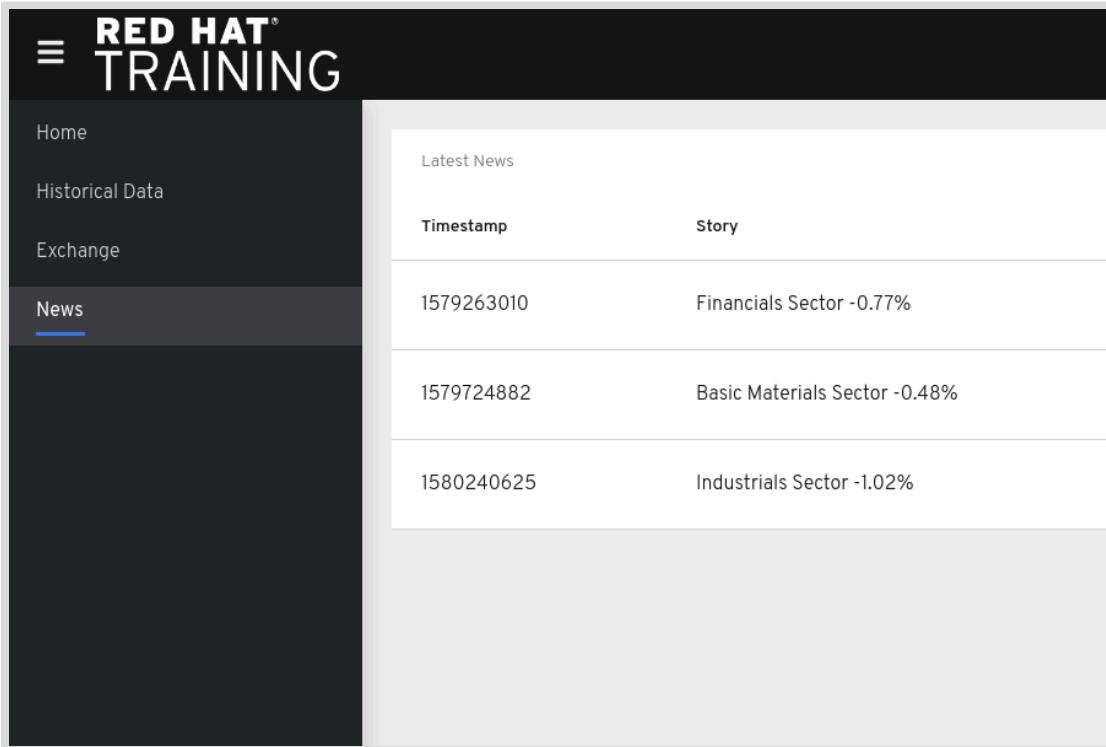
- 1.2. Retrieve the URL of the Istio ingress gateway by running the following command:

```
[student@workstation ~]$ ISTIO_GW=$(oc get route istio-ingressgateway \
-n istio-system -o jsonpath=".spec.host{.spec.path}")
[student@workstation ~]$ echo $ISTIO_GW
istio-ingressgateway-istio-system.apps.ocp4.example.com
```

- 1.3. Open a web browser to verify the application is functioning correctly. The Financial application is accessed through the ingress gateway URL as just retrieved, with the `/frontend` path appended. You can use your favorite browser to open that URL, or use the following command to open the URL in Firefox:

```
[student@workstation ~]$ firefox $ISTIO_GW/frontend &
```

- 1.4. Navigate through the application to generate traffic between services. Make sure you gather historical data, exchange data, and news. Note that the News service resides in a different namespace, `traffic-external-news`, and hence is considered egress traffic. Gathering news successfully proves that egress traffic is allowed.



The screenshot shows a web application interface with a dark header bar containing the text "RED HAT® TRAINING". Below the header is a sidebar with the following menu items: Home, Historical Data, Exchange, and News. The "News" item is highlighted with a blue underline. To the right of the sidebar is a main content area titled "Latest News". This area contains a table with three rows, each representing a news story. The columns are labeled "Timestamp" and "Story". The data is as follows:

Timestamp	Story
1579263010	Financials Sector -0.77%
1579724882	Basic Materials Sector -0.48%
1580240625	Industrials Sector -1.02%

Figure 4.13: News section in the finance application

- 1.5. Observe the application graph Kiali generates for the Financial application. You can find the Kiali URL in the Red Hat OpenShift console, or use the following commands:

```
[student@workstation ~]$ KIALI_URL=$(oc get route kiali \
-n istio-system -o jsonpath="https://{{.spec.host}}{{.spec.path}}")
[student@workstation ~]$ firefox $KIALI_URL &
```

Log in by using the developer credentials. Click **Graph** and review the **Service** graph for the `traffic-external` namespace. The graph should be similar to the following one:

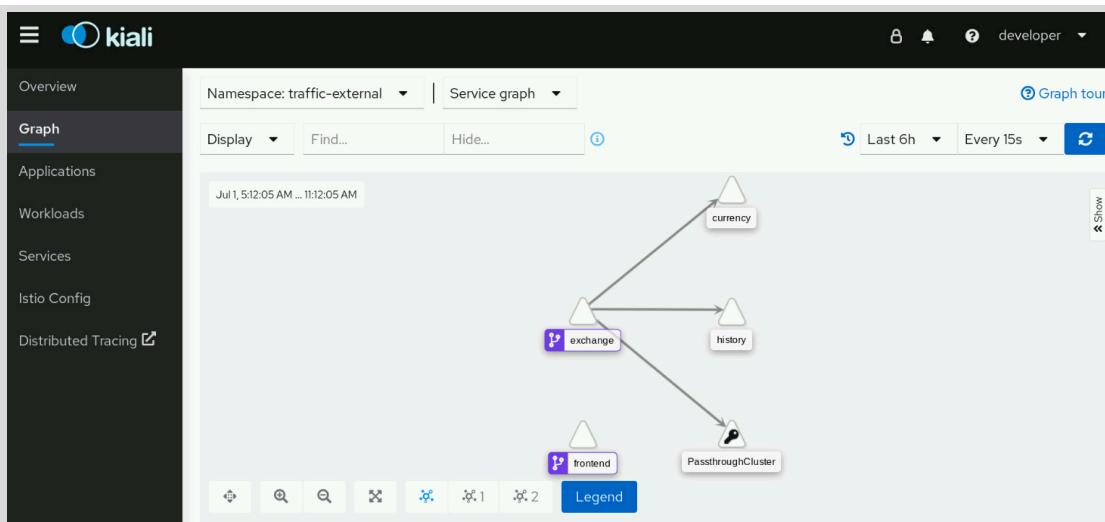


Figure 4.14: Service graph for the finance application

For details about how to log in and navigate through Kiali interface refer to the *Observing Service Interactions with Kiali* section in the *Chapter 3, Observing a Service Mesh* chapter.

Note that the News service does not appear in the graph. Instead, a generic `PassthroughCluster` restricted namespace shows. This generic entry proves that the service mesh is not managing external traffic to the News service.

- ▶ 2. Restrict egress traffic globally to registered services only.
  - 2.1. Update Istio configuration and define outbound traffic policy to allow egress traffic only to registered services. To do so, edit the `basic` control plane, and set the `proxy.networking.trafficControl.outbound.policy` entry to `REGISTRY_ONLY`.

```
[student@workstation ~]$ oc patch smcp basic \
--type merge -n istio-system \
-p '{"spec":{"proxy":{"networking":{"trafficControl":{"outbound":{"policy":"REGISTRY_ONLY"}}}}}' \
servicemeshcontrolplane.maistra.io/basic patched
```

The preceding command adds the following configuration to your control plane deployment:

```
spec:
  proxy:
    networking:
      trafficControl:
        outbound:
          policy: REGISTRY_ONLY
```

- 2.2. Validate the external News service is not available anymore. Get back to the Financial application front end in your browser and navigate to the News section in the left menu. The application shows that no news can be loaded.

Alternatively, you can check how Kiali detects the failing connection and updates the service graph:

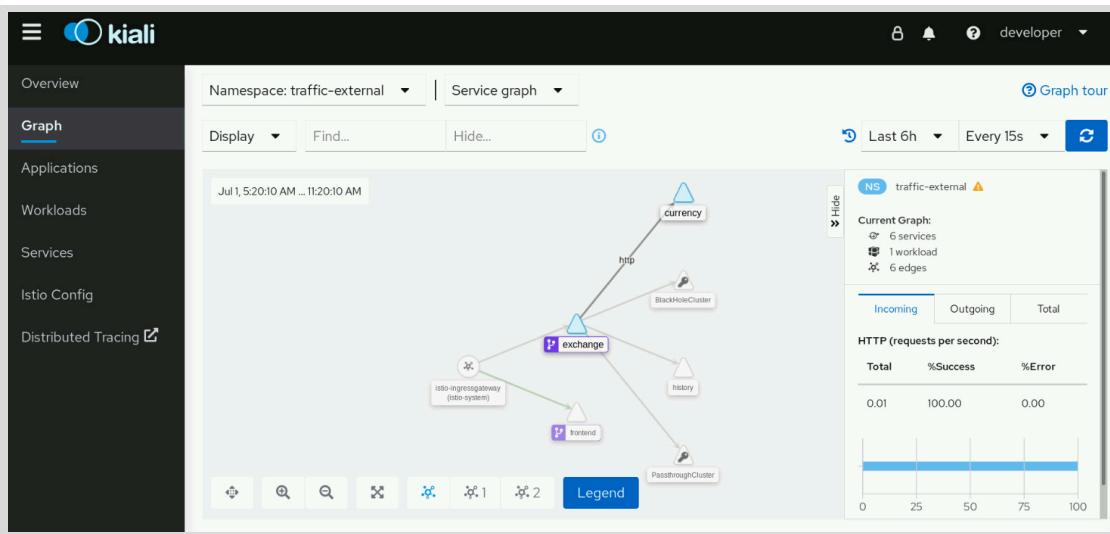


Figure 4.15: Service graph displaying blocked egress traffic

**Note**

Browser cache may cause the application to still display the news on the page. Force reload the web page to instruct the browser to obtain the new page, or use browser instructions to delete cache, and reload the page.

The Service graph in Kiali may also require some time to update. Some arrows may look different, depending on the time span selected and traffic analyzed.

- ▶ 3. Create a **ServiceEntry** resource for the News service. The presence of that resource includes the News service in the registry of allowed targets for egress traffic.
  - 3.1. Retrieve the host where the external News service is available, either through the OpenShift console or through CLI commands:
    - Log in to the OpenShift console and select to the **traffic-external-news** project. Within this project, navigate to the **Networking → Routes** menu entry. The only route available shows the host used to publish the service.
    - Use the `oc get route` command to retrieve the host defined in the `news` route in the **traffic-external-news** project:

```
[student@workstation ~]$ NEWS_HOST=$(oc get route news -n traffic-external-news \
-o jsonpath="{.spec.host}")
```

- 3.2. Create a **ServiceEntry** resource in the **traffic-external** namespace. You can use the file `~/D0328/solutions/traffic-external/news_serviceentry.yml` as a template, and replace the host with the one obtained in the previous step.

```
[student@workstation ~]$ cd ~/DO328/solutions/traffic-external/
[student@workstation traffic-external]$ sed -e "s/_NEWS_HOST_/$NEWS_HOST/g" \
news_serviceentry.yml | oc create -n traffic-external -f -
serviceentry.networking.istio.io/news created
[student@workstation traffic.external]$ cd
```

- 3.3. Validate now the external News service is allowed. Get back to the Financial application front end in your browser and navigate to the News section in the left menu. The application shows that news are again displayed.

After reviewing the application, you can also review how Kiali is now displaying the News service as a managed service:

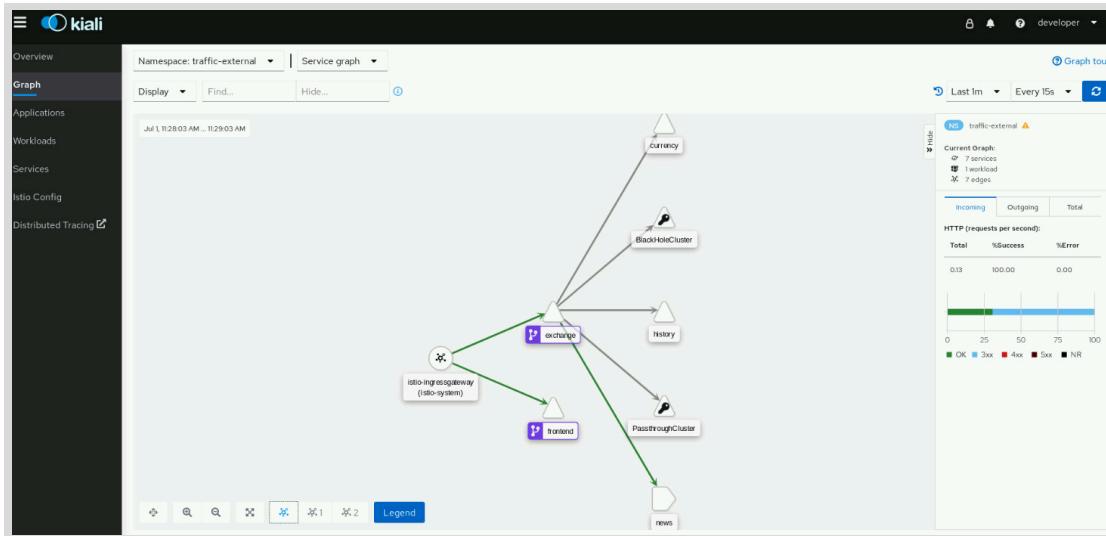


Figure 4.16: Service graph displaying allowed egress traffic

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab traffic-external finish
```

This concludes the guided exercise.

## ► Lab

# Controlling Service Traffic

### Performance Checklist

In this lab, you will deploy multiple versions of a service in the service mesh, route traffic based on request headers, and restrict the egress traffic.

### Outcomes

You should be able to deploy applications on Red Hat OpenShift Service Mesh, route traffic inside the mesh and restrict egress traffic.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the student user on the workstation machine, use the `lab` command to prepare your system for this lab.

This command deploys the Financial application, the News service, and the AB Proxy in separate projects in the Red Hat OpenShift cluster.

The command also includes the Financial application in the Red Hat OpenShift Service Mesh.

```
[student@workstation ~]$ lab traffic-mesh start
```

The following project information is needed for this exercise. This lab uses two projects:

- **traffic-mesh**: financial application composed of multiple services. This project is used to deploy a variation of the front end service and to set routes based on request headers.
- **traffic-mesh-news**: project deployed outside of the service mesh to provide a news feed for the financial application. This project is used to configure restrictions to the egress traffic in OpenShift Service Mesh.

Variations of the front end service that you will use in this lab:

- **v2**: initial deployment of the front end service that has a dark header.
- **beta**: new version of the front end service that has a red header.

To help with the testing, the **traffic-mesh-proxy** project is deployed and ready to use in the cluster. This project contains an application that works as a proxy for the main application, adding custom HTTP headers to the requests.

To configure the behavior of the proxy, the following helper scripts are available:

- proxy-set-beta-config.sh: configures the proxy to add the version:beta header to all requests.
- proxy-set-v2-config.sh: configures the proxy to add the version:v2 header to all requests.

## Instructions

- The companion scripts for this lab are located in ~/D0328/labs/traffic-mesh. Change to that directory using the cd command.

```
[student@workstation ~]$ cd ~/D0328/labs/traffic-mesh
```

- Log in to the OpenShift cluster as a unprivileged user and verify that the lab projects are successfully deployed.

- Source the classroom configuration file that is accessible at /usr/local/etc/ocp4.config.

```
[student@workstation traffic-mesh]$ source /usr/local/etc/ocp4.config
```

- Log in to OpenShift as the developer user.

```
[student@workstation traffic-mesh]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

- Change to the traffic-mesh project.

```
[student@workstation traffic-mesh]$ oc project traffic-mesh
Now using project "traffic-mesh" on server ...
```

- Verify the status of the traffic-mesh project pods.

```
[student@workstation traffic-mesh]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
currency-v1-67bfd775-59f8v  2/2     Running   0          66s
exchange-v2-5d5c669777-s9zgk  2/2     Running   0          66s
frontend-v2-5cf6499bcd-hfp44  2/2     Running   0          66s
history-v1-8656f7d44f-ddp7c   2/2     Running   0          66s
```

- Verify the status of the traffic-mesh-news project pods.

```
[student@workstation traffic-mesh]$ oc get pods -n traffic-mesh-news
NAME                  READY   STATUS    RESTARTS   AGE
news-cfcfd97f4f-9nfkr  1/1     Running   0          10m
```

- Verify the status of the traffic-mesh-proxy project pods.

```
[student@workstation traffic-mesh]$ oc get pods -n traffic-mesh-proxy
NAME                  READY   STATUS    RESTARTS   AGE
ab-proxy-7bc6db76dc-bfjgp   1/1     Running   0          10m
```

3. Configure an ingress gateway named **traffic-mesh-gateway** to allow ingress HTTP traffic on port 80 to enter the mesh.
4. Deploy a new beta version of the **frontend** service with the following characteristics:
  - **Name:** frontend-beta.
  - **Labels**
    - **Version:** beta
    - **App:** frontend
  - Use the `quay.io/redhattraining/ossm-frontend:beta` image and port 3000.
  - The container needs a environment variable called `REACT_APP_GW_ENDPOINT`. This variable gathers the value for the key `GW_ADDR` stored in the `frontend-cm` config map.

Use the template located at `~/D0328/labs/traffic-mesh/new-frontend-deployment.yaml`. Modify the placeholders with the right information.

5. Split the **frontend** service into subsets with the following characteristics:
  - **Name:** frontend-destination-rule.
  - Create a group with all the instances that have the **version:** v2 tag and assign to this group the name **v2**.
  - Create a group with all the instances that have the **version:** beta tag and assign to this group the name **beta**.
6. Create a virtual service named **frontend-vs**, which uses the ingress gateway and redirects the **frontend** traffic following this rules:
  - Traffic with a header matching **version: beta** is redirected to the **beta** subset.
  - Traffic with wrong or missing headers is redirected to the **v2** subset.



### Note

All traffic for the front end service uses the `/frontend` prefix.

7. Test the routing configuration using the **traffic-mesh-proxy** application.
8. Restrict egress traffic globally to registered services only.
9. Test the restricted egress policy using the **traffic-mesh-proxy** application.
10. Allow egress traffic for the **news** service. Assign the name **news-se** to the required custom resource.
11. Test the egress traffic using the **traffic-mesh-proxy** application.
12. Return to the home directory.

```
[student@workstation traffic-mesh]$ cd
```

## Evaluation

Grade your work by running the `lab traffic-mesh grade` command from your `workstation` machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab traffic-mesh grade
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab traffic-mesh finish
```

This concludes the lab.

## ► Solution

# Controlling Service Traffic

### Performance Checklist

In this lab, you will deploy multiple versions of a service in the service mesh, route traffic based on request headers, and restrict the egress traffic.

### Outcomes

You should be able to deploy applications on Red Hat OpenShift Service Mesh, route traffic inside the mesh and restrict egress traffic.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the student user on the workstation machine, use the `lab` command to prepare your system for this lab.

This command deploys the Financial application, the News service, and the AB Proxy in separate projects in the Red Hat OpenShift cluster.

The command also includes the Financial application in the Red Hat OpenShift Service Mesh.

```
[student@workstation ~]$ lab traffic-mesh start
```

The following project information is needed for this exercise. This lab uses two projects:

- **traffic-mesh**: financial application composed of multiple services. This project is used to deploy a variation of the front end service and to set routes based on request headers.
- **traffic-mesh-news**: project deployed outside of the service mesh to provide a news feed for the financial application. This project is used to configure restrictions to the egress traffic in OpenShift Service Mesh.

Variations of the front end service that you will use in this lab:

- **v2**: initial deployment of the front end service that has a dark header.
- **beta**: new version of the front end service that has a red header.

To help with the testing, the **traffic-mesh-proxy** project is deployed and ready to use in the cluster. This project contains an application that works as a proxy for the main application, adding custom HTTP headers to the requests.

To configure the behavior of the proxy, the following helper scripts are available:

- proxy-set-beta-config.sh: configures the proxy to add the version:beta header to all requests.
- proxy-set-v2-config.sh: configures the proxy to add the version:v2 header to all requests.

## Instructions

- The companion scripts for this lab are located in ~/D0328/labs/traffic-mesh. Change to that directory using the cd command.

```
[student@workstation ~]$ cd ~/D0328/labs/traffic-mesh
```

- Log in to the OpenShift cluster as a unprivileged user and verify that the lab projects are successfully deployed.

- Source the classroom configuration file that is accessible at /usr/local/etc/ocp4.config.

```
[student@workstation traffic-mesh]$ source /usr/local/etc/ocp4.config
```

- Log in to OpenShift as the developer user.

```
[student@workstation traffic-mesh]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

- Change to the traffic-mesh project.

```
[student@workstation traffic-mesh]$ oc project traffic-mesh
Now using project "traffic-mesh" on server ...
```

- Verify the status of the traffic-mesh project pods.

```
[student@workstation traffic-mesh]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
currency-v1-67bfd775-59f8v  2/2     Running   0          66s
exchange-v2-5d5c669777-s9zgk  2/2     Running   0          66s
frontend-v2-5cf6499bcd-hfp44  2/2     Running   0          66s
history-v1-8656f7d44f-ddp7c   2/2     Running   0          66s
```

- Verify the status of the traffic-mesh-news project pods.

```
[student@workstation traffic-mesh]$ oc get pods -n traffic-mesh-news
NAME                  READY   STATUS    RESTARTS   AGE
news-cfcfd97f4f-9nfkr  1/1     Running   0          10m
```

- Verify the status of the traffic-mesh-proxy project pods.

```
[student@workstation traffic-mesh]$ oc get pods -n traffic-mesh-proxy
NAME                  READY   STATUS    RESTARTS   AGE
ab-proxy-7bc6db76dc-bfjgp   1/1     Running   0          10m
```

3. Configure an ingress gateway named `traffic-mesh-gateway` to allow ingress HTTP traffic on port 80 to enter the mesh.
  - 3.1. Create a Gateway object YAML file, for example `traffic-mesh-gateway.yaml`, to store the object definition.  
The completed object definition is available in the `~/D0328/solutions/traffic-mesh/traffic-mesh-gateway.yaml` file. Use it to verify your file and fix mistakes.
  - 3.2. Create the gateway configuration with `oc create`.

```
[student@workstation traffic-mesh]$ oc create -f
~/D0328/solutions/traffic-mesh/traffic-mesh-gateway.yaml
gateway.networking.istio.io/traffic-mesh-gateway created
```

4. Deploy a new beta version of the `frontend` service with the following characteristics:
  - **Name:** `frontend-beta`.
  - **Labels**
    - **Version:** `beta`
    - **App:** `frontend`
  - Use the `quay.io/redhattraining/ossm-frontend:beta` image and port 3000.
  - The container needs a environment variable called `REACT_APP_GW_ENDPOINT`. This variable gathers the value for the key `GW_ADDR` stored in the `frontend-cm` config map.

Use the template located at `~/D0328/labs/traffic-mesh/new-frontend-deployment.yaml`. Modify the placeholders with the right information.

- 4.1. Create a Deployment object YAML file, for example `new-frontend-deployment.yaml`, to store the object definition.  
The completed object definition is available in the `~/D0328/solutions/traffic-mesh/new-frontend-deployment.yaml` file. You can use the solution file to verify and fix mistakes in your file.
- 4.2. Create the deployment with the `oc create` command.

```
[student@workstation traffic-mesh]$ oc create -f
~/D0328/solutions/traffic-mesh/new-frontend-deployment.yaml
deployment.apps/frontend-beta created
```

5. Split the `frontend` service into subsets with the following characteristics:
  - **Name:** `frontend-destination-rule`.
  - Create a group with all the instances that have the `version: v2` tag and assign to this group the name `v2`.

- Create a group with all the instances that have the `version: beta` tag and assign to this group the name `beta`.
- 5.1. Create a `DestinationRule` object YAML file, for example `frontend-destination-rule.yaml`, to store the object definition.
- The completed object definition is available in the `~/D0328/solutions/traffic-mesh/frontend-destination-rule.yaml` file. You can use the solution file to verify and fix mistakes in your file.
- 5.2. Create the destination rules with the `oc create` command.

```
[student@workstation traffic-mesh]$ oc create -f
~/D0328/solutions/traffic-mesh/frontend-destination-rule.yaml
destinationrule.networking.istio.io/frontend-destination-rule created
```

6. Create a virtual service named `frontend-vs`, which uses the ingress gateway and redirects the `frontend` traffic following this rules:

- Traffic with a header matching `version: beta` is redirected to the `beta` subset.
- Traffic with wrong or missing headers is redirected to the `v2` subset.



#### Note

All traffic for the front end service uses the `/frontend` prefix.

- 6.1. Create a `VirtualService` object YAML file, for example `frontend-virtual-service.yaml`, to store the object definition.
- The completed object definition is available in the `~/D0328/solutions/traffic-mesh/frontend-virtual-service.yaml` file. You can use the solution file to verify and fix mistakes in your file.

- 6.2. Create the virtual service with the `oc create` command.

```
[student@workstation traffic-mesh]$ oc create -f
~/D0328/solutions/traffic-mesh/frontend-virtual-service.yaml
virtualservice.networking.istio.io/frontend-vs created
```

7. Test the routing configuration using the `traffic-mesh-proxy` application.

- 7.1. Export the `traffic-mesh-proxy` URL to an environment variable called `AB_PROXY_URL`.

```
[student@workstation traffic-mesh]$ AB_PROXY_URL=$(oc get route ab-proxy \
-n traffic-mesh-proxy -o template --template '{{ "http://" }}{{ .spec.host }}')
```

- 7.2. Use the `proxy-set-v2-config.sh` helper script to configure the proxy to append the `version: v2` headers to all requests.

```
[student@workstation traffic-mesh]$ sh proxy-set-v2-config.sh
Updated proxy to send version:v2 headers
```

- 7.3. Use a web browser to verify the route configuration for the **version: v2** HTTP headers. The Financial application is accessible through the AB proxy URL. Use your favorite browser to open that URL, or use the following command to open the URL in Firefox:

```
[student@workstation traffic-mesh]$ firefox ${AB_PROXY_URL}/frontend
```

All requests through the AB proxy append the **version: v2** header, so the web UI shows a dark header.

- 7.4. Use the `proxy-set-beta-config.sh` helper script to configure the proxy to append the **version: beta** headers to all requests.

```
[student@workstation traffic-mesh]$ sh proxy-set-beta-config.sh
```

Updated proxy to send version:beta headers

- 7.5. Reload the web page in the browser to verify the route configuration for the **version: beta** HTTP headers.

All requests through the AB proxy append the **version: beta** header, so the web UI shows a red header.



#### Note

Browser cache may cause the application to still display the dark header. Force the web page to reload, instructing the browser to obtain the new page, or use browser instructions to delete the cache and reload the page.

8. Restrict egress traffic globally to registered services only.

- 8.1. Update the Istio configuration and define outbound traffic policy to allow egress traffic only to registered services.

```
[student@workstation traffic-mesh]$ oc patch smcp basic \
--type merge -n istio-system \
-p '{"spec":{"proxy":{"networking":{"trafficControl":{"outbound":{"policy":"REGISTRY_ONLY"}}}}}' \
servicemeshcontrolplane.maistra.io/basic patched
```

9. Test the restricted egress policy using the `traffic-mesh-proxy` application.

- 9.1. Reload the web page in your browser, and then navigate to the **News** section. The application reports that it cannot load any news.



#### Note

The propagation of the new policy can take several seconds; you might need to wait to see the changes.

10. Allow egress traffic for the `news` service. Assign the name `news-se` to the required custom resource.

- 10.1. Retrieve the host where the external news service is available.

```
[student@workstation traffic-mesh]$ NEWS_HOST=$(oc get route news \
-n traffic-mesh-news -o jsonpath="{.spec.host}")
```

- 10.2. Create a service entry for the news service. A template object definition is available in the ~/D0328/solutions/traffic-mesh/service-entry.yaml file. Replace the NEWS\_HOST placeholder with the host from the previous step.

```
[student@workstation traffic-mesh]$ sed -e "s/_NEWS_HOST_/$NEWS_HOST/g" \
~/D0328/solutions/traffic-mesh/service-entry.yaml | oc create -f -
serviceentry.networking.istio.io/news-se created
```

11. Test the egress traffic using the **traffic-mesh-proxy** application.

- 11.1. Reload the web page in your browser and navigate to the News section. The application shows a list of news.

12. Return to the home directory.

```
[student@workstation traffic-mesh]$ cd
```

## Evaluation

Grade your work by running the **lab traffic-mesh grade** command from your **workstation** machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab traffic-mesh grade
```

## Finish

On the **workstation** machine, use the **lab** command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab traffic-mesh finish
```

This concludes the lab.

# Summary

---

In this chapter, you learned:

- Red Hat OpenShift Service Mesh implements the sidecar pattern injecting an Envoy sidecar into application pods.
- A **Gateway** resource configures how Istio handles ingress and egress connections and exposes services deployed in the mesh.
- **DestinationRule** resources define how to route traffic to subsets of services based on different conditions, such as request headers.
- Gateways either allow all egress traffic or restrict egress traffic to services that are registered as **ServiceEntry** resources.



## Chapter 5

# Releasing Applications with OpenShift Service Mesh

### Goal

Release applications with canary and mirroring release strategies.

### Objectives

- Release application services with a safe canary rollout.
- Deploy a "mirror" service to test a new service with a realistic load.

### Sections

- Deploying an Application with Canary Releases (and Guided Exercise)
- Deploying an Application with a Mirror Launch (and Guided Exercise)

### Lab

Releasing Applications with OpenShift Service Mesh

# Deploying an Application with Canary Releases

---

## Objectives

After completing this section, you should be able to release application services with a safe canary rollout.

## Describing Canary Releases

Deploying software is a complex and risky process. After a release, developers carry out verification activities to check that the deployment is successful, such as watching logs, monitoring metrics and validating that the changes are applied. If something goes wrong, the team rolls back the deployment to the previous stable version.

A simple release approach is to deploy the new version replacing the old one. However, this deployment strategy immediately exposes all users to any defects introduced by the new version.

Canary releases address this problem using a progressive and safe deployment approach where both versions of the application, the old and the new, run in parallel until the new version is completely validated and ready for all users. The new version, also called the canary, initially receives only a small amount of all application traffic. Therefore, if something goes wrong with this new version of the application, a minimal number of users are affected. As you gain confidence with how the canary works, you progressively route more traffic to it.

The complete process is as follows:

- Initially, send a small amount of the traffic to the canary. The old version receives most of the traffic, whereas only a small portion goes to the new version. This ensures that the new version can be tested in production without compromising the stability of the service for the majority of users.
- Test the new version against the limited amount of traffic you configured in the previous step. When you are satisfied with the results, increase the amount of traffic sent to the canary. Repeat this step to slowly make the canary available to more users. Continue this process until the canary receives most of the traffic, while monitoring test results and performance.
- After demonstrating that the new version is sufficiently stable, route the remaining traffic to the canary. At this point, the old version stops receiving traffic. You can remove the old version of the application from the cluster or leave it there temporarily in case you need the option of a quick rollback.

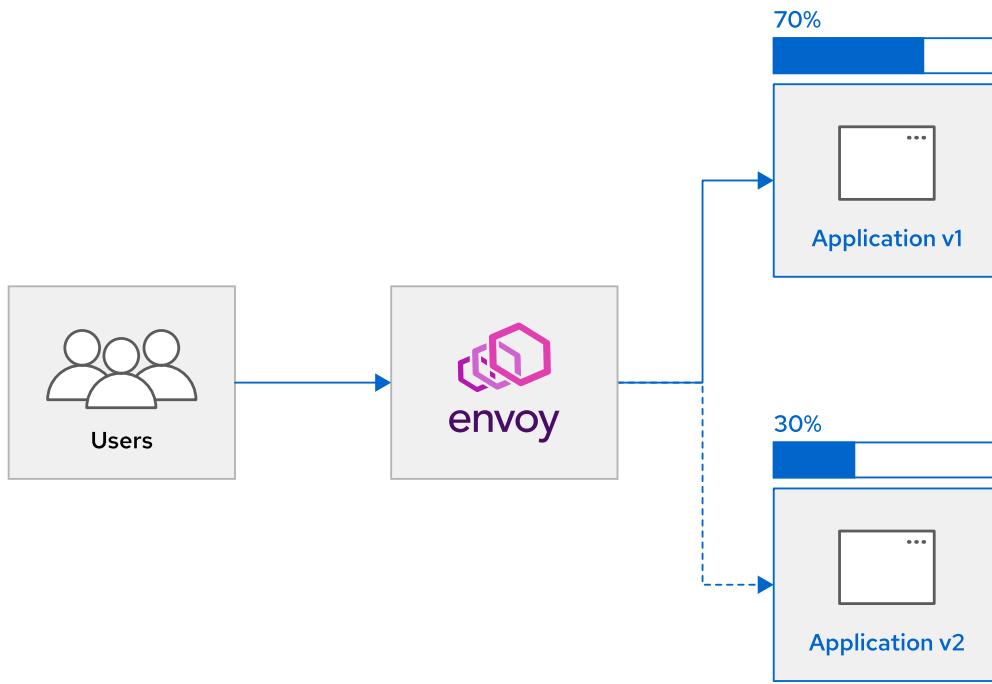


Figure 5.1: Canary release strategy

## Use Cases

Canary deployment is a good strategy whenever you want to have more control and increase the level of confidence in your deployments. The following cases are scenarios where a canary release approach makes sense:

- Your application handles high loads and you want to perform load or stress testing on a new version.
- You want to validate the new version against a reduced group of users to analyze how this affects your key performance indicators. User groups can be defined according to different conditions, such as user type or location. For example, a common scenario is releasing canaries only for internal users or trusted clients.
- You need a safe strategy to deploy a new critical version.

## Deploying a Canary Release with OpenShift Service Mesh

Canary releases are not specific to OpenShift Service Mesh. You can adopt a canary strategy if you have a way to control how traffic is distributed between each version. The most common case is using a router or a load balancer that lets you manage traffic routing.

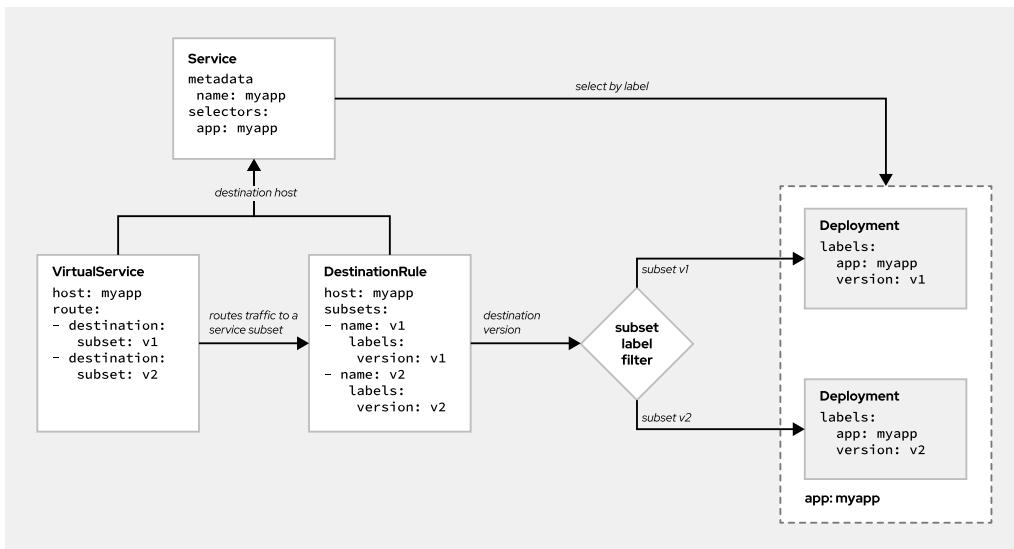
In Kubernetes, you can use the canary strategy by creating a new deployment with the same service selector label as the old version, and adjusting the replica ratio between the old and the new version. The number of replicas of each version dictates the amount traffic that each version receives. Therefore, if both versions, the old and the new, scale to one replica, each of them receives 50% of the traffic.

However, if you want to send only 1% of the traffic to the canary, you would need to scale the old version to 99 replicas to adjust the replica ratio. This is a clear problem, as it requires more cluster

resources and leads to an inefficient use of those resources. Moreover, this solution only allows you to control how traffic is routed based on percentages.

With OpenShift Service Mesh, you can take advantage of the Istio traffic management features to handle traffic distribution without a dependency on replica ratios. Furthermore, Istio offers various traffic routing policies, so you are not restricted to a strategy based on traffic percentage.

Virtual services, in combination with destination rules, can define traffic routes for each version. Each version is released as a Deployment and represented by a DestinationRule subset, which filters the service endpoints for that version. *Figure 5.2* shows how these configuration resources relate in a canary scenario.



**Figure 5.2: Example of resources configuration for canary releases**

First, assume that you have already deployed an application called `myapp`. The Deployment and the Service resources also already exist. The service that represents the application looks like the following:

```

apiVersion: v1
kind: Service
metadata:
  labels:
    app: myapp
  name: myapp
spec:
  selector:
    app: myapp
  ...
  
```

The deployment for the initial version of the application (`v1`) looks like the following:

```

apiVersion: apps/v1
kind: Deployment
metadata:
  name: myapp-v1
spec:
  
```

```

...
template:
  metadata:
    labels:
      app: myapp
      version: v1
    annotations:
      sidecar.istio.io/inject: "true"
  spec:
    ...

```

Pay special attention to the `version` label of the deployment. Labels are the main property used to identify the version of the application, and to split traffic between versions. Also note that you must enable the injection of the Envoy sidecar by setting the `sidecar.istio.io/inject` annotation to "true". This allows the application to use Istio routing features.

## Deploying a Canary Release

To deploy a canary release, you must create a new deployment for the new version and split traffic between versions using a virtual service and a destination rule.

- 1 Create a `Deployment` resource for the new version. For example, for `v2`, create a new `Deployment` that looks like this:

```

kind: Deployment
metadata:
  name: myapp-v2①
spec:
  replicas: 1
  template:
    metadata:
      labels:
        app: myapp②
        version: v2③
      annotations:
        sidecar.istio.io/inject: "true"
  spec:
    containers:
      ...

```

As the example shows, the new deployment must meet the following requirements:

- 1 Use a unique name for this deployment, different from the name of the old deployment.
  - 2 Specify the same application label used in the old deployment, so that the service is aware that the new version belongs to the same application as the old version.
  - 3 Change the value of the `version` label so that OpenShift Service Mesh can distinguish between versions when routing traffic.
- 2 Create a `DestinationRule` resource to define the subsets that represent each version.

```

apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:

```

```

name: myapp
spec:
  host: myapp❶
  subsets:
    - name: v1❷
      labels:
        version: v1
    - name: v2❸
      labels:
        version: v2

```

This destination rule defines the following configuration:

- ❶ The name of the targeted service.
  - ❷ A subset for v1, filtering labels specified in the `myapp-v1` deployment. In this case, `version: v1`.
  - ❸ A subset for v2, filtering labels specified in the `myapp-v2` deployment. In this case, `version: v2`.
3. Create a `VirtualService` resource to define the traffic route for each version. Associate each subset with a route destination and add a weight.

```

apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: myapp
spec:
  hosts:
    - "*"
  gateways:
    - my-gateway
  http:
    - route:
        - destination:
            host: myapp❶
            subset: v1❷
            port:
              number: 3000
            weight: 90❸
        - destination:
            host: myapp
            subset: v2
            port:
              number: 3000
            weight: 10

```

There are two `destination` configurations defined in this virtual service, one for each version. `v1` receives 90% of the traffic, whereas `v2` receives the remaining 10%. Each destination must contain the following information:

- ❶ The service hostname. It must be the same as the `host` field defined in the destination rule.

- ❷ The name of one of the subsets defined in the associated destination rule.
- ❸ The percentage of traffic routed to the version.

If you need to route traffic using more advanced criteria, then you can use `spec.http.match` for HTTP traffic or `spec.tcp.match` for TCP traffic.

After you create these resources, ensure that traffic is being routed as expected. To verify the routing, send traffic to your application and check that each version receives the expected amount of traffic. You can check your application responses, inspect the logs, or use Kiali, as discussed in *Inspecting Canary Traffic with Kiali*.

When you are ready to send more traffic to your canary, update the route weights or matching filters. For example, if you want to increase the traffic share received by the canary to 60%, update the `weight` field of each subset to adjust the new percentages.

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: myapp
spec:
  ...
  http:
    - route:
        - destination:
            host: myapp
            subset: v1
            ...
            weight: 40
        - destination:
            host: myapp
            subset: v2
            ...
            weight: 60
```

Similarly, if you need to quickly roll back to the previous version, update the weights to direct more traffic to it.

## Splitting Traffic Using Kiali

Kiali provides a web user interface to observe and manage the services in your service mesh in real time. As well as providing observability of the platform, Kiali offers configuration features to help you manage the platform. With Kiali, you can edit the configuration of Istio traffic management features to control canary releases. In particular, you can edit resource files in `yaml` format to modify the configuration of Istio resources. You can also use traffic management wizards to balance traffic between versions in a user-friendly interface.

Kiali can help you to control how traffic is routed to different versions without explicitly creating the `VirtualService` and the `DestinationRule` resources. Instead of creating or editing these resources in OpenShift, for example with the `oc` command, you can use the Kiali configuration capabilities.

In the Kiali menu, navigate to **Services** to open the services page.

Next, select your project in the **Namespace** selector and click the name of your application service to go to the service configuration page:

The screenshot shows the Kiali interface with the sidebar menu open. The 'Services' tab is selected. A dropdown menu shows 'Namespace: my-project'. The main area is titled 'Services' and displays a table with one row. The row contains a service icon (blue circle with 'S'), the name 'my-app', a namespace icon (blue circle with 'NS'), the namespace name 'my-project', and a label 'app: my-app'. To the right of the table are two status indicators: a blue diamond with a white checkmark and a green checkmark.

**Figure 5.3: Kiali services page**

Click the service name to review routing details for the service. You can review information about workloads on the lower part of the page. Additionally, you can review service mesh configuration, such as virtual services and destination rules, in the **Istio Config** tab.

If you did not create any Istio traffic management resources, the **Istio Config** tab should show no configuration, as shown in the following example:

The screenshot shows the 'Service resources' section of Kiali. The 'Istio Config (0)' tab is selected. The table header includes columns for Status, Name, Type, Created at, Resource version, and Actions. Below the table, there is a large 'No Istio Config found' message with a small network icon above it, and a smaller note below stating 'No Istio Config found for myapp'.

**Figure 5.4: Service resources section in Kiali**

Click **Actions → Request Routing** to open the Kiali routing wizard. The Kiali routing wizard enables you to create routing configuration for your services.

The screenshot shows the Kiali interface for managing service meshes. In the top navigation bar, 'Services' > 'Namespace:my-project' > 'myapp'. Below this, there are tabs for 'Overview' (selected), 'Traffic', 'Inbound Metrics', and 'Traces'. On the right, there's a 'Actions' dropdown menu with options like 'Create', 'Request Routing' (which is highlighted with a red box), 'Fault Injection', 'Traffic Shifting', 'Request Timeouts', and 'Delete Traffic Routing'. A modal window titled 'Graph Overview' is open, showing an 'Empty Graph' message: 'Not enough data to generate a graph.' To the left, the 'Service Info' panel shows the service name 'myapp' and labels 'app myapp'. The overall status is 'No health' under 'Overall Health'.

Figure 5.5: Kiali weighted routing wizard selector

In the **Create Request Routing** dialog window, select the **Route To** tab to configure traffic splitting. Click **Add Rule** to add your traffic splitting configuration to the generated service mesh configuration.

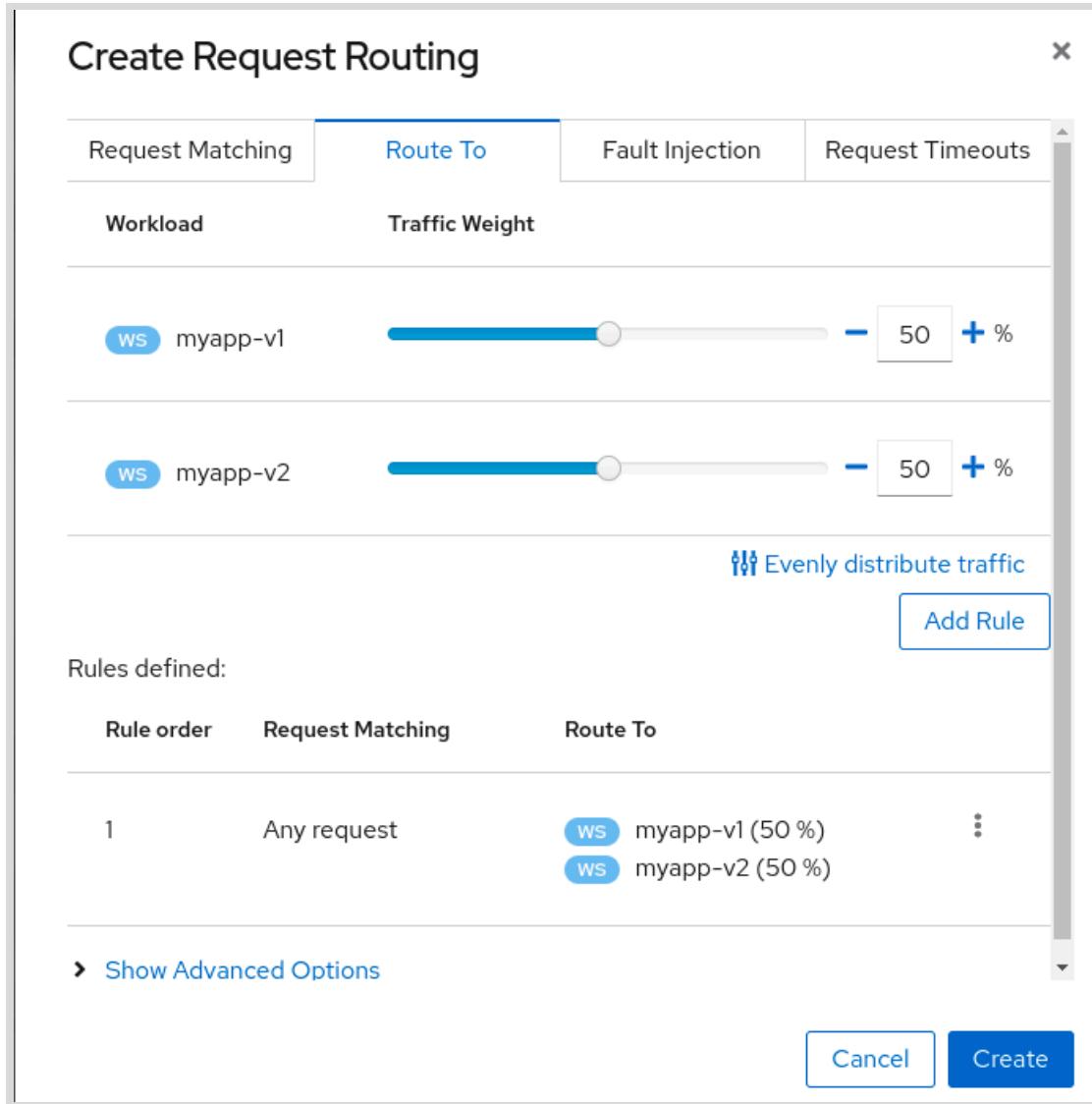


Figure 5.6: Kiali weighted routing wizard

You can also configure other traffic options, such as fault injection, request timeouts, TLS, and circuit breakers.



#### Note

Currently, the routing wizard can manage only `VirtualService` and `DestinationRule` resources created with the wizard. It does not allow the management of `VirtualService` and `DestinationRule` resources created directly in OpenShift.

When you need to increase the amount of traffic directed to the canary, click **Actions → Request Routing** to reopen the wizard and delete the previous distribution. Then, adjust the traffic splitting, add the adjusted configuration as a new rule, and click **Update** to create a new virtual service.

## Inspecting Canary Traffic with Kiali

You can inspect the traffic flow in the Kiali Graph section and visualize how traffic is distributed to each version. Click **Graph** in the navigation pane to visualize the graph. Click **Display → Requests Percentage** to include percentage of requests that Envoy proxy routed to each graph edge.

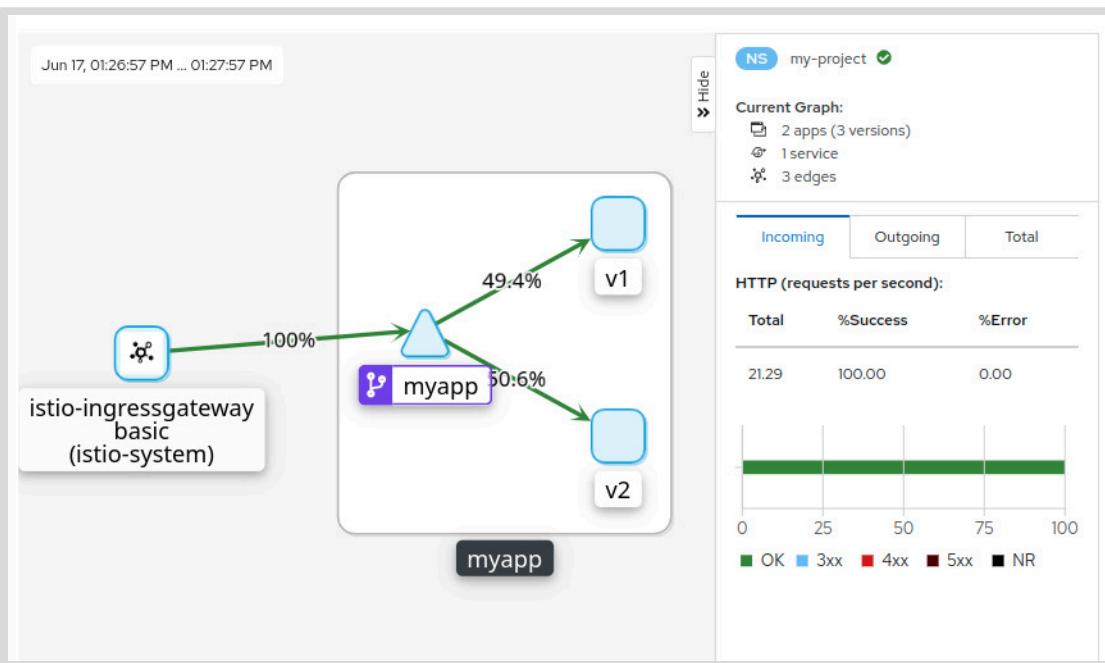


Figure 5.7: Kiali traffic graph

Notice how Kiali identifies that the two versions belong to the same application. You can also see the amount of traffic that each version receives. This allows you to verify that your traffic splitting configuration works as expected.

## Configuring Istio Resources in Kiali

As well as providing wizards to manage traffic, Kiali also allows you to edit the configuration of Istio resources in `yaml` format. To edit the configuration of these resources, select **Services** in the Kiali navigation pane, select the service you want to edit, and then click the **Istio Config** pane to see Istio resources.

In the **Istio Config** pane, click **View YAML** to edit a resource.

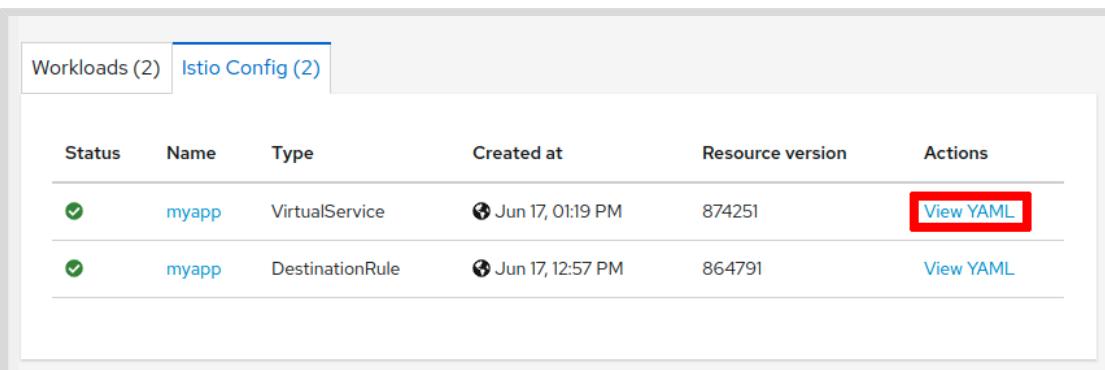


Figure 5.8: Kiali edit resources

Editing the configuration of a resource from the Kiali UI has the same result as editing the resource using the `oc` command.

Additionally, you can modify Istio configuration in Kiali by editing the `yaml` code in the Istio Config section. Select **Istio config** in navigation pane. Select the resource you want to edit, and then click the YAML tab. In this tab, you can view the specification in `yaml` format and modify it.

The screenshot shows the Kiali interface with the 'YAML' tab selected. On the left, a large code editor displays the YAML configuration for a Virtual Service named 'myapp'. The configuration includes details like namespace ('my-project'), self-link, uid, resourceVersion, managedFields (operations like kubectl-create and kubectl-edit), and spec (hosts, gateways, http routes). On the right, a 'Virtual Service Overview' panel provides a summary of the service, including Gateways ('myapp-gateway'), HTTP Routes (a chart showing 100% traffic to myapp), and Hosts ('myapp'). Below the code editor are buttons for 'Save', 'Reload', and 'Cancel', and a 'Close Overview' button.

```

5   name: myapp
6   namespace: my-project
7   selfLink: >-
8     /apis/networking.istio.io/v1alpha3/namespaces
9       /my-project/virtualservices/myapp
10  uid: 6fc90a46-c69c-4bfd-82aa-8d28aff7bca6
11  resourceVersion: '874251'
12  generation: 3
13  creationTimestamp: '2021-06-17T11:19:39Z'
14  managedFields:
15    - manager: kubectl-create
16      operation: Update
17      apiVersion: networking.istio.io/v1alpha3
18      time: '2021-06-17T11:19:39Z'
19    - manager: kubectl-edit
20      operation: Update
21      apiVersion: networking.istio.io/v1beta1
22      time: '2021-06-17T11:27:28Z'
23
24  spec:
25    hosts:
26      - '*'
27    gateways:
28      - myapp-gateway
29    http:
30      - route:
31        - destination:
32          host: myapp
33          port:
34            number: 8080
35          subset: v1

```

Figure 5.9: YAML edition screen in Kiali

## References

- Istio 1.6 Docs: Destination Rule**  
<https://istio.io/v1.6/docs/reference/config/networking/destination-rule/>
- Istio 1.6 Docs: Virtual Service**  
<https://istio.io/v1.6/docs/reference/config/networking/virtual-service/>
- Kiali: Service mesh observability and configuration**  
[https://pre-v1-41.kiali.io/documentation/v1.24/features/#\\_istio\\_wizards](https://pre-v1-41.kiali.io/documentation/v1.24/features/#_istio_wizards)

For more information, refer to the *Kiali* overview section in the *Red Hat Service Mesh Guide* at  
[https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.6/html-single/service\\_mesh/index](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.6/html-single/service_mesh/index)

## ► Guided Exercise

# Deploying an Application with Canary Releases

In this exercise, you will use Red Hat OpenShift Service Mesh to deploy different versions of a service using canary releases.

You will deploy a single-pod `vertx-greet` application. The `vertx-greet` application exposes a GET endpoint that returns a greeting message.

It also implements a basic rate limit feature to help you simulate a failing canary deployment scenario. This rate limiting feature is not the same as the rate limit feature included in OpenShift Service Mesh.

The source code is available in the Git repository at <https://github.com/RedHatTraining/D0328-apps/tree/master/vertx-greet>.

## Outcomes

You should be able to:

- Roll out versions of an application as canary releases using OpenShift Service Mesh.
- Specify the traffic percentage directed to each canary deployment.
- Visualize traffic distribution and identify errors using Kiali.

## Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- An installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (`/usr/local/bin/oc`).

As the `student` user on the `workstation` machine, use the `lab` command to prepare your system for this exercise.

Run the following command on `workstation` to setup the environment.

```
[student@workstation ~]$ lab release-canary start
```

## Instructions

- 1. Review the resource files provided. The setup script used these files to deploy the initial version of the `vertx-greet` application.
- 1.1. Navigate to the directory where the cluster resource files for this exercise are located.

```
[student@workstation ~]$ cd ~/D0328/labs/release-canary/
```

1.2. Review the `deployment-v1.yaml` resource file.

```

apiVersion: apps/v1
kind: Deployment
metadata:
  name: vertx-greet-v1
spec:
  selector:
    matchLabels:
      app: vertx-greet
  replicas: 1
  template:
    metadata:
      labels:
        app: vertx-greet
        version: v1
      annotations:
        sidecar.istio.io/inject: "true"
    spec:
      containers:
        - name: vertx-greet
          image: quay.io/redhattraining/ossm-vertx-greet:1.0
          imagePullPolicy: Always
          ports:
            - containerPort: 8080

```

This file defines the `Deployment` resource for the initial version of the application. Each version is associated to a deployment. The initial version is `v1`, which is reflected both in `metadata.name` and `spec.template.metadata.labels.version`.

1.3. Review the `service.yaml` resource file.

```

apiVersion: v1
kind: Service
metadata:
  labels:
    app: vertx-greet
    name: vertx-greet
spec:
  ports:
    - name: http
      port: 8080
  selector:
    app: vertx-greet

```

The service directs internal traffic to the deployment pods. You do not need to change this service or create new ones when deploying canary releases.

1.4. Review the `gateway.yaml` resource file.

```

apiVersion: networking.istio.io/v1beta1
kind: Gateway
metadata:
  name: vertx-greet-gateway
spec:

```

```

selector:
  istio: ingressgateway
servers:
  - port:
      number: 80
      name: http
      protocol: HTTP
    hosts:
      - "*"

```

The istio gateway sits at the edge of the service mesh and allows incoming connections to the application.

### 1.5. Review the `virtual-service.yaml` resource file.

```

apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: vertx-greet
spec:
  hosts:
    - "*"
  gateways:
    - vertx-greet-gateway
  http:
    - route:
        - destination:
            host: vertx-greet
            port:
              number: 8080

```

The Istio virtual service defines traffic routes from the istio gateway to the application and defines traffic splitting for each version. Initially, the virtual service only includes one route, as only one version of the application is deployed.

## ▶ 2. Verify that the initial version application is deployed and running.

### 2.1. Run the following command to source the environment variables for this exercise.

```
[student@workstation release-canary]$ source /usr/local/etc/ocp4.config
```

### 2.2. Log in to OpenShift as the developer user.

```
[student@workstation release-canary]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

Ensure that you are using the `release-canary` project.

```
[student@workstation release-canary]$ oc project release-canary
...output omitted...
```

Next, perform the rest of the steps in this project.

- 2.3. Verify that the application is in the `ready` state:

```
[student@workstation release-canary]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
pod/vertx-greet-v1-bd87877dd-6rj2m   2/2     Running   0          5m38s
```

- 2.4. Use the `oc get route` command to get the URL of the istio gateway.

Save the result into a variable for later use.

```
[student@workstation release-canary]$ GATEWAY_URL=$(oc get route \
istio-ingressgateway -n istio-system -o jsonpath='{.spec.host}')
```

- 2.5. Verify that the application works. Make a request to the route URL that you stored in the `GATEWAY_URL` variable.

```
[student@workstation release-canary]$ curl $GATEWAY_URL
Hello World!
```

- ▶ 3. Generate the canary release. Deploy version 2 of the `vertx-greet` application by creating a new deployment. After the new version is deployed, route 20% of the traffic to the new version.

- 3.1. Make a copy of the `deployment-v1.yaml` file and name it `deployment-v2.yaml`.

```
[student@workstation release-canary]$ cp deployment-v1.yaml deployment-v2.yaml
```

- 3.2. Modify the `deployment-v2.yaml` file to introduce the changes for version 2. Change the value of `metadata.name` to `vertx-greet-v2`, change the value of `spec.template.metadata.labels.version` to v2. Finally, add the `GREETING` environment variable with the value `Hello Red Hat!`.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: vertx-greet-v2
spec:
  selector:
    matchLabels:
      app: vertx-greet
  replicas: 1
  template:
    metadata:
      labels:
        app: vertx-greet
        version: v2
    annotations:
      sidecar.istio.io/inject: "true"
  spec:
    containers:
      - name: vertx-greet
        image: quay.io/redhattraining/ossm-vertx-greet:1.0
```

```

  ports:
    - containerPort: 8080
  env:
    - name: GREETING
      value: "Hello Red Hat!"

```

You can see the complete deployment for version 2 at `~/DO328/solutions/release-canary/deployment-v2.yaml`.

- 3.3. Deploy version 2 by creating the new deployment.

```
[student@workstation release-canary]$ oc create -f deployment-v2.yaml
deployment.apps/vertx-greet-v2 created
```

- 3.4. Review the provided `destination-rule.yaml` file.

```

apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: vertx-greet
spec:
  host: vertx-greet
  subsets:
    - name: v1
      labels:
        version: v1
    - name: v2
      labels:
        version: v2

```

The file defines two subsets, one for each version. Each subset represents a portion of the traffic, and includes a name and a label that associates the subset with the deployment version. The version is the one specified by the `spec.template.metadata.labels.version` property in each Deployment resource.

- 3.5. Create a DestinationRule with the `destination-rule.yaml` file.

```
[student@workstation release-canary]$ oc create -f destination-rule.yaml
destinationrule.networking.istio.io/vertx-greet created
```

- 3.6. Modify the `VirtualService` resource with the `oc edit` command to send 80% of the traffic to v1 and the remaining 20% to v2. Associate the existing destination with the v1 subset and add a weight of 80. Next, add another destination for the v2 subset with a weight of 20.

```
[student@workstation release-canary]$ oc edit virtualservice vertx-greet
```

Apply the changes in the text editor.

```

...output omitted...
apiVersion: networking.istio.io/v1beta1
kind: VirtualService

```

```

metadata:
  ...output omitted...
  name: vertx-greet
  ...output omitted...
spec:
  hosts:
  - "*"
  gateways:
  - vertx-greet-gateway
  http:
  - route:
    - destination:
        host: vertx-greet
        subset: v1
        port:
          number: 8080
        weight: 80
    - destination:
        host: vertx-greet
        subset: v2
        port:
          number: 8080
        weight: 20
  ...output omitted...

```

Save your changes to the resource, and then close the editor.

You can see the complete virtual service at `~/D0328/solutions/release-canary/virtual-service-v1.yaml`. Apply the configuration by using the `oc apply` command.

- Run `test_canary.py` to check that the portion of responses expected for each service corresponds to the weights configured in the previous steps. This script sends a sequence of 50 requests to the specified URL and shows the result. From a previous step, you should have the gateway route URL stored in the `GATEWAY_URL` environment variable. Execute the script passing this variable as the first parameter.

```
[student@workstation release-canary]$ ./test_canary.py $GATEWAY_URL
```

Wait until the script ends.

```

...output omitted...
Hello World!
Hello Red Hat!
...output omitted...
Total requests: 50
* 'Hello World!' responses: 42 (84.0%)
* 'Hello Red Hat!' responses: 8 (16.0%)
* Errors: 0 (0.0%)

```

The response percentage for each version approaches the weights that you specified in the `VirtualService` resource. Expect to see small deviations in the traffic statistics when compared to the configured weights, as there is a degree of random variation in traffic splitting.

- ▶ 4. Create another canary release for version 3. This version includes a rate limit feature, which establishes the maximum number of requests per second that the application can handle. The application will reject requests received at a rate that exceeds this limit.

After deploying version 3, modify the traffic weights so that:

- 10% of the traffic reaches the v1 deployment.
- 45% of the traffic reaches the v2 deployment.
- 45% of the traffic reaches the v3 deployment.

4.1. Make a copy of the `deployment-v2.yaml` file and name it `deployment-v3.yaml`.

```
[student@workstation release-canary]$ cp deployment-v2.yaml deployment-v3.yaml
```

4.2. Introduce the changes for version 3 in `deployment-v3.yaml`.

Change the name to `vertx-greet-v3`, change the value of `spec.template.metadata.labels.version` to v3, change the `GREETING` value, and add a new environment variable `MAX_REQUESTS_PER_SECOND` with a value of 1.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: vertx-greet-v3
spec:
  selector:
    matchLabels:
      app: vertx-greet
  replicas: 1
  template:
    metadata:
      labels:
        app: vertx-greet
        version: v3
    annotations:
      sidecar.istio.io/inject: "true"
  spec:
    containers:
      - name: vertx-greet
        image: quay.io/redhattraining/ossm-vertx-greet:1.0
        ports:
          - containerPort: 8080
        env:
          - name: GREETING
            value: "Hello v3!"
          - name: MAX_REQUESTS_PER_SECOND
            value: "1"
```

You can see the complete deployment for version 3 at `~/D0328/solutions/release-canary/deployment-v3.yaml`.

- 4.3. Deploy version 3 by creating the new deployment.

```
[student@workstation release-canary]$ oc create -f deployment-v3.yaml
deployment.apps/vertx-greet-v3 created
```

- 4.4. Modify the `DestinationRule` resource. Use the `oc edit` command to create a new subset for version 3.

```
[student@workstation release-canary]$ oc edit destinationrule vertx-greet
```

In the text editor, add the subset for v3.

```
...output omitted...
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  ...output omitted...
  name: vertx-greet
  ...output omitted...
spec:
  host: vertx-greet
  subsets:
    - labels:
        version: v1
        name: v1
    - labels:
        version: v2
        name: v2
    - labels:
        version: v3
        name: v3
  ...output omitted...
```

Save and close the editor to apply the changes.

You can see the complete virtual service at `~/D0328/solutions/release-canary/destination-rule.yaml`. Apply the configuration by using the `oc apply` command.

- 4.5. Modify the `VirtualService` resource to assign a small portion of traffic to v1 and balance the rest between v2 and v3. Use the `oc edit` command to modify the `weight` property of v1 and v2, and to add a new destination node for v3.

```
[student@workstation release-canary]$ oc edit virtualservice vertx-greet
```

In the text editor, modify the `weight` property of v1 and v2, and add a new destination for v3.

```
...output omitted...
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
```

```
metadata:  
  ...output omitted...  
name: vertx-greet  
  ...output omitted...  
spec:  
  hosts:  
  - "*"  
gateways:  
  - vertx-greet-gateway  
http:  
  - route:  
    - destination:  
      host: vertx-greet  
      subset: v1  
      port:  
        number: 8080  
      weight: 10  
    - destination:  
      host: vertx-greet  
      subset: v2  
      port:  
        number: 8080  
      weight: 45  
    - destination:  
      host: vertx-greet  
      subset: v3  
      port:  
        number: 8080  
      weight: 45  
  ...output omitted...
```

Save and close the editor to apply the changes.

You can see the complete virtual service at `~/D0328/solutions/release-canary/virtual-service-v2.yaml`. Apply the configuration by using the `oc apply` command.

- 4.6. Run `test_canary.py` again to check that the portion of responses expected for each service corresponds to the weights configured. Execute `test_canary.py` passing `GATEWAY_URL` as a parameter.

```
[student@workstation release-canary]$ ./test_canary.py $GATEWAY_URL  
...output omitted...  
Hello Red Hat!  
Hello World!  
Hello Red Hat!  
Hello Red Hat!  
Hello v3!  
Server responded with error  HTTP Error 503: Service Unavailable  
  
Server responded with error  HTTP Error 503: Service Unavailable  
  
Hello World!  
...output omitted...  
Total requests: 50
```

```
* 'Hello World!' responses: 5 (10.0%)
* 'Hello Red Hat!' responses: 18 (36.0%)
* 'Hello v3!' responses: 3 (6.0%)
* Errors: 24 (48.0%)
```

Notice how version 3 only returns a few correct responses, even though there are a significant number of errors.

The new version, which limits the number of requests per second, is unable to attend all requests when they come at a high rate.

► 5. Inspect traffic with Kiali to gain more insight into traffic routing.

- 5.1. Obtain the Kiali web console url.

```
[student@workstation release-canary]$ KIALI_URL=$(oc get route \
-n istio-system kiali \
-o jsonpath='http://{.spec.host}')
```

- 5.2. Open the Kiali web console in the web browser.

```
[student@workstation release-canary]$ firefox $KIALI_URL &
```

- 5.3. Click **Log in with OpenShift**. Log in using the developer account. Find your credentials in the `/usr/local/etc/ocp4.config` classroom configuration file. The user name is in the `RHT_OCP4_DEV_USER` variable and the password is in `RHT_OCP4_DEV_PASSWORD`.
- 5.4. In the Kiali web console navigation pane, click **Graph** to open the graph view.
- 5.5. Click **Select a namespace → release-canary** to gather metrics for the `release-canary` project.

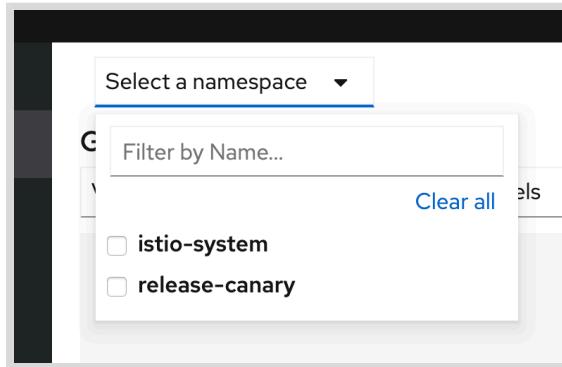


Figure 5.10: Kiali namespace selector



**Note**

If you see only the `istio-system` project in the Kiali console, then wait and refresh the page several times. It can take several minutes for the `release-canary` project to appear in the Kiali console.

- 5.6. Click **Display → Requests percentage** to activate traffic percentage labels in graph edges.

- 5.7. Specify a longer duration for metric queries to make sure you can inspect all recent traffic. Click **Last 1m** → **Last 30m** to show the graph with metrics from the last 30 minutes.
- 5.8. Take a moment to inspect the traffic graph. Whereas v1 and v2 are working as expected, v3 is causing the errors. Click the v3 rounded square representing the workload. Notice how many of the requests to this version result in an error.

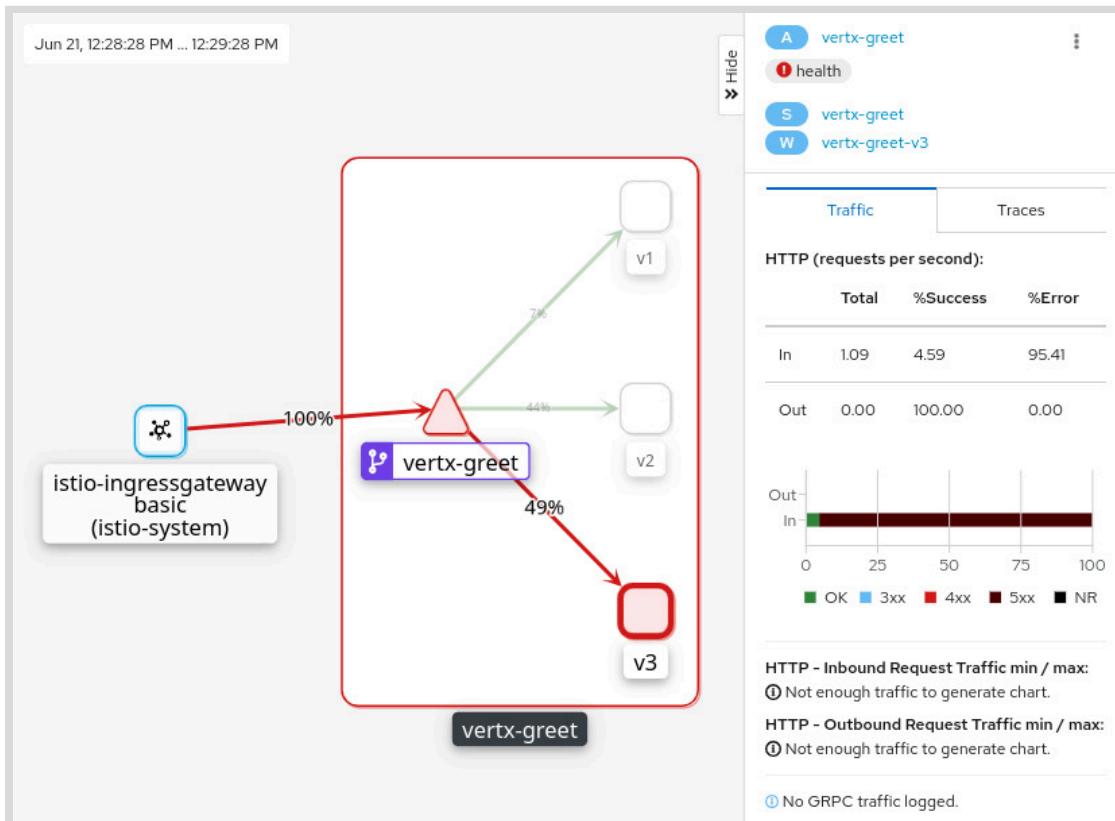


Figure 5.11: Kiali traffic graph with errors

The new rate limiting feature introduced in v3 causes this behavior, as it does not allow for more than one request per second. When you run the `test_canary.py` script, you send a sequence of 50 requests to the application. Roughly 45% of them are routed to v3, as you specified in the `VirtualService` resource. The script does not apply any delay between requests, so as soon as one is completed, the next one is sent. Under this scenario, v3 is receiving more than one request per second. Therefore, you must modify the traffic share so that v3 does not receive more requests than it can handle.



### Note

If you see different routing percentages than the expected traffic split, then execute the `test_canary.py` script multiple times.

- ▶ 6. Reduce the traffic share of version 3. Modify the `VirtualService` resource to adjust the traffic load of version 3.
  - 6.1. Use the `oc edit` command to modify the `VirtualService` resource again and reduce the traffic share of v3.

```
[student@workstation release-canary]$ oc edit virtualservice vertx-greet
```

In the text editor, reduce the **weight** of v3 and send the rest to v2.

```
...output omitted...
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: vertx-greet
spec:
  hosts:
  - "*"
  gateways:
  - vertx-greet-gateway
  http:
  - route:
    - destination:
        host: vertx-greet
        subset: v1
        port:
          number: 8080
        weight: 10
    - destination:
        host: vertx-greet
        subset: v2
        port:
          number: 8080
        weight: 88
    - destination:
        host: vertx-greet
        subset: v3
        port:
          number: 8080
        weight: 2
...output omitted...
```

Save and close the editor to apply the changes.

You can see the complete virtual service at `~/D0328/solutions/release-canary/virtual-service-v3.yaml`. Apply the configuration by using the `oc apply` command.

- 6.2. Run `test_canary.py` again. Increase the number of requests to 100 by adding the `requests` parameter, so that you can see some requests routed to v3.

```
[student@workstation release-canary]$ ./test_canary.py $GATEWAY_URL --requests 100
```

Wait until the script ends.

```
...output omitted...
Total requests: 100
* 'Hello World!' responses: 5 (5.0%)
* 'Hello Red Hat!' responses: 93 (93.0%)
* 'Hello v3!' responses: 2 (2.0%)
* Errors: 0 (0.0%)
```

Now, v3 does not limit requests, as only 2% of the traffic is sent to this version. Therefore, v3 returns no errors.



### Note

If you do not see any requests routed to v3, run the `test_canary.py` script again. The traffic weight assigned to v3 is now very low and it is possible that v3 receives 0 out of 100 requests.

Similarly, errors can occur if, by chance, two requests are directed to v3 in less than a second. Rerun the `test_canary.py` script in that case too.

- ▶ 7. Inspect the traffic graph in Kiali again and verify that v3 is working as expected after the traffic reduction.
  - 7.1. Switch back to the Kiali console in the browser.
  - 7.2. Click **Graph** in the Kiali console navigation pane. Select **Last 5min** in the metrics duration selector to only show traffic for the last 5 minutes. Check that the traffic graph does not show any errors.

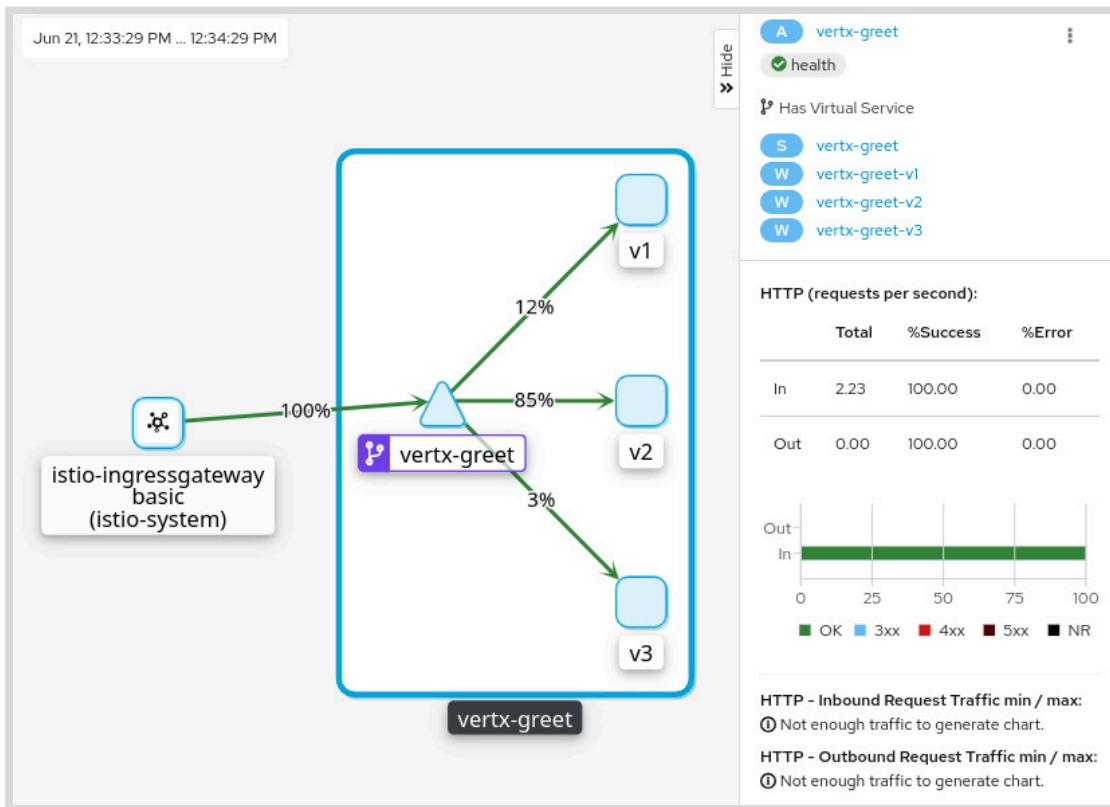


Figure 5.12: Kiali traffic graph without errors

- 8. Return to the home directory.

```
[student@workstation release-canary]$ cd
```

## Finish

On the **workstation** machine, use the **lab** command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab release-canary finish
```

This concludes the guided exercise.

# Deploying an Application with a Mirror Launch

## Objectives

After completing this section, you should be able to deploy a "mirror" service to test a new service with a realistic load.

## Testing in Production

When releasing new versions of services, it is often necessary to test the new versions of the services in a production environment. Testing in production is important because it is difficult to simulate production workloads or realistic production data in testing or staging environments.

Testing in production consists of:

- Deploying the new version of the service in a production environment alongside the existing version of the service.
- Sending a copy of production traffic to both the new service and the existing service. This is known as **traffic mirroring**.
- Verifying the correct behavior of the new service.

The responses sent back to clients are sent from the previous version of the service, so there is little risk of service disruption.

Traffic mirroring is also beneficial when the services involved are stateful. When the new version of the service starts functioning, it starts with a state known to be compatible with the current state of the old version. Sending the same traffic to both stateful services allows them to maintain a synchronized state. When the new version of the service becomes the production version, it will hold the right state.

These situations may be complex to solve programmatically, but OpenShift Service Mesh features make them feasible. Traffic mirroring allows testing the new service in production, with production requests, without service disruption, and keeping the state of both versions of stateful services synchronized.



### Note

Traffic mirroring is also known as **Mirror Launches** or **Dark Launches**, referring to the capacity of releasing new versions of services while keeping them hidden from clients.

## Mirroring in OpenShift Service Mesh

OpenShift Service Mesh uses the `DestinationRule` resources to define subsets (usually service versions) and the `destination` entry in `VirtualService` resources to route the requests between subsets. OpenShift Service Mesh provides traffic mirroring by using the same `DestinationRule` resources and introducing a `mirror` entry in the `VirtualService` route:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: my_virtual_service
spec:
  hosts:
    - target_host
  http:
    - route:
      - destination:
          host: old_service_name
          subset: old_subset
      mirror: ①
        host: new_service_name②
        subset: new_subset③
```

- ① The `mirror` entry defines the service to which Istio is sending request copies.
- ② The name of the service that receives the mirrored traffic.
- ③ The subset of hosts that receive the mirrored traffic, as defined in the `DestinationRule`.

**Note**

The `mirror` entry is an attribute of the objects forming the `http` array. If you find the indentation and representation in `yaml` format to be confusing, consider the following snippet of the same resource in `json` format:

```
{
  "apiVersion": "networking.istio.io/v1beta1",
  "kind": "VirtualService",
  "metadata": {
    "name": "my_virtual_service",
  },
  "spec": {
    "hosts": [
      "target_host"
    ],
    "http": [
      {
        "route": [
          {
            "destination": {
              "host": "old_service_name",
              "subset": "old_subset"
            }
          }
        ],
        "mirror": {
          "host": "new_service_name",
          "subset": "new_subset"
        }
      }
    ]
  }
}
```

Istio does not distinguish whether the mirror host is an external or an internal service. Istio can mirror traffic to any service with a related `VirtualService` resource.

## Mirroring a Percentage of the Traffic

There are situations where it is not needed or desirable to mirror all the traffic to the new service. For example, when maintaining the latest state of the service is not required, or when reducing traffic between services is more important than testing all requests. In those situations, Istio and OpenShift Service Mesh allow defining a percentage of the mirrored traffic:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: my_virtual_service
spec:
  hosts:
    - target_host
  http:
```

```
- route:  
  - destination:  
    host: old_service_name  
    subset: old_subset  
  mirror:  
    host: new_service_name  
    subset: new_subset  
  mirror_percent: 10
```

In the preceding example, only 10% of the requests sent to `old_service_name` are mirrored to `new_service_name`.

## Selecting the Appropriate Deployment Strategy

Canary releases and traffic mirroring are both deployment strategies that help you validate the release of new service versions. Depending on your deployment and testing plan, you may want to use one or the other. To pick the right strategy, follow these guidelines:

- Use canary releases when you want to deploy a new version directly in production while minimizing the risk. Also, choose this strategy if you need to introduce real users in the validation process of the new version. By picking canary releases, you accept that a small portion of your users might experience problems derived from the new version.
- Use traffic mirroring when you want to test the new version with production load without making the version available to the public. For example, traffic mirroring can be suitable if you want to test how the application responds to 100% of the production load. This approach is less risky than canary releases. If something goes wrong, it does not affect users. However, traffic mirroring is also more limited, because you can not include real users in the validation process.

Combining both strategies is also an interesting option. First, you use traffic mirroring to validate that the new version works correctly with production traffic. Next, you deploy the new version as a canary to start validating it against real users.



### References

#### Mirroring

<https://istio.io/v1.6/docs/tasks/traffic-management/mirroring/>  
in Istio documentation.

## ► Guided Exercise

# Deploying an Application with a Mirror Launch

In this exercise, you will perform a Dark Launch release of an application and control the amount of traffic mirrored to it.

The application you are deploying is a stateful variant of the greetings service: the service respond request with a predefined response in v1, and a configurable response in v2. The status kept by both versions includes the amount of requests received. This status is stored in memory, so it is lost if the service is restarted.

## Outcomes

You should be able to mirror all or part of the traffic from one service to another to execute a Dark Launch release.

## Before You Begin

To perform this exercise, ensure you have:

- A configured and running OpenShift cluster.
- An installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the `student` user on the `workstation` machine, use the `lab` command to prepare your system for this exercise.

This command creates the `release-dark` project in your OpenShift cluster and deploys a single service on it. Although not needed for this exercise, you can review the source code of this service at <https://github.com/RedHatTraining/D0328-apps/> in the `vertex-greet` directory.

```
[student@workstation ~]$ lab release-dark start
```

## Instructions

- 1. Validate that the application has successfully deployed.
- 1.1. Run the following command to source the environment variables created in *Guided Exercise: Creating a Lab Environment*:
- ```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```
- 1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

13. Use the `release-dark` namespace for the remainder of this exercise.

```
[student@workstation ~]$ oc project release-dark
Now using project "release-dark" on server ...output omitted...
```

14. Verify the application is running:

```
[student@workstation ~]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
vertx-greet-v1-f44b9976c-skbch   2/2     Running   0          3m11s
```

The actual name of your pods may be different.

- ▶ 2. Deploy a new version of the application, but continue sending traffic to the old version. The new version uses the same image as the old one, `quay.io/redhattraining/vertx-greet:latest`, but introduces a new environment variable that changes the greeting message: `GREETING="Hola Mundo!"`.
- 2.1. Create the deployment resource for the same `quay.io/redhattraining/vertx-greet:latest` image. Use `vertx-greet-v2` as the deployment name, and set the `version` label to `v2`. Inject the `GREETING` environment variable into the deployed container.

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: vertx-greet-v2
spec:
  selector:
    matchLabels:
      app: vertx-greet
      version: v2
  replicas: 1
  template:
    metadata:
      labels:
        app: vertx-greet
        version: v2
    annotations:
      sidecar.istio.io/inject: "true"
  spec:
    containers:
      - name: vertx-greet
        image: quay.io/redhattraining/ossm-vertx-greet:latest
        imagePullPolicy: Always
```

```

  ports:
    - containerPort: 8080
  env:
    - name: GREETING
      value: "Hola Mundo!"

```

Save the Deployment resource in a file named `deployment-v2.yml`. You can use the provided solution file at `/home/student/D0328/solutions/release-dark/deployment-v2.yml`.

## 2.2. Create the Deployment resource:

```
[student@workstation ~]$ oc create -f deployment-v2.yml
deployment.apps/vertx-greet-v2 created
```

## 2.3. Validate the new pod is deployed and running:

```
[student@workstation ~]$ oc get pods
NAME                               READY   STATUS    RESTARTS   AGE
vertx-greet-v1-f44b9976c-dps95   2/2     Running   0          5m4s
vertx-greet-v2-7849968c47-mq7hc  2/2     Running   0          2m39s
```

## ► 3. Generate traffic to the v1 service. Visualize in Grafana, and verify v2 is not receiving traffic.

### 3.1. Retrieve the gateway URL where the service is exposed. Open a new terminal and execute the following command:

```
[student@workstation ~]$ GATEWAY_URL=$(oc get route istio-ingressgateway \
-n istio-system -o jsonpath='{.spec.host}')
```

### 3.2. In the same terminal, send a request to the `vertx-greet` service every 0.5 seconds:

```
[student@workstation ~]$ watch -p -n0.5 curl -s $GATEWAY_URL
```

Keep the script active until the end of the exercise.

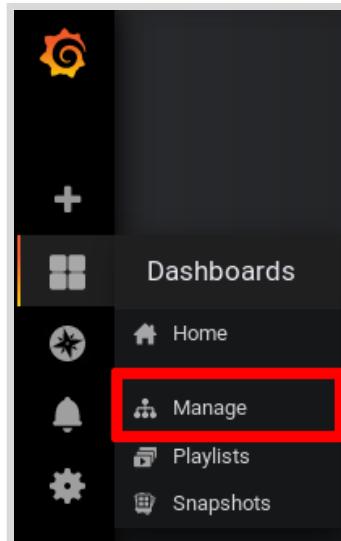
### 3.3. Return to the previous terminal window. Find the URL to the Grafana dashboard:

```
[student@workstation ~]$ GRAFANA_URL=$(oc get route grafana \
-n istio-system -o jsonpath='https://{{.spec.host}}')
```

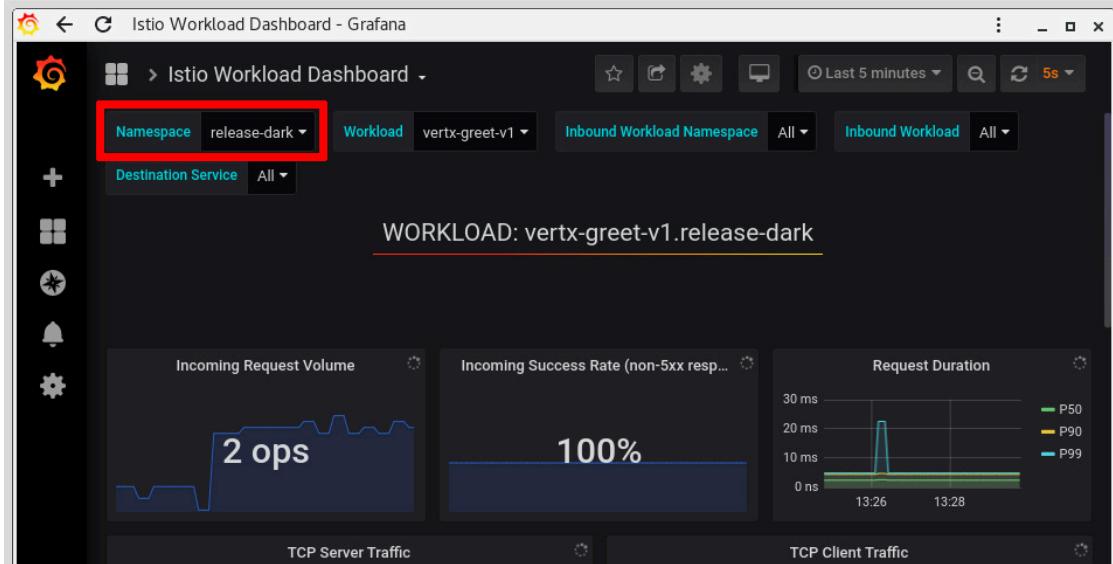
### 3.4. Open the URL in the a web browser. Use the lessons learned in *Collecting Service Metrics*, and the instructions from *Guided Exercise: Collecting Service Metrics*, to log into Grafana using your developer credentials.

```
[student@workstation ~]$ firefox $GRAFANA_URL &
```

### 3.5. Open the `Istio Workload Dashboard`. Click `Dashboards → Manage → Istio → Istio Workload Dashboard`.



- 3.6. In the dashboard, select the `release-dark` namespace and the `vertx-greet-v1` workload. Note how the Incoming Request Volume indicates the service is receiving around two requests per second.



Leave the browser open.

- 3.7. Validate that the state of the service changes with the requests. Execute the following command several times and see how the request number increases as the service receives requests. Note also that only the v1 service is showing, indicating no traffic is sent to the v2 service:

```
[student@workstation ~]$ oc get pods -o name | \
xargs -L 1 oc logs --tail 1 -c vertx-greet
INFO: Attending greeting request #109 from vertx-greet-v1-f44b9976c-pkq44
```

- ▶ 4. Configure OpenShift Service Mesh to mirror all requests sent to v1 to v2. Visualize the traffic in Grafana, and verify that v2 is receiving the same amount of traffic. Validate that both versions change the state synchronously.

- 4.1. Update the DestinationRule resource to include the new version of the service as a subset. Execute `oc edit DestinationRule vertx-greet -n release-dark`. Then, add a subset named v2 matching the version: v2 label:

```
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: vertx-greet
  labels:
    kiali_wizard: weighted_routing
spec:
  host: vertx-greet
  subsets:
    - labels:
        version: v1
      name: v1
    - labels:
        version: v2
      name: v2
```

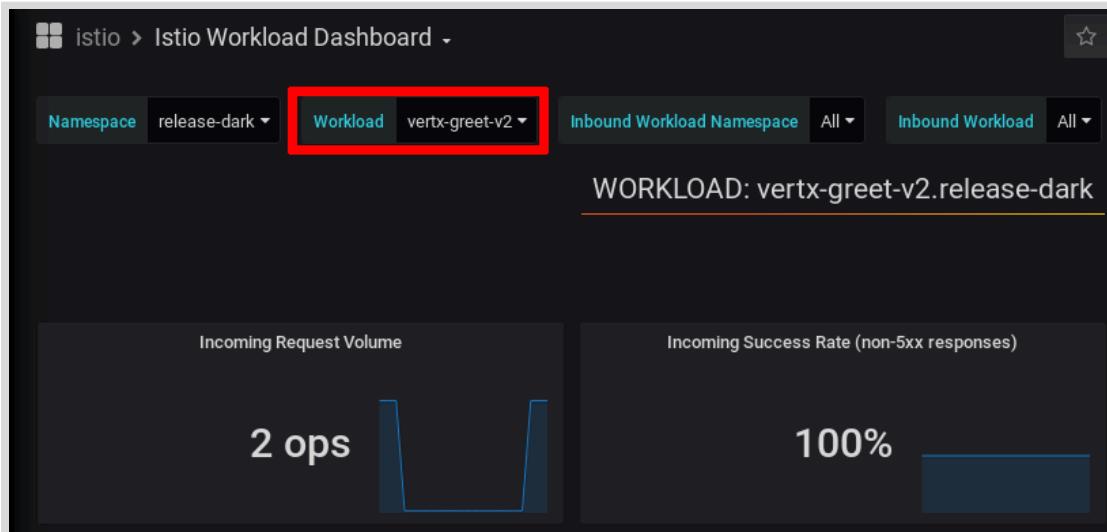
The finished resource is at `/home/student/D0328/solutions/release-dark/destination-rule.yml`. You can use the `oc apply` command to apply the configuration.

- 4.2. Update the VirtualService to mirror traffic to the v2 subset. In this way, a copy of all requests sent to the v1 subset of the `vertx-greet` host are also sent to the v2 subset. Execute `oc edit VirtualService vertx-greet -n release-dark` to edit the VirtualService resource:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: vertx-greet
  labels:
    kiali_wizard: weighted_routing
spec:
  hosts:
    - "*"
  gateways:
    - vertx-greet-gateway
  http:
    - route:
        - destination:
            host: vertx-greet
            subset: v1
            port:
              number: 8080
  mirror:
    host: vertx-greet
    subset: v2
```

The finished resource is at `/home/student/D0328/solutions/release-dark/vservice-v2.yml`. You can use the `oc apply` command to apply the configuration.

- 4.3. Return to the browser and observe that the amount of traffic sent to v1 is roughly the same. Open a new browser tab to the same URL. Navigate back to the **Istio Workload Dashboard** and select the `release-dark` namespace. This time, select the `vertx-greet-v2` workload.

**Note**

If you do not see the `vertx-greet-v2` workload, then reload the Grafana dashboard. The Grafana dashboard might require several reloads for the new workload to appear.

Review the **Incoming Request Volume** graph. Note the amount of traffic received by the v2 version of the service is the same as the traffic received by the v1 version.

- 5. Mirror 10% of the requests sent to v1 to v2. Visualize in Grafana, and verify v2 receives roughly one tenth of the traffic v1 receives.

- 5.1. Update the `VirtualService` resource to restrict traffic mirroring to 10% by using the `oc edit VirtualService vertx-greet -n release-dark` command:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: vertx-greet
  labels:
    kiali_wizard: weighted_routing
spec:
  hosts:
  - "*"
  gateways:
  - vertx-greet-gateway
  http:
  - mirror:
      host: vertx-greet
      subset: v2
  mirror_percent: 10
```

```
route:
- destination:
  host: vertx-greet
  subset: v1
  port:
    number: 8080
```

The finished resource is at `/home/student/D0328/solutions/release-dark/vservice-v3.yml`. You can use the `oc apply` command to apply the configuration.

- 5.2. Return to your browser. Observe that the traffic sent to `v2` has reduced to one tenth of the traffic received by `v2`. Verify that the traffic sent to `v1` is still the same as before, roughly two requests per second.



### Note

The traffic might temporarily increase to double. This is caused by restarting pods in previous steps. You can wait for the data to normalize, or restrict the time window in your Grafana dashboard.

- ▶ 6. Accept the `v2` version of the service by transferring all traffic to this version. Update the `VirtualService` resource to route all traffic to the `v2` subset. Execute the `oc edit VirtualService vertx-greet -n release-dark` command:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  creationTimestamp: "2020-05-12T10:30:01Z"
  generation: 4
  labels:
    kiali_wizard: weighted_routing
  name: vertx-greet
  namespace: release-dark
spec:
  gateways:
  - vertx-greet-gateway
  hosts:
  - '*'
  http:
  - route:
    - destination:
      host: vertx-greet
      port:
        number: 8080
      subset: v2
```

The finished resource is at `/home/student/D0328/solutions/release-dark/vservice-v4.yml`. You can use the `oc apply` command to apply the configuration.

Confirm that the `v2` service is receiving all traffic by reviewing the `Incoming Request Volume` graph for both versions. The `v1` service receives no requests, while the `v2` service receives all requests.

- 7. Finalize the traffic generation process. In the window terminal running the `watch` command, press `Ctrl+C` to terminate the process. Then, you can close that terminal and the browser window.

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab release-dark finish
```

This concludes the guided exercise.

## ► Lab

# Releasing Applications with OpenShift Service Mesh

### Performance Checklist

In this lab, you will deploy different versions of a service using canary releases, and use service mesh mirroring to perform a dark launch.

### Outcomes

You should be able to:

- Deploy a new version of a service using canary releases and redirect a percentage of traffic to the new version.
- Mirror traffic between two versions of a microservice using Red Hat OpenShift Service Mesh mirroring.

### Before You Begin

To perform this lab, ensure you have:

- A configured and running OpenShift cluster.
- An installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift client (oc) installed on workstation.

You will be using an application that simulates an online payment processor for an e-commerce application in this lab. The application has two microservices:

- **gateway**: Written in Java using the Quarkus framework. It simulates processing of payments using multiple payment gateways like banks, bitcoin, mobile wallets and more. This microservice is specific to this application and is not equivalent to the ingress gateway.
- **payment**: Written in Java using the Quarkus framework. The payment microservice acts as an API gateway and the single point of communication for traffic coming into the service mesh. It communicates with the gateway microservice to process payments.

The source code for the application is available in the `payments` folder in the GitHub repository at <https://github.com/RedHatTraining/DO328-apps>.

On the `workstation` machine, use the `lab` command to prepare your system for this exercise.

```
[student@workstation ~]$ lab release-mesh start
```

The `lab release-mesh start` command creates a new project called `release-mesh`, owned by the `developer` user (the value of the `$RHT_OCP4_DEV_USER` environment variable in your `/usr/local/etc/ocp4.config` file). It deploys an initial version of the `payment` and `gateway` microservices in this project.

You can examine the template that deploys the microservices in the `~/D0328/labs/release-mesh/app-deployment.yaml` file.

## Instructions

1. Verify that the `payment` and `gateway` microservices are deployed and running.
  - 1.1. Run the following command to load the environment variables defined in the guided exercise where you created the lab environment:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

- 1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

- 1.3. Set the current project to `release-mesh`:

```
[student@workstation ~]$ oc project release-mesh
Now using project "release-mesh" on server ...output omitted...
```

- 1.4. Verify that the pods for the initial version(v1) of the `payment` and `gateway` microservices are deployed, and in a `Running` state:

```
[student@workstation ~]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
gateway-v1-5484d6fb59-8vrxf   2/2     Running   0          111s
payment-v1-d74848855-whncc    2/2     Running   0          111s
```

2. Test the initial version (v1) of the `payment` and `gateway` microservices. Invoke the `/pay/{amount}` endpoint relative to the service mesh gateway URL, where the `amount` is an integer value representing a random amount.

You can also use the `test_app.py` script in the `/home/student/D0328/labs/release-mesh` directory to test the application. This script takes the service mesh gateway URL as an argument (`./test_app.py $GW_URL`).

The script sends 50 requests and prints the version, and percentage of traffic processed by each version of the `payment` microservice. It also prints the error rate (if any) during request processing.

Verify that you see the response only from v1 of the `payment` microservice. Verify that all payment requests are processed by v1 of the `gateway` microservice.



### Note

You cannot directly invoke the `gateway` microservice. Inspect the log output from the `gateway` microservice to verify the version of the microservice that is processing the payments.

3. The development team is ready to deploy and test v2 of the payment microservice. This version has several new enhancements that must be tested in a production environment.

You are given an incomplete deployment file. The file is available at `/home/student/D0328/labs/release-mesh/payment-v2-deploy.yaml`

Add the following information to the Deployment resource:

- The Deployment resource has a label `version:v2`.
  - The Deployment resource name is `payment-v2`.
  - The pods managed by the Deployment resource have a label `version: v2`.
  - The application uses the `quay.io/redhattraining/ossp-payment:2.0` container image.
  - The application container name is `payment-v2`.
4. Route 10% of all traffic to v2 of the payment microservice. v1 of the payment microservice should respond to 90% of the traffic.



**Note**

A virtual service resource for the payment microservice was created by the lab start script.

Use the `test_app.py` script to verify the traffic split.

5. The developers are also working on a new version of the gateway microservice. The developers are not yet ready to deploy the new version of the gateway microservice to

process payments. They want to test this new version with real production data and monitor the performance characteristics of the microservice.

You are given an incomplete deployment file. The file is available at `/home/student/D0328/labs/release-mesh/gateway-v2-deploy.yaml`

Add the following information to the `Deployment` resource:

- The `Deployment` resource has a label `version:v2`.
- The `Deployment` resource name is `gateway-v2`.
- The pods managed by the `Deployment` resource have a label `version: v2`.
- The application uses the `quay.io/redhattraining/ossm-gateway:2.0` container image.
- The application container name is `gateway-v2`.

Deploy v2 of the gateway microservice.

Enable mirroring of traffic from v1 of the gateway microservice to v2 of the gateway microservice. v1 of the gateway microservice should still exclusively process all transactions.

Use the `app_test.py` script to test the changes and verify that you do not see any errors. Inspect the log output from both versions of the gateway microservice to verify that all transactions sent to v1 are mirrored to v2.



### Note

A virtual service and destination rule resource has already been created by the lab start script.

6. Return to the home directory.

```
[student@workstation release-mesh]$ cd
```

## Evaluation

Grade your work by running the `lab release-mesh grade` command from your workstation machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab release-mesh grade
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab release-mesh finish
```

This concludes the lab.

## ► Solution

# Releasing Applications with OpenShift Service Mesh

### Performance Checklist

In this lab, you will deploy different versions of a service using canary releases, and use service mesh mirroring to perform a dark launch.

### Outcomes

You should be able to:

- Deploy a new version of a service using canary releases and redirect a percentage of traffic to the new version.
- Mirror traffic between two versions of a microservice using Red Hat OpenShift Service Mesh mirroring.

### Before You Begin

To perform this lab, ensure you have:

- A configured and running OpenShift cluster.
- An installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift client (oc) installed on workstation.

You will be using an application that simulates an online payment processor for an e-commerce application in this lab. The application has two microservices:

- **gateway**: Written in Java using the Quarkus framework. It simulates processing of payments using multiple payment gateways like banks, bitcoin, mobile wallets and more. This microservice is specific to this application and is not equivalent to the ingress gateway.
- **payment**: Written in Java using the Quarkus framework. The payment microservice acts as an API gateway and the single point of communication for traffic coming into the service mesh. It communicates with the gateway microservice to process payments.

The source code for the application is available in the `payments` folder in the GitHub repository at <https://github.com/RedHatTraining/DO328-apps>.

On the `workstation` machine, use the `lab` command to prepare your system for this exercise.

```
[student@workstation ~]$ lab release-mesh start
```

The `lab release-mesh start` command creates a new project called `release-mesh`, owned by the `developer` user (the value of the `$RHT_OCP4_DEV_USER` environment variable in your `/usr/local/etc/ocp4.config` file). It deploys an initial version of the `payment` and `gateway` microservices in this project.

You can examine the template that deploys the microservices in the ~/D0328/labs/release-mesh/app-deployment.yaml file.

## Instructions

1. Verify that the payment and gateway microservices are deployed and running.
  - 1.1. Run the following command to load the environment variables defined in the guided exercise where you created the lab environment:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

- 1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

- 1.3. Set the current project to release-mesh:

```
[student@workstation ~]$ oc project release-mesh
Now using project "release-mesh" on server ...output omitted...
```

- 1.4. Verify that the pods for the initial version(v1) of the payment and gateway microservices are deployed, and in a Running state:

```
[student@workstation ~]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
gateway-v1-5484d6fb59-8vrxf   2/2     Running   0          111s
payment-v1-d74848855-whncc    2/2     Running   0          111s
```

2. Test the initial version (v1) of the payment and gateway microservices. Invoke the /pay/{amount} endpoint relative to the service mesh gateway URL, where the amount is an integer value representing a random amount.

You can also use the test\_app.py script in the /home/student/D0328/labs/release-mesh directory to test the application. This script takes the service mesh gateway URL as an argument (`./test_app.py $GW_URL`).

The script sends 50 requests and prints the version, and percentage of traffic processed by each version of the payment microservice. It also prints the error rate (if any) during request processing.

Verify that you see the response only from v1 of the payment microservice. Verify that all payment requests are processed by v1 of the gateway microservice.



### Note

You cannot directly invoke the gateway microservice. Inspect the log output from the gateway microservice to verify the version of the microservice that is processing the payments.

- 2.1. Save the service mesh gateway URL into a variable:

```
[student@workstation ~]$ GW_URL=$(oc get route istio-ingressgateway \
-n istio-system -o jsonpath='{.spec.host}')
```

- 2.2. Make a request to the /pay/{amount} endpoint of the gateway URL (GW\_URL) to test the application:

```
[student@workstation ~]$ curl $GW_URL/pay/10
[payment-v1] OK. Transaction id is 6493
```

Note the response from v1 of the payment microservice. Your transaction id may be different.

- 2.3. Test the application using the `test_app.py` script.

Do not add any relative endpoints to the gateway URL. It automatically generates a random amount when invoking the payment microservice.

```
[student@workstation ~]$ cd ~/DO328/labs/release-mesh
[student@workstation release-mesh]$ ./test_app.py $GW_URL
Canary Release Test
Sending 50 requests to istio-ingressgateway ...output omitted...
[payment-v1] OK. Transaction id is 9918
[payment-v1] OK. Transaction id is 8137
...output omitted...
[payment-v1] OK. Transaction id is 7685

# Stats #

Total requests: 50
* '[payment-v1] OK' responses: 50 (100.0%)
* Errors: 0 (0.0%)
```

Note that `payment-v1` is used to process all requests.

- 2.4. Use the `oc logs` command to view the logs for the gateway microservice:

```
[student@workstation release-mesh]$ oc get pods -o name | \
grep gateway | xargs oc logs -c gateway-v1
...output omitted...
Processing payment for $10 through gateway-v1...
Processing payment for $0 through gateway-v1...
Processing payment for $1 through gateway-v1...
Processing payment for $2 through gateway-v1...
...output omitted...
Processing payment for $48 through gateway-v1...
Processing payment for $49 through gateway-v1...
```

The logging output shows only the log message and has been trimmed to fit the width of the page. You will see time stamps, the class name, and the logging level printed before the log messages in your console.

Note that `gateway-v1` is processing payments for all requests.

3. The development team is ready to deploy and test v2 of the payment microservice. This version has several new enhancements that must be tested in a production environment.

You are given an incomplete deployment file. The file is available at /home/student/D0328/labs/release-mesh/payment-v2-deploy.yaml

Add the following information to the Deployment resource:

- The Deployment resource has a label `version:v2`.
- The Deployment resource name is `payment-v2`.
- The pods managed by the Deployment resource have a label `version: v2`.
- The application uses the `quay.io/redhattraining/ossm-payment:2.0` container image.
- The application container name is `payment-v2`.

- 3.1. Edit the `payment-v2-deploy.yaml` file and add the following information.

The full deployment YAML resource is also available in the `/home/student/D0328/solutions/release-mesh/payment-v2-deploy.yaml` file.

The YAML resource snippet to deploy v2 is as follows:

```
apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  labels:
    app: payment
    version: v2
  name: payment-v2
spec:
  replicas: 1
  selector:
    matchLabels:
      app: payment
      version: v2
  template:
    metadata:
      labels:
        app: payment
        version: v2
      annotations:
        sidecar.istio.io/inject: "true"
    spec:
      containers:
        - name: payment-v2
          image: quay.io/redhattraining/ossm-payment:2.0
          imagePullPolicy: Always
          ports:
...deployment omitted...
```

Deploy v2 using the `oc create` command.

```
[student@workstation release-mesh]$ oc create -f payment-v2-deploy.yaml
deployment.apps/payment-v2 created
```

- 3.2. Verify that v2 of the payment microservice is deployed and in Running state.

```
[student@workstation release-mesh]$ oc get pods
NAME          READY   STATUS    RESTARTS   AGE
gateway-v1-5484d6fb59-8vrxf   2/2     Running   0          46m
payment-v1-d74848855-whncc   2/2     Running   0          46m
payment-v2-64d475cb84-wc7cc   2/2     Running   0          22s
```

4. Route 10% of all traffic to v2 of the payment microservice. v1 of the payment microservice should respond to 90% of the traffic.



### Note

A virtual service resource for the payment microservice was created by the lab start script.

Use the `test_app.py` script to verify the traffic split.

- 4.1. Create a destination rule resource for the payment microservice.

The full destination rule YAML resource is also available in the `/home/student/D0328/solutions/release-mesh/payment-dest-rule.yaml` file.

The YAML resource snippet to create the destination rule is as follows:

```
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: payment-dr
spec:
  host: payment
  subsets:
    - name: v1
      labels:
        version: v1
    - name: v2
      labels:
        version: v2
```

Create the destination rule using the `oc create` command.

```
[student@workstation release-mesh]$ oc create -f payment-dest-rule.yaml
destinationrule.networking.istio.io/payment-dr created
```

- 4.2. Edit the `payment-vs` virtual service resource.

```
[student@workstation release-mesh]$ oc edit vs payment-vs
```

Split the traffic between v1 and v2.

```
...output omitted...
spec:
  gateways:
    - payment-api-gw
```

```

hosts:
- '*'
http:
- route:
  - destination:
    host: payment
    port:
      number: 8080
    subset: v1
    weight: 90
  - destination:
    host: payment
    port:
      number: 8080
    subset: v2
    weight: 10

```

Save your changes.

The finished resource is available in the `/home/student/D0328/solutions/release-mesh/payment-vs-v2.yaml` file. You can use the `oc apply` command to apply the configuration.

#### 4.3. Test the application using the `test_app.py` script.

```

[student@workstation release-mesh]$ ./test_app.py $GW_URL
...output omitted...
# Stats #

Total requests: 50
* '[payment-v1] OK' responses: 48 (96.0%)
* '[payment-v2] OK' responses: 2 (4.0%)
* Errors: 0 (0.0%)

```



#### Note

The traffic is split between v1 and v2 (approximately 90/10 ratio). The split might not be exact.

5. The developers are also working on a new version of the gateway microservice. The developers are not yet ready to deploy the new version of the gateway microservice to process payments. They want to test this new version with real production data and monitor the performance characteristics of the microservice.

You are given an incomplete deployment file. The file is available at `/home/student/D0328/labs/release-mesh/gateway-v2-deploy.yaml`

Add the following information to the Deployment resource:

- The Deployment resource has a label `version:v2`.
- The Deployment resource name is `gateway-v2`.
- The pods managed by the Deployment resource have a label `version: v2`.
- The application uses the `quay.io/redhattraining/ossm-gateway:2.0` container image.

- The application container name is `gateway-v2`.

Deploy v2 of the `gateway` microservice.

Enable mirroring of traffic from v1 of the `gateway` microservice to v2 of the `gateway` microservice. v1 of the `gateway` microservice should still exclusively process all transactions.

Use the `app_test.py` script to test the changes and verify that you do not see any errors. Inspect the log output from both versions of the `gateway` microservice to verify that all transactions sent to v1 are mirrored to v2.



### Note

A virtual service and destination rule resource has already been created by the lab start script.

- 5.1. Edit the `gateway-v2-deploy.yaml` file and add the following information.

The full deployment YAML resource is also available in the `/home/student/D0328/solutions/release-mesh/gateway-v2-deploy.yaml` file.

The YAML resource snippet to deploy v2 is as follows:

```
apiVersion: extensions/v1beta1
kind: Deployment
metadata:
  labels:
    app: gateway
    version: v2
  name: gateway-v2
spec:
  replicas: 1
  selector:
    matchLabels:
      app: gateway
      version: v2
  template:
    metadata:
      labels:
        app: gateway
        version: v2
    annotations:
      sidecar.istio.io/inject: "true"
  spec:
    containers:
      - name: gateway-v2
        image: quay.io/redhattraining/ossm-gateway:2.0
        imagePullPolicy: Always
        ports:
...output omitted...
```

Deploy v2 using the `oc create` command.

```
[student@workstation release-mesh]$ oc create -f gateway-v2-deploy.yaml
deployment.apps/gateway-v2 created
```

- 5.2. Verify that v2 of the gateway microservice is deployed and in Running state.

```
[student@workstation release-mesh]$ oc get pods
NAME          READY   STATUS    RESTARTS   AGE
gateway-v1-5484d6fb59-8vrxf  2/2     Running   0          64m
gateway-v2-f4dc796bd-c72zc  2/2     Running   0          49s
payment-v1-d74848855-whncc  2/2     Running   0          64m
payment-v2-64d475cb84-wc7cc 2/2     Running   0          18m
```

- 5.3. Edit the destination rule for the gateway microservice and add details for v2. You can get the name of the destination rule resource using the `oc get dr` command.

```
[student@workstation release-mesh]$ oc edit dr gateway-dr
```

Add the details for v2 as follows:

```
...output omitted...
spec:
  host: gateway
  subsets:
  - labels:
      version: v1
      name: v1
  - labels:
      version: v2
      name: v2
```

Save your changes. The finished resource is available in the `/home/student/D0328/solutions/release-mesh/gateway-dr.yaml` file. You can use the `oc apply` command to apply the configuration.

- 5.4. Edit the virtual service for the gateway microservice and enable mirroring. You can get the name of the virtual service resource using the `oc get vs` command.

```
[student@workstation release-mesh]$ oc edit vs gateway-vs
```

Enable mirroring as follows:

```
...output omitted...
spec:
  gateways:
  - payment-api-gw
  hosts:
  - gateway
  http:
  - mirror:
      host: gateway
      subset: v2
    route:
    - destination:
        host: gateway
        subset: v1
        weight: 100
```

Save your changes. The finished resource is available in the `/home/student/D0328/solutions/release-mesh/gateway-vs-v2.yaml` file. You can use the `oc apply` command to apply the configuration.

- 5.5. Test the application using the `test_app.py` script.

```
[student@workstation release-mesh]$ ./test_app.py $GW_URL
...output omitted...
# Stats #

Total requests: 50
* '[payment-v1] OK' responses: 44 (88.0%)
* '[payment-v2] OK' responses: 6 (12.0%)
* Errors: 0 (0.0%)
```

Note that the traffic split between v1 and v2 remains the same (approximately 90/10 ratio) as configured earlier.

- 5.6. Use the `oc logs` command to view the logs for both versions of the `gateway` microservice. Get the pod names from the `oc get pods` command.

```
[student@workstation release-mesh]$ oc get pods -o name | \
grep gateway-v1 | xargs oc logs -c gateway-v1
...output omitted...
Processing payment for $0 through gateway-v1...
Processing payment for $1 through gateway-v1...
Processing payment for $2 through gateway-v1...
...output omitted...
Processing payment for $48 through gateway-v1...
Processing payment for $49 through gateway-v1...
```

```
[student@workstation release-mesh]$ oc get pods -o name | \
grep gateway-v2 | xargs oc logs -c gateway-v2
...output omitted...
Processing payment for $0 through gateway-v2...
Processing payment for $1 through gateway-v2...
Processing payment for $2 through gateway-v2...
...output omitted...
Processing payment for $48 through gateway-v2...
Processing payment for $49 through gateway-v2...
```

The logging output shows only the log message, and has been trimmed to fit the width of the page. Notice the time stamps, the class name, and the logging level printed before the log messages in your console.

Note that all requests sent to `gateway-v1` are mirrored to `gateway-v2`.

6. Return to the home directory.

```
[student@workstation release-mesh]$ cd
```

## Evaluation

Grade your work by running the `lab release-mesh grade` command from your `workstation` machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab release-mesh grade
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab release-mesh finish
```

This concludes the lab.

# Summary

---

In this chapter, you learned:

- Red Hat OpenShift Service Mesh supports canary releases. You can control the percentage of traffic sent to new versions of microservices.
- You can configure traffic routing to specific versions based on URL and HTTP header matching.
- Kiali can be used to visualize the traffic flow in the service mesh and to configure weighted routing.
- Red Hat OpenShift Service Mesh supports traffic mirroring to perform dark launches. You can use this feature to test newer versions of your microservices without impacting currently running services in production.



## Chapter 6

# Testing Service Resilience with Chaos Testing

### Goal

Test the resilience of an OpenShift Service Mesh with Chaos Testing.

### Objectives

- Create test errors to identify weaknesses in your application.
- Create a delay in your services to test for weaknesses in your application.

### Sections

- Throwing HTTP Errors (and Guided Exercise)
- Creating Delays in Services (and Guided Exercise)

### Lab

Testing Service Resilience with Chaos Testing

# Throwing HTTP Errors

## Objectives

After completing this section, you should be able to create test errors to identify weaknesses in your application.

## Chaos Testing

Although microservice-based applications are highly scalable, they also suffer from common problems or fallacies associated with distributed computing.

There are eight fallacies of distributed computing. In this lecture, we will focus on two of the most common in general use cases.

- The network is reliable.
- There is zero latency.

These two assumptions must be addressed because network instability occurs and, if not dealt with, can create unpredictable application behavior.

For example, presenting unexpected errors to the user, or silently ignoring errors without sending any notifications.

To validate how applications respond to network instability, you can introduce chaos to simulate network instability.

Chaos Testing is the process of testing a microservices-based application in production or in an environment similar to production by introducing random errors to verify that the steps taken to handle these problems are correct.

Netflix coined the term Chaos Testing to refer to the techniques they used to test their systems in production, aimed at verifying that all their complex applications behaved as expected in the event of network errors. Netflix engineers resorted to these techniques because they knew that network errors and instability are inevitable.

You can use service mesh traffic management capabilities to introduce latency spikes or connection errors in your application so that you can perform chaos testing.

## Throwing HTTP Errors

Use the `HTTPFaultInjectionAbort` object on path spec `.http.fault.abort` to inject errors into the `VirtualService`.

The `Abort` object requires two configuration values:

### **HttpStatus**

HTTP status code returned on abort

### **percentage**

Percentage of total requests to abort

The `httpStatus` value is the literal number representing the HTTP status code. If you want to return an Internal Server Error then use:

```
httpStatus: 500
```

The percentage is configured using a `double` value, ranging from 0.0 for a 0% and 100.0 for 100%.

For example, if you want to drop 20% of the connections to `example-svc` from other services and return the `Bad Request` error, you can use a code like this in the Virtual Service:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: example-vs
spec:
  hosts:
    - example-svc
  http:
    - route:
        - destination:
            host: example-svc
            subset: v1
        fault: ①
        abort: ②
        percentage: ③
        value: 20.0
      httpStatus: 400 ④
```

- ① The `HTTPFaultInjection` configuration object responsible for all the faults injected into the service.
- ② The `HTTPFaultInjectionAbort` configuration object responsible for the error injection configuration.
- ③ Percentage of the connections to abort.
- ④ The HTTP status code to return on abort.

When testing your application with HTTP errors, the percentage of failed requests can be lower than your configured value. This is because the virtual service resources contain automatic retries of failed requests.

For more information about retries, see [Configuring Retry](#).



## References

### Istio 1.6 / Fault Injection

<https://istio.io/v1.6/docs/tasks/traffic-management/fault-injection/>

### Istio 1.6 / Virtual Service / HTTPFaultInjectionAbort

<https://istio.io/v1.6/docs/reference/config/networking/virtual-service/#HTTPFaultInjection-Abort>

### Fallacies of distributed computing

[https://en.wikipedia.org/wiki/Fallacies\\_of\\_distributed\\_computing](https://en.wikipedia.org/wiki/Fallacies_of_distributed_computing)

### Chaos engineering

[https://en.wikipedia.org/wiki/Chaos\\_engineering](https://en.wikipedia.org/wiki/Chaos_engineering)

## ► Guided Exercise

# Throwing HTTP Errors

In this exercise, you will set up Service Mesh to throw errors in an application route and verify these errors.

### Outcomes

You should be able to set up a route to throw HTTP errors.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the `student` user on the `workstation` machine, use the `lab` command to prepare your system for this exercise.

This command ensures that the application is deployed in the cluster to test its behavior.

The source code is in the Git repository at <https://github.com/RedHatTraining/D0328-apps/> in the `customer`, `preference`, and `recommendation` directories.

```
[student@workstation ~]$ lab chaos-error start
```

### Instructions

► 1. Log in to OpenShift and verify that the sample project deployed successfully.

- 1.1. Run the following command to load the environment variables created in the Verifying OpenShift Credentials guided exercise:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

- 1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

- 1.3. Change to project `chaos-error`:

```
[student@workstation ~]$ oc project chaos-error
Now using project "chaos-error" on server ...
```

- 1.4. Verify that pods are ready:

```
[student@workstation ~]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
customer-6948b8b959-cl5zf   2/2     Running   0          11s
preference-6d5d86cb79-9cjkv  2/2     Running   0          11s
recommendation-69db8d6c48-wrkc6 2/2     Running   0          11s
```

- 1.5. Save the ingress-gateway route host name with the /chaos endpoint into a variable:

```
[student@workstation ~]$ INGRESS_URL=$(oc get route -n istio-system \
istio-ingressgateway -o jsonpath='{.spec.host}'/chaos)
```

- 1.6. Verify that the service responds using the INGRESS\_URL variable:

```
[student@workstation ~]$ for i in {1..10};do curl $INGRESS_URL; done
customer => preference => recommendation v1 from 'f11b097f1dd0': 1
customer => preference => recommendation v1 from 'f11b097f1dd0': 2
customer => preference => recommendation v1 from 'f11b097f1dd0': 3
customer => preference => recommendation v1 from 'f11b097f1dd0': 4
customer => preference => recommendation v1 from 'f11b097f1dd0': 5
customer => preference => recommendation v1 from 'f11b097f1dd0': 6
customer => preference => recommendation v1 from 'f11b097f1dd0': 7
customer => preference => recommendation v1 from 'f11b097f1dd0': 8
customer => preference => recommendation v1 from 'f11b097f1dd0': 9
customer => preference => recommendation v1 from 'f11b097f1dd0': 10
```

- ▶ 2. Edit the recommendation VirtualService and configure it to always throw the HTTP error 500:

```
[student@workstation ~]$ oc edit virtualservice recommendation
```

Add this after the route section under the http block with this fault section:

```
fault:
  abort:
    httpStatus: 500
    percentage:
      value: 50.0
```

The spec section should look like:

```
spec:
  hosts:
  - recommendation
  http:
  - route:
    - destination:
      host: recommendation
  fault:
    abort:
```

```
httpStatus: 500
percentage:
  value: 50.0
```

Save the file to update the VirtualService.

If you have trouble editing the VirtualService, then you can find the new VirtualService definition in the file D0328/solutions/chaos-error/vs-recommendation-error.yml. Apply this definition by using the following command:

```
[student@workstation ~]$ oc replace -f
D0328/solutions/chaos-error/vs-recommendation-error.yml
virtualservice.networking.istio.io/recommendation replaced
```

- ▶ 3. To verify that the recommendation application is throwing random errors, repeat the previous service verification:

```
[student@workstation ~]$ for i in {1..10};do curl $INGRESS_URL; done
customer => preference => recommendation v1 from 'f11b097f1dd0': 11
customer => Error: 503 - preference => Error: 500 - fault filter abort
customer => Error: 503 - preference => Error: 500 - fault filter abort
customer => preference => recommendation v1 from 'f11b097f1dd0': 14
customer => preference => recommendation v1 from 'f11b097f1dd0': 15
customer => Error: 503 - preference => Error: 500 - fault filter abort
customer => Error: 503 - preference => Error: 500 - fault filter abort
customer => Error: 503 - preference => Error: 500 - fault filter abort
customer => preference => recommendation v1 from 'f11b097f1dd0': 19
customer => preference => recommendation v1 from 'f11b097f1dd0': 20
```



### Note

By default, Istio retries each request twice. To clearly show how abort injections result in errors, retries are deactivated in this exercise.

If no errors are thrown in the first ten requests, then redo the test to see the errors.

## Finish

On the workstation machine, use the lab command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab chaos-error finish
```

This concludes the guided exercise.

# Creating Delays in Services

---

## Objectives

After completing this section, you should be able to create a delay in your services to test for weaknesses in your application.

## Creating Delays in Services

The second distributed computing fallacy is network latency, which can spike at any moment. Similar to network errors, network latency must be tested in your application to avoid unexpected errors. During chaos testing you can inject artificial delays into services to simulate latency, verifying that the application handles these problems gracefully.

You can inject delay errors independently or in parallel with connection errors. Red Hat recommends that you perform both types of tests.

To inject delays in a `VirtualService` resource, use the `HTTPFaultInjection.Delay` object inside the `HTTPFaultInjection` configuration object.

The `Delay` object requires two configuration values:

### **fixedDelay**

Delay to add to the connection.

### **percentage**

Percentage of total requests into which the delay is injected.

You can declare the `fixedDelay` value in hours, minutes, seconds, and milliseconds (h/m/s/ms).

```
fixedDelay: 1h
```

The `percentage` value is a double value, ranging from 0.0 for a 0% and 100.0 for 100%.

For example, to add a 400 milliseconds delay to 10% of connections to the `example-svc` service, you can use the following:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: example-vs
spec:
  hosts:
    - example-svc
  http:
    - route:
        - destination:
            host: example-svc
            subset: v1
        fault: ①
        delay: ②
```

```
percentage: ③  
  value: 10.0  
fixedDelay: 400ms ④
```

- ① The `HTTPFaultInjection` configuration object responsible for injecting faults into the service.
- ② The `HTTPFaultInjection.Delay` configuration object responsible for the delay injection configuration.
- ③ Percentage of the connections to delay.
- ④ Amount of time to delay the connection.



## References

### Istio 1.6 / Fault Injection

<https://istio.io/v1.6/docs/tasks/traffic-management/fault-injection/>

### Istio 1.6 / Virtual Service / HTTPFaultInjection.Delay

<https://istio.io/v1.6/docs/reference/config/networking/virtual-service/#HTTPFaultInjection-Delay>

## ► Guided Exercise

# Creating Service Delays

In this exercise, you will set up Services Mesh to add and verify delays in an application route.

### Outcomes

You should be able to set up a delay in a route.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the student user on the workstation machine, use the `lab` command to prepare your system for this exercise.

This command ensures that the microservices application is deployed in the cluster to test its behavior.

The source code is in the Git repository at <https://github.com/RedHatTraining/DO328-apps/> in the customer, preference, and recommendation directories.

```
[student@workstation ~]$ lab chaos-delay start
```

### Instructions

► 1. Log in to OpenShift and verify that the sample project is successfully deployed.

1.1. Run the following command to load the environment variables created in the Verifying OpenShift Credentials guided exercise:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

1.3. Change to project `chaos-delay`:

```
[student@workstation ~]$ oc project chaos-delay
Now using project "chaos-delay" on server ...
```

- 1.4. Verify that pods are ready:

```
[student@workstation ~]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
customer-69d5499fc4-h77bx   2/2     Running   0          11s
preference-558cf4f584-9bpd5  2/2     Running   0          11s
recommendation-c495d86d7-4h8rf 2/2     Running   0          11s
```

- 1.5. Save the ingress-gateway route host name with the /delay endpoint into a variable:

```
[student@workstation ~]$ INGRESS_URL=$(oc get route -n istio-system \
istio-ingressgateway -o jsonpath='{.spec.host}'/delay)
```

- 1.6. Verify that the service responds using the INGRESS\_URL variable:

```
[student@workstation ~]$ for i in {1..10};do curl -m 2 $INGRESS_URL; done
customer => preference => recommendation v1 from 'f11b097f1dd0': 1
customer => preference => recommendation v1 from 'f11b097f1dd0': 2
customer => preference => recommendation v1 from 'f11b097f1dd0': 3
customer => preference => recommendation v1 from 'f11b097f1dd0': 4
customer => preference => recommendation v1 from 'f11b097f1dd0': 5
customer => preference => recommendation v1 from 'f11b097f1dd0': 6
customer => preference => recommendation v1 from 'f11b097f1dd0': 7
customer => preference => recommendation v1 from 'f11b097f1dd0': 8
customer => preference => recommendation v1 from 'f11b097f1dd0': 9
customer => preference => recommendation v1 from 'f11b097f1dd0': 10
```

## ▶ 2. Edit the recommendation VirtualService and configure it to add a delay of 7 seconds:

```
[student@workstation ~]$ oc edit virtualservice recommendation
```

Add this after the route section under the http block with this fault section:

```
fault:
  delay:
    percentage:
      value: 50
    fixedDelay: 7s
```

The spec section should look like:

```
spec:
  hosts:
    - recommendation
  http:
    - route:
        - destination:
            host: recommendation
  fault:
    delay:
```

```
percentage:  
  value: 50  
fixedDelay: 7s
```

Save the file to perform the update of the VirtualService.

If you have any trouble editing the VirtualService, then you can find the new VirtualService definition in the file D0328/solutions/chaos-delay/vs-recommendation-delayed.yml. Apply this definition with the following command:

```
[student@workstation ~]$ oc replace -f  
D0328/solutions/chaos-delay/vs-recommendation-delayed.yml  
virtualservice.networking.istio.io/recommendation replaced
```

- 3. To verify that the recommendation service is disrupting the flow of the application, repeat the previous verification with a timeout of 2 seconds:

```
[student@workstation ~]$ for i in {1..10};do curl -m 2 $INGRESS_URL; done  
customer => preference => recommendation v1 from 'f11b097f1dd0': 1  
curl: (28) Operation timed out after 2001 milliseconds with 0 bytes received  
curl: (28) Operation timed out after 2001 milliseconds with 0 bytes received  
curl: (28) Operation timed out after 2001 milliseconds with 0 bytes received  
customer => preference => recommendation v1 from 'f11b097f1dd0': 5  
curl: (28) Operation timed out after 2001 milliseconds with 0 bytes received  
curl: (28) Operation timed out after 2001 milliseconds with 0 bytes received  
customer => preference => recommendation v1 from 'f11b097f1dd0': 8  
customer => preference => recommendation v1 from 'f11b097f1dd0': 9  
customer => preference => recommendation v1 from 'f11b097f1dd0': 10
```

## Finish

On the workstation machine, use the lab command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab chaos-delay finish
```

This concludes the guided exercise.

## ► Lab

# Testing Service Resilience with Chaos Testing

### Performance Checklist

In this lab, you will simulate network issues to test application resilience and graceful handling of network issues.

### Outcomes

You should be able to use OpenShift Service Mesh to simulate network failures and delays.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the student user on the workstation machine, use the `lab` command to prepare your system for this lab.

The `lab` command deploys the exchange application into your Red Hat OpenShift cluster. The source code is in the Git repository at <https://github.com/RedHatTraining/DO328-apps> in the `exchange-application` directory.

The exchange application consists of the following services:

- Frontend
- Currency
- Exchange
- History

You can examine the services in the `chaos-mesh` project. The application is available using the `istio-ingressgateway` route at the `/frontend` endpoint.

```
[student@workstation ~]$ lab chaos-mesh start
```

### Instructions

1. Log in to OpenShift and verify that the application is ready.
  - 1.1. Run the following command to load the environment variables created in the Verifying OpenShift Credentials guided exercise:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

1.3. Change to project chaos-mesh:

```
[student@workstation ~]$ oc project chaos-mesh
Now using project "chaos-mesh" on server ...
```

1.4. Verify that pods are in the Running state:

```
[student@workstation ~]$ oc get pods
NAME           READY   STATUS    RESTARTS   AGE
currency-566cddc8c6-jtd5g  2/2     Running   0          13s
exchange-66b78bf65c-s72gv  2/2     Running   0          13s
frontend-5648fbb85f-td5dg  2/2     Running   0          13s
history-54b5c9d476-rk4pd   2/2     Running   0          13s
```

1.5. Save the ingress-gateway route hostname with the /frontend endpoint into a variable:

```
[student@workstation ~]$ FRONTEND=$(oc get route -n istio-system \
istio-ingressgateway -o jsonpath='{.spec.host}'/frontend)
```

1.6. Verify that the application responds using the FRONTEND variable:

```
[student@workstation ~]$ firefox $FRONTEND
```

1.7. Verify that the Historical Data page of the application works. Open the page:

```
[student@workstation ~]$ firefox $FRONTEND/history
```

On the Historical Data page, click Submit.

1.8. Verify that the Exchange page of the application works. Open the page:

```
[student@workstation ~]$ firefox $FRONTEND/exchange
```

On the Exchange page, click Submit.

2. Introduce a delay fault to the exchange-vservice virtual service resource with the following parameters:

- Delay time: 10s.
- The fault should influence 20% of all requests to the exchange-vservice virtual service.

With the delay fault in place, test how the `frontend` application responds to large delay times.

3. Introduce an abort fault to the `exchange-vservice` virtual service resource with the following parameters:

- HTTP error code: 500.

The fault should influence 30% of all requests to the `exchange-vservice` virtual service.

With the abort fault in place, test how the `frontend` application reacts to HTTP errors.

4. Optionally, update the `frontend` deployment to use the `quay.io/redhattraining/ossm-frontend:3.0` image.

With both the delay and abort faults in place, test how the new application handles the injected network issues.

## Evaluation

Grade your work by running the `lab chaos-mesh grade` command from your workstation machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab chaos-mesh grade
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab chaos-mesh finish
```

This concludes the lab.

## ► Solution

# Testing Service Resilience with Chaos Testing

### Performance Checklist

In this lab, you will simulate network issues to test application resilience and graceful handling of network issues.

### Outcomes

You should be able to use OpenShift Service Mesh to simulate network failures and delays.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the student user on the workstation machine, use the `lab` command to prepare your system for this lab.

The `lab` command deploys the exchange application into your Red Hat OpenShift cluster. The source code is in the Git repository at <https://github.com/RedHatTraining/DO328-apps> in the `exchange-application` directory.

The exchange application consists of the following services:

- Frontend
- Currency
- Exchange
- History

You can examine the services in the `chaos-mesh` project. The application is available using the `istio-ingressgateway` route at the `/frontend` endpoint.

```
[student@workstation ~]$ lab chaos-mesh start
```

### Instructions

1. Log in to OpenShift and verify that the application is ready.
  - 1.1. Run the following command to load the environment variables created in the Verifying OpenShift Credentials guided exercise:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

1.3. Change to project chaos-mesh:

```
[student@workstation ~]$ oc project chaos-mesh
Now using project "chaos-mesh" on server ...
```

1.4. Verify that pods are in the Running state:

```
[student@workstation ~]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
currency-566cddc8c6-jtd5g  2/2     Running   0          13s
exchange-66b78bf65c-s72gv  2/2     Running   0          13s
frontend-5648fbb85f-td5dg  2/2     Running   0          13s
history-54b5c9d476-rk4pd   2/2     Running   0          13s
```

1.5. Save the ingress-gateway route hostname with the /frontend endpoint into a variable:

```
[student@workstation ~]$ FRONTEND=$(oc get route -n istio-system \
istio-ingressgateway -o jsonpath='{.spec.host}'/frontend)
```

1.6. Verify that the application responds using the FRONTEND variable:

```
[student@workstation ~]$ firefox $FRONTEND
```

1.7. Verify that the Historical Data page of the application works. Open the page:

```
[student@workstation ~]$ firefox $FRONTEND/history
```

On the Historical Data page, click Submit.

1.8. Verify that the Exchange page of the application works. Open the page:

```
[student@workstation ~]$ firefox $FRONTEND/exchange
```

On the Exchange page, click Submit.

2. Introduce a delay fault to the exchange-vservice virtual service resource with the following parameters:

- Delay time: 10s.

- The fault should influence 20% of all requests to the exchange-vservice virtual service.

With the delay fault in place, test how the frontend application responds to large delay times.

- 2.1. Edit the exchange-vservice virtual service resource. You can use the ~/DO328/solutions/chaos-mesh/vservice-delay.yaml. Alternatively, add the delay fault manually:

```
[student@workstation ~]$ oc edit virtualservice exchange-vservice
```

Add the following fault section to the first object in the .spec.http path:

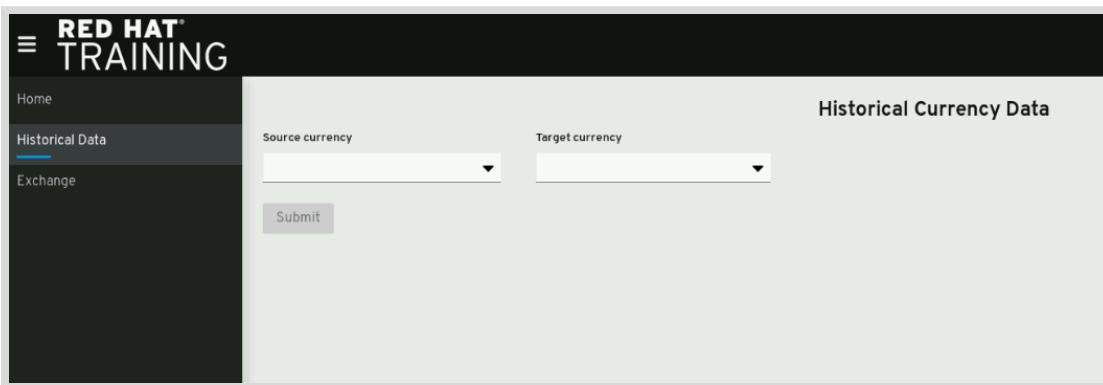
```
http:
- match:
  - uri:
    prefix: /exchange
  rewrite:
    uri: /
  route:
  - destination:
    host: exchange
    port:
      number: 8080
  fault:
    delay:
      fixedDelay: 10s
      percentage:
        value: 20
```

Save the file to update the virtual service.

- 2.2. Retest the application. Open the Historical Data page:

```
[student@workstation ~]$ firefox $FRONTEND/history
```

Refresh the Historical Data page until you encounter the delay. You will notice the delay by looking at the Submit button, which can not be clicked. The Source currency and Target currency are also empty because the application is waiting for the available currencies.



**Figure Error.1: Delay while fetching currencies**

The application waits until the delay is resolved. This is suboptimal in case of a non-responsive service, and is considered a bug in the application.

3. Introduce an abort fault to the exchange-vservice virtual service resource with the following parameters:

- HTTP error code: 500.

The fault should influence 30% of all requests to the exchange-vservice virtual service.

With the abort fault in place, test how the **frontend** application reacts to HTTP errors.

- 3.1. Edit the exchange-vservice virtual service resource. You can use the `~/D0328/solutions/chaos-mesh/vservice-abort.yaml`. Alternatively, add the delay fault manually:

```
[student@workstation ~]$ oc edit virtualservice exchange-vservice
```

Add the following abort section into the already existing fault section:

```
fault:  
  delay:  
    fixedDelay: 10s  
    percentage:  
      value: 20  
  abort:  
    percentage:  
      value: 30  
    httpStatus: 500
```

- 3.2. Retest the application. Open the **Historical Data** page:

```
[student@workstation ~]$ firefox $FRONTEND/history
```

- 3.3. Open the Firefox developer console. Right-click anywhere on the web page. Then, click **Inspect Element**.

In the **Inspector** window, click **Console**.

- 3.4. With the developer console open, refresh the page until you see the following error:

```
SyntaxError: "JSON.parse: unexpected keyword at line 1 column 1 of the JSON data"
```

The application does not inform the user about any network errors. It fails silently and prints errors only into the developer console.

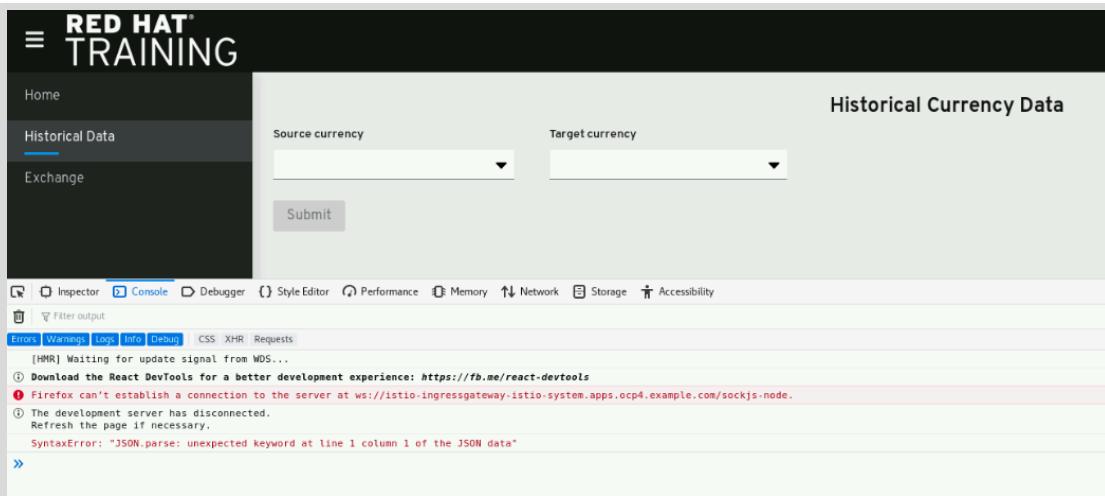


Figure Error.2: Abort while fetching currencies

This behavior leads to user confusion and is considered a bug.

4. Optionally, update the frontend deployment to use the `quay.io/redhattraining/ossm-frontend:3.0` image.

With both the delay and abort faults in place, test how the new application handles the injected network issues.

#### 4.1. Update the frontend deployment:

```
[student@workstation ~]$ oc edit deployment frontend
```

Change the image version in the `.spec.template.spec.containers[0].image` path:

```
spec:
  containers:
  - env:
    - name: REACT_APP_GW_ENDPOINT
      valueFrom:
        configMapKeyRef:
          key: GW_ADDR
          name: frontend-cm
  image: quay.io/redhattraining/ossm-frontend:3.0
```

Save the file to update the deployment.

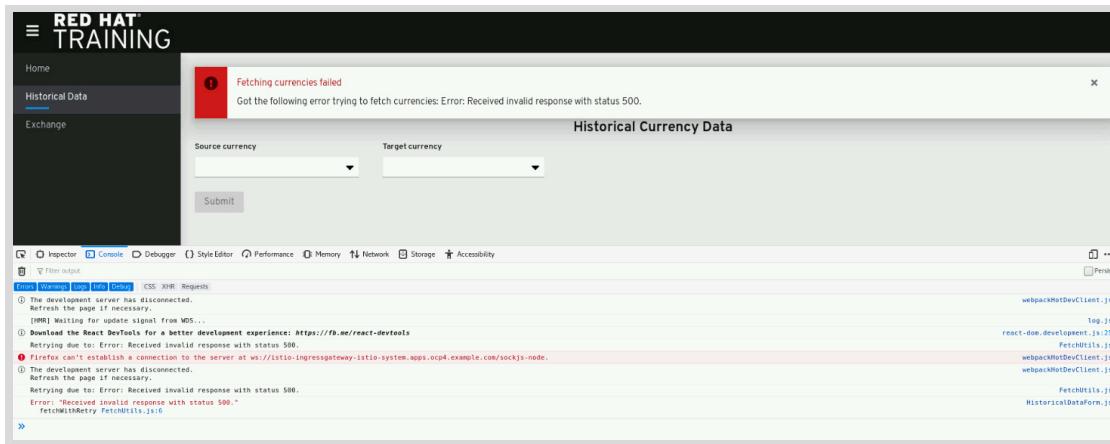
#### 4.2. Verify that the frontend pod is in the Running state:

```
[student@workstation ~]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
currency-c6879ff94-d7xdr   2/2     Running   0          151m
exchange-b8bb857cd-7xl6l   2/2     Running   0          151m
frontend-847f8bb99f-h4ssf  2/2   Running  0          40s
history-548b7f4954-jdj8r8  2/2     Running   0          151m
```

#### 4.3. Retest the application. Open the Historical Data page:

```
[student@workstation ~]$ firefox $FRONTEND/history
```

Refresh the page until you get the following user-friendly error message in your web browser



**Figure Error.3: Abort while fetching currencies in a user-friendly way**

Note the following:

- Because of time-out, no request takes longer than 3 seconds. After 3 seconds, the request is discarded and another request is issued.

The time-out pattern addresses long delays.

- When the exchange service returns a 5xx response, requests are re-executed up to 3 times.

The retry pattern addresses service and network unreliability.

- When the application encounters more than 3 errors, the last error is propagated to the user.

## Evaluation

Grade your work by running the `lab chaos-mesh grade` command from your `workstation` machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab chaos-mesh grade
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab chaos-mesh finish
```

This concludes the lab.

# Summary

---

In this chapter, you learned:

- How to inject random errors into services to test the application resilience to network errors.
- How to inject random delays into network connections to test an application's behavior when faced with network latency.
- How to use errors and delays to perform Chaos Testing.

## Chapter 7

# Building Resilient Services

### Goal

Leverage OpenShift Service Mesh strategies for creating resilient services.

### Objectives

- Describe the strategies for creating resilient services with Service Mesh.
- Configure time-outs to maintain service reliability.
- Configure a service retry to maintain service reliability.
- Configure a circuit breaker pattern to maintain service reliability.

### Sections

- Describing Strategies for Resilient Services with OpenShift Service Mesh (and Quiz)
- Configuring Time-outs (and Guided Exercise)
- Configuring Retry (and Guided Exercise)
- Configuring a Circuit Breaker (and Guided Exercise)

### Lab

Building Resilient Services

# Describing Strategies for Resilient Services with OpenShift Service Mesh

## Objectives

After completing this section, you should be able to describe the strategies for creating resilient services with Service Mesh.

## Describing Strategies for Resilience

As discussed in *Chapter 6, Testing Service Resilience with Chaos Testing*, microservices-based architectures are subject to the negative effects of distributed computing, such as:

- unreliable networks
- transport costs
- latencies

Therefore, assume that applications will experience problems and outages.

Preparing for resilience is a way to make applications more reliable and ready to overcome some of these challenges. Istio takes reliability into account and includes resilience features as a part of its traffic management model. In particular, virtual services and destination rules enable you to configure flexible resilience strategies at different levels, such as the service level or the subset level.

Resilience strategies include:

### Load balancing

Use load balancing to prevent service overloads by distributing the load among several service replicas sufficient to handle the load. To achieve resiliency with load balancing, you must have at least one redundant replica. Thus, if a replica fails, then the load balancer can redistribute all traffic among the rest of the healthy replicas without overwhelming them.

### Time-outs

When making a request to a service, you might encounter errors, such as a slow-down or failure in the service or network.

Instead of waiting indefinitely when these errors occur, establish a time-out after which the request is rejected. Setting a time-out helps applications release resources that are blocked waiting for a response. It also protects the whole system against cascading failures.

### Retries

Services might be temporarily unavailable due to transient problems, such as network outages or momentary overloads. To address this situation, configure Istio to retry the initially failed request a given number of times.

A request that would otherwise fail due to a momentary problem can eventually succeed.

### Circuit breakers

When a service approaches its throughput capacity, additional requests can start failing. You can configure a circuit breaker to stop sending traffic to such service. The request fails fast and you protect the service from becoming overloaded, which can cause instability.

Istio enables you to configure circuit breakers statically and dynamically. You can define static connection and request limits to protect a service against high loads. The dynamic mechanism uses outlier detection, which monitors the status of each service host and stops sending traffic to hosts that become unhealthy.

## Implementing Service Resilience with Load Balancing

One way of implementing service resilience is to distribute the load among multiple replicas of the same service. If one of the replicas experiences a failure, then the load balancer removes that replica from its pool and distributes the load among the healthy nodes. To be resilient, the service must have at least one redundant replica, which is known as the  $N+1$  redundancy rule.

For example, if a service receives 50 requests per second, and each replica can handle 10 requests per second, then the minimum number of replicas to be resilient is six. If one of the replicas fails, then the service still has five replicas that can handle 100% of the load.

To configure load balancing for resilience at the service level, you must use the `DestinationRule` configuration resource. Specifically, you must set the value of the `spec.trafficPolicy.loadBalancer.simple` field to one of the following algorithms:

### **ROUND\_ROBIN**

Requests are sent to each host in turn to distribute the load evenly. This is the default algorithm.

### **RANDOM**

Requests are sent to hosts randomly. Under high loads, requests are distributed randomly across instances.

### **LEAST\_CONN**

Requests are sent to a host with few connections. This algorithm picks two random hosts and chooses the host with the fewest active connections.

The following is an example of a destination rule that uses the least requested load balancer:

```
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: my-destination-rule ①
spec:
  host: my-svc②
  trafficPolicy: ③
    loadBalancer:
      simple: LEAST_CONN④
```

- ①** Name of the destination rule.
- ②** Service affected by the defined policies.
- ③** Traffic policy defined for the `my-svc` service.
- ④** Load balancing algorithm name.

You can also define load balancing policies at the subset level, applying specific load balancers to different versions of the same service. The following example shows how to specify load balancing features both at the service and the subset level for a specific version:

```

apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: my-destination-rule
spec:
  host: my-svc
  trafficPolicy: ①
    loadBalancer:
      simple: LEAST_CONN
  subsets:
    - name: v1
      labels:
        version: v1
    - name: v2
      labels:
        version: v2
      trafficPolicy: ②
        loadBalancer:
          simple: RANDOM

```

- ① Traffic policy that applies the LEAST\_CONN load balancer to the service.
- ② Traffic policy that applies the RANDOM load balancer to the v2 subset, overriding the policy at the service level.

## Consistent Hash Load Balancing

Istio includes a more advanced load balancing algorithm called Consistent Hash-based load balancing. This load balancer provides soft session affinity by mapping HTTP headers, cookies, or source IP to a particular service host. When hosts are added to or removed from the service, the affinity is lost.

You can use this load balancer to keep a user session on a host when you want all requests from that user to go to the same host. The following example demonstrates using the `session_id` cookie as the hash key to apply this strategy:

```

apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: my-destination-rule
spec:
  host: my-svc
  trafficPolicy:
    loadBalancer:
      consistentHash:
        httpCookie:
          name: session_id
          ttl: 0s

```

Similarly, you can use the same approach with other HTTP headers or cookies. For example, you can distribute the load based on the requested endpoint.

Because Consistent Hash-based load balancing establishes affinity between request data and specific hosts, this type of load balancing can lead to host overload when your traffic is

unbalanced. For example, demanding users generating high loads, or popular endpoints receiving much more load than other endpoints may cause this overload.



## References

### N+1 redundancy

[https://en.wikipedia.org/wiki/N%2B1\\_redundancy](https://en.wikipedia.org/wiki/N%2B1_redundancy)

### Istio Docs: Traffic Management

<https://istio.io/v1.6/docs/concepts/traffic-management/>

### Istio Docs: LoadBalancerSettings

<https://istio.io/v1.6/docs/reference/config/networking/destination-rule/#LoadBalancerSettings>

For more information, refer to the *Traffic management* section in the *Red Hat Service Mesh Guide* at

[https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.6/html-single/service\\_mesh/index](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.6/html-single/service_mesh/index)

## ► Quiz

# Describing Strategies for Resilient Services with OpenShift Service Mesh

Choose the correct answers to the following questions:

- 1. Which three strategies can be used to implement service resiliency in OpenShift Service Mesh? (Choose three.)
- a. Canary releases.
  - b. Load balancing.
  - c. Time-outs.
  - d. Distributed tracing.
  - e. Circuit breakers.
- 2. Your networking provider is experiencing problems that affect your cluster. These problems cause outages in the network that last for less than a second. As a result, a small percentage of requests directed to your services fail. Which resilience strategy can make the failing requests succeed?
- a. Load balancing.
  - b. Circuit breaker.
  - c. Retries.
  - d. Time-outs.
- 3. You are deploying an application on OpenShift Service Mesh. You estimate that the application will receive an average of 30 requests per second. Assuming that the application can handle up to 10 requests per second, what is a good strategy for resilience?
- a. Scale the service to 4 replicas and balance the load among them.
  - b. Scale the service to 3 replicas and balance the load among them.
  - c. Limit the load to 10 requests per second with a circuit breaker.
  - d. Configure retries to resend a request to the service if the request fails.
- 4. Which resilience strategy protects a service from overloading by stopping traffic directed to it?
- a. Retries.
  - b. Circuit breaker.
  - c. Time-outs.
  - d. Load balancing.

## ► Solution

# Describing Strategies for Resilient Services with OpenShift Service Mesh

Choose the correct answers to the following questions:

- ▶ 1. Which three strategies can be used to implement service resiliency in OpenShift Service Mesh? (Choose three.)
  - a. Canary releases.
  - b. Load balancing.
  - c. Time-outs.
  - d. Distributed tracing.
  - e. Circuit breakers.
  
- ▶ 2. Your networking provider is experiencing problems that affect your cluster. These problems cause outages in the network that last for less than a second. As a result, a small percentage of requests directed to your services fail. Which resilience strategy can make the failing requests succeed?
  - a. Load balancing.
  - b. Circuit breaker.
  - c. Retries.
  - d. Time-outs.
  
- ▶ 3. You are deploying an application on OpenShift Service Mesh. You estimate that the application will receive an average of 30 requests per second. Assuming that the application can handle up to 10 requests per second, what is a good strategy for resilience?
  - a. Scale the service to 4 replicas and balance the load among them.
  - b. Scale the service to 3 replicas and balance the load among them.
  - c. Limit the load to 10 requests per second with a circuit breaker.
  - d. Configure retries to resend a request to the service if the request fails.
  
- ▶ 4. Which resilience strategy protects a service from overloading by stopping traffic directed to it?
  - a. Retries.
  - b. Circuit breaker.
  - c. Time-outs.
  - d. Load balancing.

# Configuring Time-outs

## Objectives

After completing this section, you should be able to configure time-outs to maintain service reliability.

## Defining Time-outs

Cloud-native applications are composed of different microservices making various internal and external requests. When an application relies on different components distributed across the network, the network connection becomes one of the largest potential problems for the stability of your application.

Both the network and external service are inherently unreliable. To improve the resilience of your applications, you can use a *time-out*.

A time-out is the amount of time that a service or an application waits for a response after a request. OpenShift Service Mesh enables you to configure the time-out outside of your application code, in the Envoy proxy, by using virtual services or HTTP headers.

Using a time-out provides:

- A simple way of mitigating cascading failures. Because your application is failing early, you stop propagating slow responses from downstream services to systems that depend on yours.
- A guarantee that a network request finishes within a limited time.
- Better resource usage, because the time-outs reduce the time an application is blocked waiting for a response.

## Configuring Time-outs in OpenShift Service Mesh

Time-outs can be managed in the application code, but that approach has drawbacks including:

- Adding an additional layer of complexity that must be maintained.
- Coupling the application with the network layer.

Using OpenShift Service Mesh to manage time-outs enables you to maintain a separation of application business logic and network management.

In OpenShift Service Mesh, you can configure the time-outs using virtual services or HTTP headers without modifying your application code.



### Note

The default time-out for HTTP connections in OpenShift Service Mesh is 15 seconds.

## Configuring Time-outs Using Virtual Services

Virtual services enable you to configure time-outs for all traffic routed to a service. You can apply a time-out setting by using the `timeout` field in the route rules and assigning a value measured in seconds.

The following example shows a time-out configuration in a virtual service:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: a-service-vs
spec:
  hosts:
    - example-svc
  http:
    - route:
      - destination:
          host: preference
        timeout: 1s
```

In the preceding example, Envoy waits up to 1 second on any call to the `example-svc` service before returning a time-out error.

## Configuring Time-outs Using HTTP Headers

In OpenShift Service Mesh, you can use HTTP headers to modify Envoy behavior. The Envoy proxy can add, remove, or modify HTTP headers for incoming requests. When requests with HTTP headers modifying Envoy proxy behaviour are made from outside the mesh, the Envoy proxy ignores them.

In OpenShift Service Mesh, you can use the `PILOT_SIDECAR_USE_REMOTE_ADDRESS` flag to modify how Envoy determines the origin of a connection. Setting the value of `PILOT_SIDECAR_USE_REMOTE_ADDRESS` to `true`, allows you to configure time-outs using headers.



### Warning

Changing Pilot settings can have unexpected consequences on the stability and behavior of your service mesh.

You can configure time-outs adding the `x-envoy-upstream-rq-timeout-ms` request HTTP header with a value assigned in milliseconds.

The following example shows a request to a service with time-out settings:

```
HTTP/1.1 200 OK
date: Wed, 13 May 2020 13:56:01 GMT
...output omitted...
x-envoy-upstream-rq-timeout-ms: 500
...output omitted...
```

The preceding example defines a time-out of 500 milliseconds that is only valid until the service responds to that request.

## Selecting Time-outs for Resilience

Each application is different, and the time required to generate a response depends on multiple factors, such as how busy the application is or if it calls external services. There is no standard way of calculating a precise value for the time-out, but there are several things to consider when defining a time-out value:

- The value allows slow responses to arrive.
- The value stops waiting for a response that is not returned.
- A high value increases latency, especially in distributed systems.
- A high value potentially increases computing resources waiting for a dead service to respond.

Time-outs are not the only solution to increase the reliability of your applications. You can combine time-outs with more advanced strategies like retries or circuit breakers.



### References

#### Time-outs in Istio

<https://istio.io/v1.6/docs/tasks/traffic-management/request-timeouts/>

#### HTTPRoute

<https://istio.io/v1.6/docs/reference/config/networking/virtual-service/#HTTPRoute>

#### HTTP Header sanitizing with Envoy

[https://www.envoyproxy.io/docs/envoy/latest/configuration/http/http\\_conn\\_man/header\\_sanitizing](https://www.envoyproxy.io/docs/envoy/latest/configuration/http/http_conn_man/header_sanitizing)

## ► Guided Exercise

# Configuring Time-outs

In this exercise, you will configure time-outs for an application deployed in OpenShift Service Mesh.

## Outcomes

You should be able to configure time-outs in OpenShift Service Mesh.

The application is composed of several services calling each other. These services pass requests as follows:

- **customer**: the entry point of the application sending requests to the **preference** service.
- **preference**: receives requests from the **customer** service, and sends requests to the **recommendation** service.
- **recommendation**: receives requests from the **preference** service and returns a response. This is the last service in the chain of requests.

The final response from the application includes the responses from each service.

## Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the student user on the workstation machine, use the `lab` command to prepare your system for this exercise.

```
[student@workstation ~]$ lab resilience-timeout start
```

## Instructions

- 1. Change to the ~/D0328/labs/resilience-timeout directory:

```
[student@workstation ~]$ cd ~/D0328/labs/resilience-timeout
```

- 2. Log in to the OpenShift cluster as an unprivileged user and verify that the lab project has successfully deployed.

- 2.1. Source the classroom configuration:

```
[student@workstation resilience-timeout]$ source /usr/local/etc/ocp4.config
```

## 2.2. Log in to OpenShift as the developer user.

```
[student@workstation resilience-timeout]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

## 2.3. Change to the resilience-timeout project.

```
[student@workstation resilience-timeout]$ oc project resilience-timeout
Now using project "resilience-timeout" on server ...
```

## 2.4. Verify the status of the resilience-timeout project pods.

```
[student@workstation resilience-timeout]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
customer-f7bffd6f6-9mbzn   2/2     Running   0          50s
preference-5585d5987f-9z26q   2/2     Running   0          50s
recommendation-75c77bd445-55bb4   2/2     Running   0          50s
```

## 2.5. Examine the response-times.sh script which uses the curl command to make a call to the lab application and returns a custom output.

Execute the response-times.sh script to test the lab application response time..

```
[student@workstation resilience-timeout]$ sh response-times.sh
customer => preference => recommendation v1 from 'f11b097f1dd0': 1
HTTP code: 200
Time: 0.143920s
```

## ▶ 3. Configure a delay of 3 seconds in the recommendation-vs virtual service.

## 3.1. Examine the recommendation-delay.yaml file that configures a 3 seconds delay.

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
...output omitted...
  http:
    - fault:
        delay:
          percent: 100
          fixedDelay: 3s
...output omitted...
```

Use the oc replace command to replace the virtual service configuration with the new one.

```
[student@workstation resilience-timeout]$ oc replace -f recommendation-delay.yaml
virtualservice.networking.istio.io/recommendation-vs replaced
```

## ▶ 4. Verify the response time of the application.

- 4.1. Execute the `response-times.sh` script to verify the increased response time.

```
[student@workstation resilience-timeout]$ sh response-times.sh
customer => preference => recommendation v1 from 'f11b097f1dd0': 2
HTTP code: 200
Time: 3,063155s
```

- 5. Configure a route time-out of 0.5 seconds in the `preference-vs` virtual service.

- 5.1. Examine the `route-timeout.yaml` file that configures the route time-out.

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
...output omitted...
http:
- route:
  ...output omitted...
  timeout: 0.5s
```

Use the `oc replace` command to replace the virtual service configuration with the new one.

```
[student@workstation resilience-timeout]$ oc replace -f route-timeout.yaml
virtualservice.networking.istio.io/preference-vs replaced
```

- 6. Verify the response time of the application.

- 6.1. Execute the `response-times.sh` script to verify the time-out setting.

```
[student@workstation resilience-timeout]$ sh response-times.sh
customer => Error: 504 - upstream request timeout
HTTP code: 503
Time: 1,630933s
```

The preference service only waits 0.5 seconds for a response from the recommendation service. The reason that the response takes more than 0.5 seconds is because of the default Istio retry policies.

- 7. Update the `preference-vs` virtual service to remove the route time-out setting.

- 7.1. Examine the `removed-timeout.yaml` file that configures the `preference-vs` virtual service to use the default route time-out settings.

Use the `oc replace` command to replace the virtual service configuration with the new one.

```
[student@workstation resilience-timeout]$ oc replace -f removed-timeout.yaml
virtualservice.networking.istio.io/preference-vs replaced
```

- 7.2. Execute the `response-times.sh` script to test the response of the lab application.

```
[student@workstation resilience-timeout]$ sh response-times.sh
customer => preference => recommendation v1 from 'f11b097f1dd0': 5
HTTP code: 200
Time: 3,034979s
```

After removing the time-out in the preference-vs virtual service, the response time returns to values close to 3 seconds.

► 8. Verify that the application applied a timeout of 0.5 seconds per request.

- 8.1. Set the PILOT\_SIDECAR\_USE\_REMOTE\_ADDRESS environment variable in the istio-pilot deployment.

By default the Envoy proxy discards any HTTP header that modifies its behaviour. Enabling the PILOT\_SIDECAR\_USE\_REMOTE\_ADDRESS environment variable allows you to modify the time-out settings by using HTTP headers.

```
[student@workstation resilience-timeout]$ oc set env deployment/istiod-basic \
PILOT_SIDECAR_USE_REMOTE_ADDRESS=true -n istio-system
deployment.apps/istiod-basic updated
```

Wait until OpenShift redeploys the istiod-basic container with the new environment variable. Use the oc command to follow the progress.

```
[student@workstation resilience-timeout]$ oc get pods -n istio-system
NAME                               READY   STATUS    RESTARTS   AGE
...output omitted...
istio-ingressgateway-5cf698d99f-sc7p8   1/1     Running   0          19d
istiod-basic-5bdd648d46-pgjrj           0/1     Terminating   0          19d
istiod-basic-7748ccb4ff-tjxvc           1/1     Running   0          13s
...output omitted...
```



### Warning

Changing Pilot settings can have unexpected consequences on the stability and behavior of your service mesh.

- 8.2. Examine the headers-timeout.yaml file that configures the customer virtual service to add a header.

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
...output omitted...
http:
  - headers:
      request:
        set:
          x-envoy-upstream-rq-timeout-ms: "500"
...output omitted...
```

Use the oc replace command to replace the virtual service configuration with the new one.

```
[student@workstation resilience-timeout]$ oc replace -f headers-timeout.yaml  
virtualservice.networking.istio.io/preference-vs replaced
```

8.3. Execute the `response-times.sh` script to verify the time-out setting.

```
[student@workstation resilience-timeout]$ sh response-times.sh  
customer => Error: 504 - upstream request timeout  
HTTP code: 503  
Time: 1,563069s
```

► 9. Return to the home directory.

```
[student@workstation resilience-timeout]$ cd
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab resilience-timeout finish
```

This concludes the guided exercise.

# Configuring Retry

## Objectives

After completing this section, you should be able to configure a service retry to maintain service reliability.

## Defining the Retry Pattern

The retry pattern is a behavioral design pattern that focuses on reducing transient, short-lived communication failures. In a cloud-native environment, microservices often rely on networks to communicate with other microservices. Because networks can be unreliable, a microservice might encounter a number of issues during a communication request, such as:

- A request is lost, mishandled, or dropped due to an overloaded network.
- A target service experiences a temporary failure, for example, due to storage becoming temporarily disconnected.
- A subset of target service pods experience a failure.
- A request response takes longer than expected, resulting in the source service experiencing a time-out.

When a request fails due to any of the errors described above, a repeated request with identical parameters might still succeed. The retry pattern prevents propagation of such transient errors into the application.

OpenShift Service Mesh enables you to implement the retry pattern without changing the application code. Consequently, you can easily change the retry configuration at runtime, without recompiling or redeploying your application.

## Configuring Retries in OpenShift Service Mesh

Implementing the retry pattern in the logic of the application is possible, but has several drawbacks:

- The application code contains non-business logic. The application code becomes less focused, and thus more difficult to understand and maintain.
- Depending on the implementation, changing the parameters of the retry configuration might require redeploying the application.

Implementing the retry pattern using OpenShift Service Mesh provides benefits, including:

- Envoy proxies in OpenShift Service Mesh provide advanced configuration integrated with the Red Hat OpenShift platform. For example, you can enable automatic outlier detection in case of multiple 50x HTTP status codes, and provide routing logic for subsequent retries.
- Both administrators and developers can change the configuration of retries and other resiliency features. This encourages the DevOps approach towards developing and maintaining an application.

## Configuring Retry Using Virtual Service

You can configure the retry pattern in the virtual service resource, for example:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: example-vs
spec:
  hosts:
    - example-svc
  http:
    - route:
        - destination:
            host: example-svc
            subset: v1
        retries: ①
          attempts: 3 ②
          perTryTimeout: 2s ③
        retryOn: 5xx,retriable-4xx ④
```

- ① The `HTTPRetry` object responsible for configuring retries.
- ② The number of times to resend a request.
- ③ A time-out value for each retry request. Valid values are in milliseconds `ms`, seconds `s`, minutes `m`, or hours `h`.
- ④ A policy that specifies conditions that cause failed requests to retry. The value is a list of comma-separated values.

Virtual services retry failed requests twice by default. To disable the retry configuration, set the `attempts` parameter of the retry configuration to `0`. For example:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: vs-with-no-retry
spec:
  hosts:
    - example-svc
  http:
    - retries:
        attempts: 0
    route:
      - destination:
          host: example-svc
```

## Selecting Retry Policies

The virtual service resource enables you to select one or more retry policies. The Envoy proxy evaluates each failed request using the retry policies. If the Envoy proxy matches a request with any of the selected policies, it retries that request.

Selecting retry policies is important for optimal behavior of your service mesh. OpenShift Service Mesh contains, among others, the following retry policies:

#### **5xx**

This policy matches any response that contains the 5xx response code. Additionally, this policy matches any requests that do not get a response, such as due to a disconnect, reset, or a read time-out.

Note that setting the `x-envoy-upstream-rq-timeout-ms` header overrides the configuration time-out. If a request violates a value set in this header, the response contains the 504 response code, but will not be matched by the 5xx policy.

#### **gateway-error**

This policy matches responses that contain the 502, 503, or 504 response codes.

#### **reset**

This policy matches requests without any response due to disconnect, reset, or read time-out.

#### **retriable-4xx**

This policy matches request responses that contain the 409 response code.

Note that the list above is not exhaustive. When choosing a retry policy, it is a good practice to first analyze all failed requests in your application and choose the most specific policy for that case. For example, an application pod might take a long time to start, and responds to first requests with a time-out. You can mitigate the issue using the `reset` retry policy.

## **Selecting Retry Parameters for Resiliency**

The configuration of the retry communication pattern requires carefully considering the parameters of your environment, such as the latency requirements, network layout, application complexity, and others.

There are no standard values for the retry configuration that are suitable for every environment. The following non-exhaustive list contains some of the considerations for selecting retry parameters:

- An incorrect retry policy can substantially impact application performance. For example, if the back end application is incorrectly configured, and any requests result in a disconnect response, then retries only increase the overall number of retries with no benefits to the end-user.
- Increasing the number of retries increases the potential probability for success at the cost of performance. A higher number of retries results in larger network saturation and can cause issues in busy environments.
- Increasing the time-out value helps to reduce the load for compute-intensive services that can take longer to respond. However, increasing the time-out values also increases the overall latency of your system.

An incorrect retry setting makes your environment less resilient, and can accelerate performance issues in your environment. Other resilience patterns, such as the circuit breaker, can mitigate worst-case retry scenarios. Additionally, Red Hat recommends implementing monitoring to alert you to possible issues as soon as they occur.



## References

### Retry Concepts

<https://istio.io/v1.6/docs/concepts/traffic-management/#retries>

### HTTP Retry Reference Documentation

<https://istio.io/v1.6/docs/reference/config/networking/virtual-service/#HTTPRetry>

### Retry Policies

[https://www.envoyproxy.io/docs/envoy/latest/configuration/http/http\\_filters/router\\_filter#x-envoy-retry-on](https://www.envoyproxy.io/docs/envoy/latest/configuration/http/http_filters/router_filter#x-envoy-retry-on)

### Envoy Proxy Outlier Detection

[https://www.envoyproxy.io/docs/envoy/latest/intro/arch\\_overview/upstream/outlier#arch-overview-outlier-detection](https://www.envoyproxy.io/docs/envoy/latest/intro/arch_overview/upstream/outlier#arch-overview-outlier-detection)

### Retries in Envoy Proxy

[https://www.envoyproxy.io/docs/envoy/latest/faq/load\\_balancing/transient\\_failures.html?highlight.retry=retries](https://www.envoyproxy.io/docs/envoy/latest/faq/load_balancing/transient_failures.html?highlight.retry=retries)

### 409 Conflict - HTTP | MDN

<https://developer.mozilla.org/en-US/docs/Web/HTTP/Status/409>

## ► Guided Exercise

# Configuring Retry

In this exercise, you will configure the retry settings of an Envoy proxy.

### Outcomes

You should be able to configure retries for a service in OpenShift Service Mesh without changing the application code.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the student user on the workstation machine, use the `lab` command to prepare your system for this exercise.

The `lab` command deploys the `customer`, `preference`, and `recommendation` services into your Red Hat OpenShift cluster. The source code is in the Git repository at <https://github.com/RedHatTraining/DO328-apps> in the `customer`, `preference`, and `recommendation` directories.

```
[student@workstation ~]$ lab resilience-retry start
```

### Instructions

► 1. Log in to the OpenShift cluster and verify that the lab project is successfully deployed.

1.1. Source the classroom configuration file that is accessible at `/usr/local/etc/ocp4.config`.

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

1.2. Log in to OpenShift as the developer user.

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

1.3. Change to the `resilience-retry` project.

```
[student@workstation ~]$ oc project resilience-retry
Now using project "resilience-retry" on server ...
```

- 1.4. Verify that pods are in the Running state:

```
[student@workstation ~]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
customer-f7bfffdbf6-9mbzn   2/2     Running   0          50s
preference-5585d5987f-9z26q   2/2     Running   0          50s
recommendation-75c77bd445-55bb4   2/2     Running   0          50s
```

- 1.5. Save the ingress-gateway route host name with the /mtls endpoint into a variable:

```
[student@workstation ~]$ INGRESS_URL=$(oc get route -n istio-system \
istio-ingressgateway -o jsonpath='{.spec.host}'/resilience-retry)
```

- 1.6. Verify that the service responds using the INGRESS\_URL variable:

```
[student@workstation ~]$ curl $INGRESS_URL
customer => preference => recommendation v1 from 'f11b097f1dd0': 1
```

Note that you may encounter an error. This error is injected in the recommendation-vs virtual service, with a 90% probability of returning the 500 HTTP code. The error injection simulates an environment where retries are useful.

- 2. Configure a retry policy for the preference-vs virtual service with the following parameters:

- The Envoy proxy executes 10 or fewer retry attempts.
- Each retry waits at most 1s before timing out.
- The Envoy proxy issues retries only when the response contains a 500 HTTP code.

- 2.1. Edit the preference-vs virtual service:

```
[student@workstation ~]$ oc edit virtualservice preference-vs
```

- 2.2. Add the retries configuration. View the ~/D0328/solutions/resilience-retry/preference-retry.yml file to see the solution.

```
spec:
  hosts:
  - preference
  http:
  - route:
    - destination:
        host: preference
        port:
          number: 8080
  retries:
    attempts: 10
    perTryTimeout: 1s
    retryOn: 5xx
```

## ▶ 3. Verify the retry configuration.

- 3.1. Change to the ~/D0328/labs/resilience-retry directory:

```
[student@workstation ~]$ cd ~/D0328/labs/resilience-retry
```

- 3.2. Examine the test-retries.sh file. Then, execute it.

```
[student@workstation resilience-retry]$ sh test-retries.sh
Executing 10 requests:

customer => preference => recommendation v1 from 'f11b097f1dd0': 6
customer => preference => recommendation v1 from 'f11b097f1dd0': 7
customer => Error: 503 - preference => Error: 500 - fault filter abort

customer => preference => recommendation v1 from 'f11b097f1dd0': 8
customer => preference => recommendation v1 from 'f11b097f1dd0': 9
customer => preference => recommendation v1 from 'f11b097f1dd0': 10
customer => preference => recommendation v1 from 'f11b097f1dd0': 11
customer => preference => recommendation v1 from 'f11b097f1dd0': 12
customer => preference => recommendation v1 from 'f11b097f1dd0': 13
customer => preference => recommendation v1 from 'f11b097f1dd0': 14

Done
```

## ▶ 4. Set the recommendation-vs virtual service to have a 99% probability of returning a 500 HTTP code.

- 4.1. Edit the recommendation-vs virtual service:

```
[student@workstation resilience-retry]$ oc edit virtualservice recommendation-vs
```

- 4.2. Change the percentage value to 99.

```
spec:
  hosts:
  - recommendation
  http:
  - fault:
      abort:
        httpStatus: 500
        percentage:
          value: 99
      route:
      - destination:
          host: recommendation
          port:
            number: 8080
```

## ▶ 5. Change the retry value of the preference-vs virtual service to retry 100 times, with a 2s time-out limit.

- 5.1. Edit the preference-vs virtual service:

```
[student@workstation resilience-retry]$ oc edit virtualservice preference-vs
```

- 5.2. Change the number of retries and time-out settings:

```
spec:
  hosts:
    - preference
  http:
    - retries:
        attempts: 100
        perTryTimeout: 2s
        retryOn: 5xx
  route:
    - destination:
        host: preference
        port:
          number: 8080
```

- 6. Verify the responsiveness of the service:

```
[student@workstation resilience-retry]$ sh test-retries.sh
Executing 10 requests:
```

```
customer => preference => recommendation v1 from 'f11b097f1dd0': 15
customer => preference => recommendation v1 from 'f11b097f1dd0': 16
customer => preference => recommendation v1 from 'f11b097f1dd0': 17
customer => preference => recommendation v1 from 'f11b097f1dd0': 18
customer => preference => recommendation v1 from 'f11b097f1dd0': 19
customer => preference => recommendation v1 from 'f11b097f1dd0': 20
customer => preference => recommendation v1 from 'f11b097f1dd0': 21
customer => preference => recommendation v1 from 'f11b097f1dd0': 22
customer => preference => recommendation v1 from 'f11b097f1dd0': 23
customer => preference => recommendation v1 from 'f11b097f1dd0': 24
```

Done

The service responds properly even when 99% of the requests fail. Note that you can still see a reduced number of time-outs or errors.

The large number of retries generates large load on your Red Hat OpenShift cluster. The script finishes correctly, but takes a long time to complete

Consequently, the retry value considerably increases the overall latency of your application. Such a high retry configuration is dangerous in case the service is faulty, or incorrectly configured.

- 7. Change into the home directory:

```
[student@workstation resilience-retry]$ cd
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab resilience-retry finish
```

This concludes the guided exercise.

# Configuring a Circuit Breaker

## Objectives

After completing this section, you should be able to configure a circuit breaker pattern to maintain service reliability.

## Describing the Circuit Breaker

When a service experiences transient errors, those errors tend to occur continuously. **Circuit Breaker** uses this knowledge to temporarily avoid directing requests to a failing host. When a request is about to reach a failing host, the circuit breaks, sending a failure to the client without the need to wait for the host to respond. This ban is temporary, so the host receives new requests when normal function is restored.

This behavior has two benefits. First, as requests do not reach the failing hosts, services are more responsive, even if the host is slow. Second, the service in the host stops receiving requests for some time, allowing the service to recover from overload and resolve pending requests.

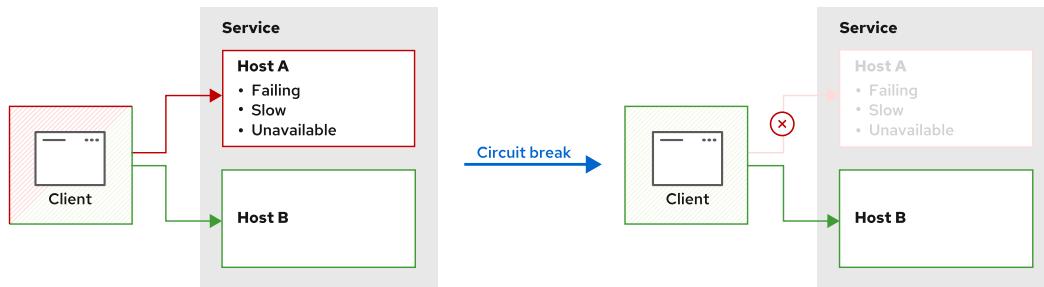


Figure 7.1: The circuit breaker

Circuit Breaker classifies host failures as two kinds.

### Local origin

Local failures are service errors (usually HTTP codes above 500) generated by the service.

### Gateway origin

Gateway failures arise when the service is unreachable or unresponsive, hence it cannot be used.

A Circuit Breaker identifies both kinds of failures and stops sending requests to the failing host, forwarding requests only to healthy hosts.

Detecting failing hosts, whether failures are of local origin or gateway failures, and marking them for eviction is called Outlier Detection.

## Selecting Circuit Breakers for Resilience

Circuit Breakers are useful to protect services prone to transient failures. Compute-intensive services, for example, receive more requests than they can respond to and may experience transient failures more often. Circuit Breakers redirect requests from the host as it starts failing or timing out, so the service has time to recover from the increased load.

Other common examples of selecting Circuit Breakers for resilience are services that need to process requests sequentially. Those services usually store pending requests in a queue that they process in order. If this queue becomes too big, the service takes too much time to respond, degrading the service. Circuit Breakers detect those time-outs and give the host time to empty the queue.

## Configuring Circuit Breakers in OpenShift Service Mesh

OpenShift Service Mesh implements Circuit Breakers at the host (network) level, not at the service level. That means OpenShift Service Mesh evicts failing hosts, not failing services nor subsets. This behavior allows services to keep functioning even if some subset or some hosts fail.

For example, if you have a service that points to three pods and one of them begins to fail, the eviction applies only to the failing pod. The service is still accessible and it will load balance requests among the two non-failing pods.



### Note

Istio terminology, and consequently OpenShift Service Mesh terminology, can be confusing when referring to a host. In many situations, like in the `DestinationRule` resource, `host` refers to a service as an entry in the Kubernetes service registry. However, in the context of Circuit Breakers, `host` refers to a physical or virtual workload, usually a container.

## Managing Unhealthy Hosts

To enable a Circuit Breaker, include an `outlierDetection` entry in the `DestinationRule` resource related to the service:

```
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: myDestinationRule
spec:
  host: myService 1
  trafficPolicy: 2
    outlierDetection:
      consecutive5xxErrors: 1 3
      interval: 1s 4
      baseEjectionTime: 3m 5
      maxEjectionPercent: 100 6
```

- 1** host does not refer to the physical host, but the service name. See references for details.
- 2** The `outlierDetection` entry belongs to a `trafficPolicy` object.
- 3** Defines how many 5xx errors are allowed before evicting the host.
- 4** The time interval between checking error counts.
- 5** The *minimum* amount of host ejection time.
- 6** The maximum percentage of evicted hosts belonging to a service at any time.

The value for `baseEjectionTime` indicates the minimum eviction time for the host, not the actual time. The first time that OpenShift Service Mesh evicts the host, the eviction lasts for approximately the minimum time. Subsequent evictions multiply the `baseEjectionTime` by the number of times the host is evicted. For example, if `baseEjectionTime` is five seconds, then the first time the host is evicted, the eviction lasts five seconds. The second time that same host is evicted, the eviction lasts ten seconds. The third time, the eviction lasts fifteen seconds. And so on.

The `maxEjectionPercent` value limits the percentage of hosts that can simultaneously be in the evicted state. If the current percentage of evicted hosts is higher than this limit, OpenShift Service Mesh evicts no other hosts, even if they fail or are unavailable. This limit is useful to avoid the eviction of all the hosts for a service, making the service unavailable even if some hosts can respond. The default value for `maxEjectionPercent` is 10%.

## Configuring Connection Limits

Another technique to protect hosts from failing is limiting the number of simultaneous connections to the host. If hosts are prone to time-out or fail when they receive too many requests, limiting the number of connections helps prevent the host from crashing.

OpenShift Service Mesh enables applying those limits using a `connectionPool` entry in the `DestinationRule`:

```
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: myDestinationRule
spec:
  host: myService
  trafficPolicy:
    connectionPool:
      tcp: ①
        maxConnections: 1 ②
        connectTimeout: 30ms ③
      http: ④
        http1MaxPendingRequests: 1 ⑤
        maxRequestsPerConnection: 1 ⑥
```

- ① Connection pool settings are divided into HTTP and TCP settings for clarity.
- ② Maximum number of simultaneous connections established to the host.
- ③ Maximum time to establish the connection.
- ④ Maximum number of requests pending service by the host.
- ⑤ Maximum number of requests permitted on a single connection. OpenShift Service Mesh reuses connections until reaching this limit, or the `tcp.tcpKeepalive` time is consumed.

See the Istio reference documentation about `DestinationRule` resources for the complete list of supported entries.

When limiting the connections to a host, if the threshold is exceeded it will generate service failures, specifically, gateway failures. Those limits can be applied simultaneously with a Circuit Breaker. Failures generated by the connection limit are used by the Circuit Breaker to break the

circuit and start eviction policies. However, connection limits and Circuit Breaker are independent traffic policies, and developers can use one of them without the other.

Connection pools apply to every host in the service. That means each host has a connection pool independent from other host pools. If the host depletes its connection pool, OpenShift Service Mesh establishes no more connections to that host, but continues using the rest of the hosts.



## References

### Istio documentation on circuit breakers

<https://istio.io/v1.6/docs/concepts/traffic-management/#circuit-breakers>

### Istio documentation on outlier detection

<https://istio.io/v1.6/docs/reference/config/networking/destination-rule/#OutlierDetection>

### Istio documentation on connection pools

<https://istio.io/v1.6/docs/reference/config/networking/destination-rule/#ConnectionPoolSettings>

### Envoy proxy documentation on circuit breaking

[https://www.envoyproxy.io/docs/envoy/v1.14.5/intro/arch\\_overview/upstream/circuit\\_breaking](https://www.envoyproxy.io/docs/envoy/v1.14.5/intro/arch_overview/upstream/circuit_breaking)

### Envoy proxy documentation on outlier detection

[https://www.envoyproxy.io/docs/envoy/v1.14.5/intro/arch\\_overview/upstream/outlier](https://www.envoyproxy.io/docs/envoy/v1.14.5/intro/arch_overview/upstream/outlier)

### Istio reference documentation for DestinationRule resources

<https://istio.io/v1.6/docs/reference/config/networking/destination-rule/#DestinationRule>

## ► Guided Exercise

# Configuring a Circuit Breaker

In this exercise, you will configure a connection pool for protecting a service from failing, and a Circuit Breaker to manage unhealthy hosts.

This exercise installs a basic greeting service that fails when it is stressed. First, you add a connection pool to avoid sending requests to the service that fails. Second, you add a new version of the service. Finally, you deploy the new version beside the old and configure Circuit Breaker to avoid service failures when the original version of the service is stressed.

## Outcomes

You should be able to configure Circuit Breaker and connection pools in OpenShift Service Mesh.

## Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the **student** user on the **workstation** machine, use the **lab** command to prepare your system for this exercise.

```
[student@workstation ~]$ lab resilience-break start
```

## Instructions

- 1. Validate that the service is working as expected. Include a `connectionPool` entry to limit the number of simultaneous connections to the host.
- 1.1. Log in your Red Hat OpenShift cluster using the developer credentials and make sure that you use the `resilience-break` project:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
[student@workstation ~]$ oc project resilience-break
Now using project "resilience-break" on server ...output omitted...
```

- 1.2. The service is exposed in the default gateway, so retrieve the URL using the following command:

```
[student@workstation ~]$ GATEWAY_URL=$(oc get route istio-ingressgateway \
-n istio-system -o template --template '{{ .spec.host }}')
```

13. Test the service to ensure that it installed and is functioning correctly.

```
[student@workstation ~]$ curl -w "%{http_code}\n" $GATEWAY_URL
Hello World!
200
```

14. The installed service fails when it receives too many requests. Use the parallel.sh script provided in the labs folder to perform twenty parallel requests to the service.

```
[student@workstation ~]$ cd ~/DO328/labs/resilience-break
[student@workstation resilience-break]$ ./parallel.sh \
"curl -w '%{http_code}\n' $GATEWAY_URL"
Hello World!
200
Hello World!
200
503
503
...output omitted...
```

These results prove that the service is unable to respond to the increased load. The service correctly responds a few times, providing the Hello World! text and the 200 HTTP code. Eventually the service fails and returns the 503 failure HTTP code.

15. Configure a connection pool to reduce the number of connections allowed to the service. Limit the number of concurrent connections, the number of requests per connections, and the number of requests pending to one.

You can edit the `vertx-greet` DestinationRule resource from the Red Hat OpenShift console, or run the following command in your terminal:

```
[student@workstation resilience-break]$ oc edit DestinationRule vertx-greet
```

Add the needed `trafficPolicy` entry to the resource. The DestinationRule must look like the following:

```
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  ...output omitted...
  name: vertx-greet
  ...output omitted...
```

```
spec:
  host: vertx-greet
  trafficPolicy:
    connectionPool:
      http:
        http1MaxPendingRequests: 1
        maxRequestsPerConnection: 1
      tcp:
        maxConnections: 1
```

You can see the complete destination rule at ~/D0328/solutions/resilience-break/dr-connection-pool.yaml.

- 1.6. Verify that the pool limits pending requests, connections, and requests per connection to 1.

```
[student@workstation resilience-break]$ ./parallel.sh \
"curl -w '%{http_code}\n' $GATEWAY_URL"
Hello World!
200
upstream connect error or disconnect/reset before headers. reset reason:
overflow503
503
503
...output omitted...
```

The connection pool drops some of the connections, but the service still fails.

- 2. Deploy a new version of the service that accepts more requests.
- 2.1. Use the file deployment-v2.yaml provided in the solutions folder to create the new Deployment resource.

```
[student@workstation resilience-break]$ oc create \
-f ~/D0328/solutions/resilience-break/deployment-v2.yaml
deployment.apps/vertx-greet-v2 created
```

- 2.2. Verify that a new pod is deployed.

```
[student@workstation resilience-break]$ oc get pods
vertx-greet-v1-5bcf556987-ssbft   2/2     Running   0          6m11s
vertx-greet-v2-6794b4bd67-qcgb5   2/2     Running   0          36s
```

Pod names are generated automatically and yours may differ.

- 2.3. Validate that the new pod is receiving traffic and responding as expected.

```
[student@workstation resilience-break]$ ./parallel.sh \
"curl -w '%{http_code}\n' $GATEWAY_URL"
Hello World!
200
upstream connect error or disconnect/reset before headers. reset reason:
overflow503
upstream connect error or disconnect/reset before headers. reset reason:
overflow503
Hello from v2
200
Hello from v2
200
upstream connect error or disconnect/reset before headers. reset reason:
overflow503
...output omitted...
```

- ▶ 3. Remove the connection pool and configure a Circuit Breaker so that OpenShift Service Mesh evicts the failing host after two failures occur during a 2 second interval. Evict hosts for a minimum of 10 seconds and ensure that OpenShift Service Mesh can evict all hosts.
- 3.1. Update the DestinationRule resource to replace the connectionPool entry with an outlierDetection entry configured with appropriate values. Again, use the Red Hat OpenShift console, or the `oc edit DestinationRule vertx-greet` command to make this update.

The DestinationRule must look like the following:

```
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: vertx-greet
spec:
  host: vertx-greet
  trafficPolicy:
    outlierDetection:
      baseEjectionTime: 10.000s
      consecutiveErrors: 2
      interval: 2.000s
      maxEjectionPercent: 100
```

You can see the complete destination rule at `~/D0328/solutions/resilience-break/dr-outlier-detection.yml`.

- 3.2. Verify the Circuit Breaker settings evict the initial service when it receives a few requests.

You can use the same `parallel.sh` script to generate a burst of requests, but the eviction might not display in the output. Use the provided `sequential.sh` script in the labs folder to emulate intense traffic to the service.

```
[student@workstation resilience-break]$ ./sequential.sh \
"curl -w '%{http_code}\n' $GATEWAY_URL"
Hello from v2
200
```

Note that the initial version provides some responses, but the Circuit Breaker eventually evicts the host. After eviction, no responses are received from this version of the service for approximately 10 seconds. The host eventually restores and starts sending responses again.

Keep this script running for some time, and then review the output. Notice that the host takes more and more time to recover after each eviction. Press **Ctrl+C** to stop the process.

Note also that there are no service failures, because the connection pool has been removed.

- 3.3. Change the current working directory to the home folder before finishing the exercise:

```
[student@workstation resilience-break]$ cd
```

## Finish

On the workstation machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab resilience-break finish
```

This concludes the guided exercise.

## ► Lab

# Building Resilient Services

### Performance Checklist

In this lab, you will apply different resilience strategies to improve the reliability of an application.

### Outcomes

You should be able to implement retry policies, limit connections to services, and add Circuit Breakers to improve the resilience of your applications.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the student user on the workstation machine, use the `lab` command to prepare your system for this lab.

This command deploys unreliable versions of the currency exchange application and the news application. The command also includes the Financial application into the Red Hat OpenShift Service Mesh. The source code is in the Git repository at <https://github.com/RedHatTraining/DO328-apps> in the `exchange-application`, and `python-flask-gossip` directories.

```
[student@workstation ~]$ lab resilience-mesh start
```

### Instructions

1. This activity uses scripts that are located in `~/D0328/labs/resilience-mesh`. Change to that directory.

```
[student@workstation ~]$ cd ~/D0328/labs/resilience-mesh
```

2. Log in to the OpenShift cluster as an unprivileged user and verify that the lab projects are successfully deployed.
3. Configure a circuit breaker in the external news service with the following characteristics:
  - A maximum of 2 5xx consecutive errors
  - An interval between ejection sweep analysis of 5 seconds
  - A minimum ejection duration of 10 seconds
  - A maximum ejection percent of 100

- Name the destination rule resource `news-circuit` and the service entry resource `news-se`.
4. Test the circuit breaker configuration.
  5. Configure a retry policy in the `currencies` service with the following characteristics.
    - Retry policy of 4 attempts
    - Retry on any 5xx error
    - Timeout between retries of 1 second
- Name the virtual service resource `currency-retries`.
6. Test the retry policy applied to the `currency` service.
  7. Configure the `frontend` service with the following connection limits:
    - A maximum of 5 pending HTTP requests
    - A maximum of 10 requests per connection
    - A maximum of 5 HTTP1/TCP connections
- Name the destination rule resource `frontend-pool`.
8. Test the connection limits to the `frontend` service.
  9. Return to the home directory.

```
[student@workstation resilience-mesh]$ cd
```

## Evaluation

Grade your work by running the `lab resilience-mesh grade` command from your workstation machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab resilience-mesh grade
```

## Finish

On the workstation machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab resilience-mesh finish
```

This concludes the lab.

## ► Solution

# Building Resilient Services

### Performance Checklist

In this lab, you will apply different resilience strategies to improve the reliability of an application.

### Outcomes

You should be able to implement retry policies, limit connections to services, and add Circuit Breakers to improve the resilience of your applications.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the student user on the workstation machine, use the `lab` command to prepare your system for this lab.

This command deploys unreliable versions of the currency exchange application and the news application. The command also includes the Financial application into the Red Hat OpenShift Service Mesh. The source code is in the Git repository at <https://github.com/RedHatTraining/DO328-apps> in the `exchange-application`, and `python-flask-gossip` directories.

```
[student@workstation ~]$ lab resilience-mesh start
```

### Instructions

1. This activity uses scripts that are located in `~/D0328/labs/resilience-mesh`. Change to that directory.

```
[student@workstation ~]$ cd ~/D0328/labs/resilience-mesh
```

2. Log in to the OpenShift cluster as an unprivileged user and verify that the lab projects are successfully deployed.
  - 2.1. Source the classroom configuration file that is accessible at `/usr/local/etc/ocp4.config`.

```
[student@workstation resilience-mesh]$ source /usr/local/etc/ocp4.config
```

- 2.2. Log in to OpenShift as the developer user.

```
[student@workstation resilience-mesh]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

2.3. Change to the `resilience-mesh` project.

```
[student@workstation resilience-mesh]$ oc project resilience-mesh
Now using project "resilience-mesh" on server ...
```

2.4. Verify the status of the `resilience-mesh` project pods.

```
[student@workstation resilience-mesh]$ oc get pods
NAME           READY   STATUS    RESTARTS   AGE
currency-84d75bdb8c-8g97h   2/2     Running   0          36s
exchange-5fd7954fb5-874kj   2/2     Running   0          36s
frontend-7559c7874f-fknr9   2/2     Running   0          36s
history-548b7f4954-fc9jx    2/2     Running   0          36s
```

2.5. Verify the status of the `resilience-mesh-news` project pods.

```
[student@workstation resilience-mesh]$ oc get pods -n resilience-mesh-news
NAME           READY   STATUS    RESTARTS   AGE
news-error-6c49447695-8ktl8   1/1     Running   0          30s
news-ok-8bbbf9f9c9-v8f58      1/1     Running   0          30s
```

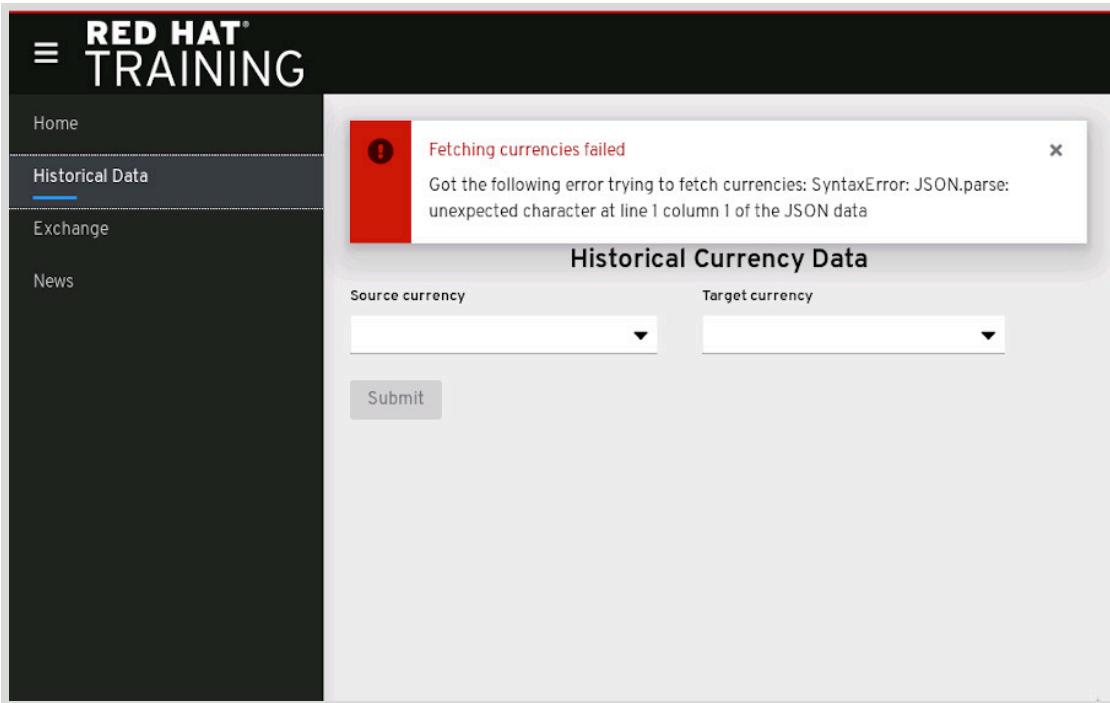
2.6. Save the front-end route into a variable.

```
[student@workstation resilience-mesh]$ FRONTEND=$(oc get route \
istio-ingressgateway -n istio-system \
-o jsonpath='{["http://"]{.spec.host}[/frontend]}')
```

2.7. Access the lab application using the Firefox web browser on your workstation machine to check the unreliable behavior of the application.

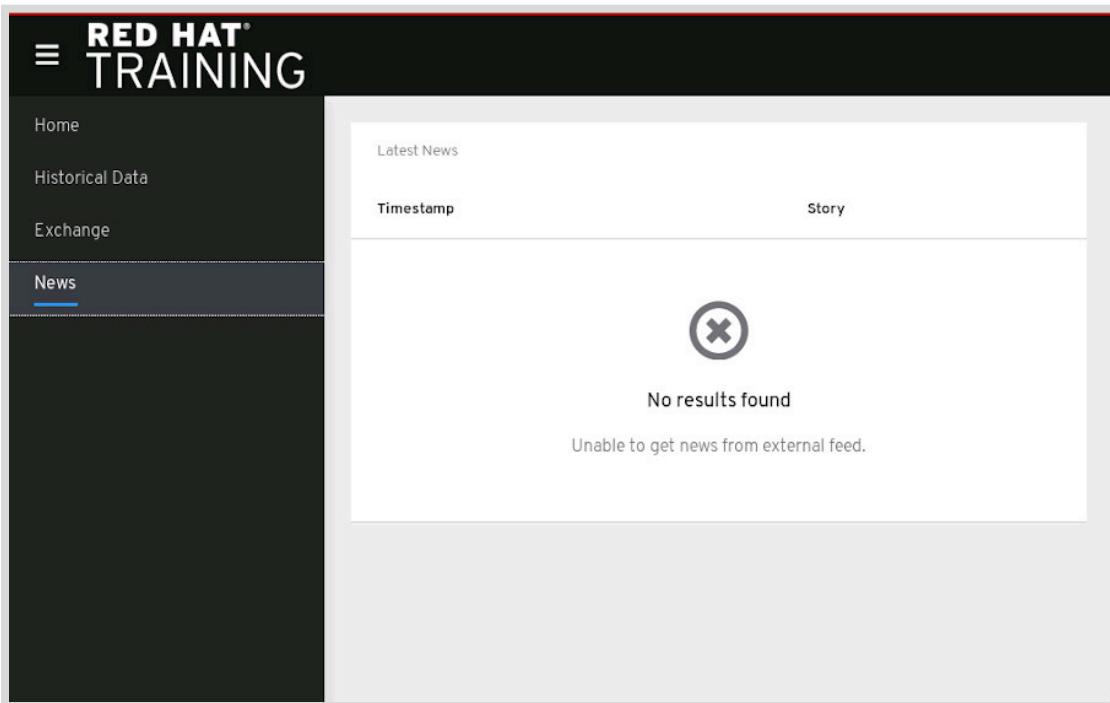
```
[student@workstation resilience-mesh]$ firefox ${FRONTEND} &
```

The Historical Data and Exchange pages rely on the currency service. This service returns a failure response for two of three requests.



- 2.8. Navigate between the Historical Data and Exchange pages several times to observe this behavior.

The News page sometimes fails to fetch data from the external service. Reload the page several times to observe this behavior.



3. Configure a circuit breaker in the external news service with the following characteristics:

- A maximum of 2 5xx consecutive errors

- An interval between ejection sweep analysis of 5 seconds
- A minimum ejection duration of 10 seconds
- A maximum ejection percent of 100

Name the destination rule resource `news-circuit` and the service entry resource `news-se`.

### 3.1. Get the news service host name.

```
[student@workstation resilience-mesh]$ oc get route news -n resilience-mesh-news \
-o jsonpath='{.spec.host}{\"\\n\"}'
news-resilience-mesh-news.apps.ocp4.example.com
```

Use the news service host in the destination rule and service entry you are going to create in the following steps.

### 3.2. Create a service entry object YAML file, for example `se-news.yaml`, to store the object definition.

```
apiVersion: networking.istio.io/v1beta1
kind: ServiceEntry
metadata:
  name: news-se
spec:
  hosts:
    - news-resilience-mesh-news.apps.ocp4.example.com
  ports:
    - number: 80
      name: http
      protocol: HTTP
  resolution: DNS
  location: MESH_EXTERNAL
```

The object definition is available in the `~/D0328/solutions/resilience-mesh/se-news.yaml` file. You can use the YAML file to verify your file and fix mistakes.

### 3.3. Create the service entry configuration using the `oc create` command.

```
[student@workstation resilience-mesh]$ oc create -f se-news.yaml
serviceentry.networking.istio.io/news-se created
```

### 3.4. Create a destination rule object YAML file, for example `dr-news.yaml`, to store the object definition.

```
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: news-circuit
spec:
  host: news-resilience-mesh-news.apps.ocp4.example.com
  trafficPolicy:
    outlierDetection:
```

```

consecutive5xxErrors: 2
interval: 5s
baseEjectionTime: 10s
maxEjectionPercent: 100

```

The object definition is available in the ~/D0328/solutions/resilience-mesh/dr-news.yaml file. You can use the YAML file to verify your file and fix mistakes.

- 3.5. Create the destination rule configuration using the oc create command.

```
[student@workstation resilience-mesh]$ oc create -f dr-news.yaml
destinationrule.networking.istio.io/news-circuit created
```

4. Test the circuit breaker configuration.

- 4.1. Go back to the lab application in your browser and access the News page.
- 4.2. Reload the News page several times to verify that it always displays news. It may take several seconds to OpenShift Service Mesh to propagate the new configuration.  
The circuit breaker detects failures in the connections to the external news feed and removes the problematic hosts.

5. Configure a retry policy in the currencies service with the following characteristics.

- Retry policy of 4 attempts
- Retry on any 5xx error
- Timeout between retries of 1 second

Name the virtual service resource currency-retries.

- 5.1. Create a virtual service object YAML file, for example vs-currency.yaml, to store the object definition.

```

apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: currency-retries
spec:
  hosts:
    - currency
  http:
    - route:
        - destination:
            host: currency
            port:
              number: 5000
  retries:
    attempts: 4
    perTryTimeout: 1s
    retryOn: 5xx

```

The object definition is available in the ~/D0328/solutions/resilience-mesh/vs-currency.yaml file. You can use the YAML file to verify your file and fix mistakes.

- 5.2. Create the service entry configuration with the `oc create` command.

```
[student@workstation resilience-mesh]$ oc create -f vs-currency.yaml
virtualservice.networking.istio.io/currency-retries created
```

6. Test the retry policy applied to the `currency` service.
  - 6.1. Go back to the lab application in your browser and access to the Historical Data or Exchange pages.
  - 6.2. Navigate through the Historical Data, Exchange and News pages to verify that all pages are working.
7. Configure the `frontend` service with the following connection limits:
  - A maximum of 5 pending HTTP requests
  - A maximum of 10 requests per connection
  - A maximum of 5 HTTP1/TCP connections
 Name the destination rule resource `frontend-pool`.
  - 7.1. Create a destination rule object YAML file, for example `dr-frontend.yaml`, to store the object definition.

```
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: frontend-pool
spec:
  host: frontend
  trafficPolicy:
    connectionPool:
      http:
        http1MaxPendingRequests: 5
        maxRequestsPerConnection: 10
      tcp:
        maxConnections: 5
```

The object definition is available in the `~/DO328/solutions/resilience-mesh/dr-frontend.yaml` file. You can use the YAML file to verify your file and fix mistakes.

- 7.2. Create the service entry configuration using the `oc create` command.

```
[student@workstation resilience-mesh]$ oc create -f dr-frontend.yaml
destinationrule.networking.istio.io/frontend-pool created
```

8. Test the connection limits to the `frontend` service.
  - 8.1. Examine the `parallel-requests.sh` script. This script generates parallel connections to the front-end service and prints the HTTP code from the response. Run the `parallel-requests.sh` script to send a small amount of traffic to the front-end service.

```
[student@workstation resilience-mesh]$ sh parallel-requests.sh 2
HTTP code: 200
HTTP code: 200
```

- 8.2. Run the `parallel-requests.sh` script to send a large amount of traffic to the front-end service.

```
[student@workstation resilience-mesh]$ sh parallel-requests.sh 33
HTTP code: 200
HTTP code: 200
...output omitted...
HTTP code: 200
HTTP code: 503
HTTP code: 503
HTTP code: 503
...output omitted...
```

The preceding command shows a mix of 200 and 503 errors. The connection pool settings are limiting the connections so that some responses are 503 errors.

9. Return to the home directory.

```
[student@workstation resilience-mesh]$ cd
```

## Evaluation

Grade your work by running the `lab resilience-mesh grade` command from your `workstation` machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab resilience-mesh grade
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab resilience-mesh finish
```

This concludes the lab.

# Summary

---

In this chapter, you learned:

- With OpenShift Service Mesh you can implement different resilience strategies without changing your code.
- Load balancing prevents service overloads by distributing the load among several service replicas.
- Time-outs guarantee that a network request finishes within a specified time limit.
- Retries focuses on reducing transient, short-lived communication failures.
- Circuit Breaker avoids directing requests to a failing host.
- Another technique to protect hosts from failing is limiting the number of simultaneous connections to the host.



## Chapter 8

# Securing an OpenShift Service Mesh

### Goal

Secure and encrypt service communication in your application with Red Hat OpenShift Service Mesh.

### Objectives

- Describe how OpenShift Service Mesh manages cryptographic identities.
- Configure Mutual TLS to secure intra-service communication.
- Configure restriction on services communication in OpenShift Service Mesh.

### Sections

- Describing Security in OpenShift Service Mesh (and Quiz)
- Configuring Mutual TLS (and Guided Exercise)
- Defining Service to Service Authorization (and Guided Exercise)

### Lab

Securing an OpenShift Service Mesh

# Describing Security in OpenShift Service Mesh

---

## Objectives

After completing this section, you should be able to describe how OpenShift Service Mesh manages cryptographic identities.

## Describing Security of the Microservice Architecture

As organizations move to cloud-native applications with DevOps principles, security practices often change. Some traditional security concepts still apply, but can become difficult to implement. For example, traditional firewall security perimeters operate on the network transport layer (L4), which becomes difficult to implement and maintain in a cloud-native environment.

Cloud-native platforms, such as Red Hat OpenShift, introduce a number of new security concepts, such as:

- Verifying and trusting your container registry.
- Adapting network security to software defined networking.
- Identifying and preventing unintended egress requests, or requests that originate from your mesh and target services outside of your mesh.

As teams continue iterating upon their application, security is often deprioritized in favor of new feature development.

Deprioritizing security can lead to:

- Outages
- Data breaches
- Legal liability and noncompliance
- Slower time to production

Security is always a priority in the Red Hat ecosystem. Red Hat products and services encourage adopting the *DevSecOps* principles.

DevSecOps is an evolution of DevOps principles. DevSecOps integrates security in the software development design and implementation loops from the beginning. Security becomes a responsibility of everyone involved in the software development cycle.

## Security and Red Hat OpenShift Service Mesh

OpenShift Service Mesh enables developers and system administrators to abstract security from application code into infrastructure configuration, enabling zero-trust perimeters and deny-by-default behavior.

OpenShift Service Mesh provides, among others, the following security features:

## Cryptographically Verifiable Service Identities

Red Hat OpenShift assigns to each deployed service a service account. OpenShift uses the service account as an identity for each deployed microservice. However, the service account identity is not cryptographically verifiable. OpenShift Service Mesh assigns microservices X.509-based identities that enable you to cryptographically verify each microservice request.

Security features, such as internal traffic encryption, verify services with the X.509-based identities.

Enabling traffic encryption means only the origin and target services can decrypt the traffic. Consequently, traffic encryption mitigates the impact of possible security breaches, and reduces avenues for attack, or attack vectors.

## Service Authorization

A service inside of Red Hat OpenShift cluster can communicate with any other service by using the resolvable DNS name, such as `svc-name.project-name.dns-domain`.

Unrestricted communication can lead to attackers communicating with services that they should not have access to. Depending on the OpenShift cluster architecture, attackers might also compromise sensitive data to external servers.

In a large service mesh, developers might also discover that services contact legacy endpoints or other unexpected services. Because legacy endpoints often become deprecated and decommissioned, depending on legacy endpoints might cause outages.

OpenShift Service Mesh enables you to explicitly permit or deny service-to-service communication. This is useful for reducing potential attack vectors and providing clarity into the communication patterns in your cluster.

## Describing PKI in OpenShift Service Mesh

Public Key Infrastructure (PKI) is necessary for providing X.509-based identities. OpenShift Service Mesh contains a self-signed certificate authority (CA). The `istiod` component uses the certificate authority to issue new identities. Service Mesh uses the cryptographic identities for further security features, such as authentication and authorization settings, or mutual TLS.

OpenShift Service Mesh simplifies identity management by providing the following features:

- *Self-rotating PKI* ensures that Envoy proxies automatically rotate certificates that are about to expire. Administrators do not manually manage certificates.

The self-rotating PKI aims to reduce the maintenance costs connected with manual PKI management, and to avoid possible outages related to certificate expiry and misconfiguration.

- *Certificate-key pair injection* ensures that Envoy proxies mount necessary certificates into any pod that OpenShift Service Mesh manages. For any new pod joining OpenShift Service Mesh, its Envoy proxy uses the OpenShift Service Mesh CA to get a certificate-key pair identity. The Envoy proxy automatically mounts the certificate, and stores the identity information for further security settings.

## Generating and Managing Certificate-based Identities

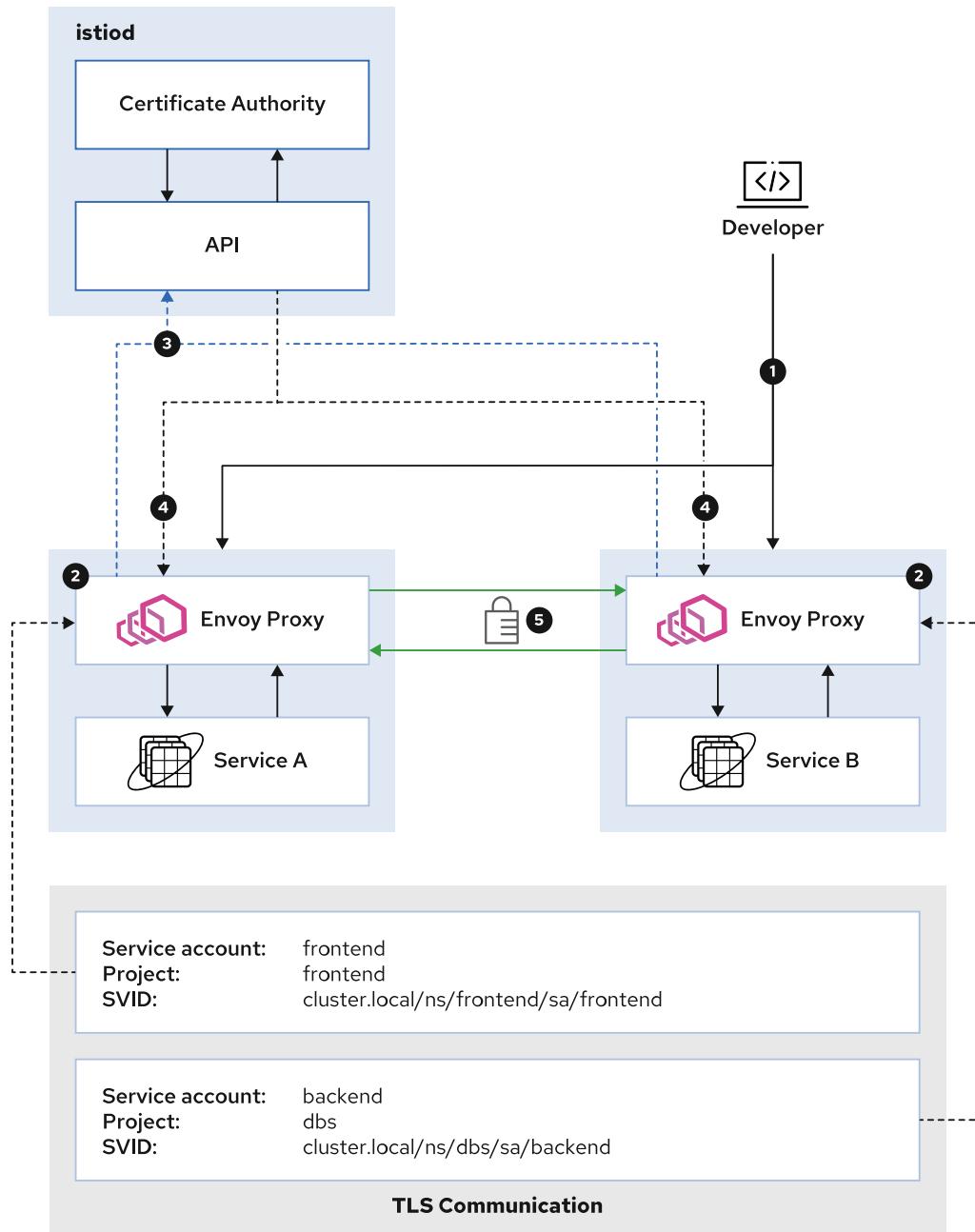
In OpenShift Service Mesh 2.x, the Pilot agent process inside the Envoy proxy sidecar container is responsible for generating and maintaining a certificate-key pair.

The Envoy proxy requests a certificate-key pair by using the *Secret Discovery Service* (SDS) API. The SDS API enables certificates to be stored directly in the Envoy configuration.

Without the SDS API, OpenShift Service Mesh stores certificates in Kubernetes Secrets and mounts the secrets into pods. Mounting certificates from secrets means rotating a certificate requires restarting the pod. SDS enables Service Mesh to rotate certificates at runtime without restarting the pods.

Envoy uses the service account associated with the microservice deployment to generate the cryptographic identity. All services in a project use the same service account by default. Therefore, all services within one project encrypt their communication with the identical private key.

Using one private key for multiple services means that a malicious container injected into the project can decrypt all traffic in the project. Although the attack surface is reduced to the same project traffic, Red Hat recommends creating a service account for each microservice in a project to further reduce the attack surface.



- ① A developer deploys two new pods with separate **backend** and **frontend** service accounts.
- ② OpenShift Service Mesh injects the Envoy proxy sidecar container into each pod.
- ③ The Envoy proxy requests a new certificate-key pair by using SDS.
- ④ Istiod uses the internal certificate authority to sign and return the identity.
- ⑤ Envoy proxy uses the certificates for security features, such as mutual TLS.

## Verifying Certificate-based Identities

Each certificate-key pair uses Secure Production Identity Framework for Everyone (SPIFFE) to provide security checks. SPIFFE is a specification maintained by the Cloud Native Computing Foundation (CNCF). SPIFFE is designed to cryptographically verify that the certificate identity presented by a microservice matches with the microservice service account.

Each certificate is encoded with a SPIFFE Verifiable Identity Document (SVID). The SVID takes the form of `cluster_domain/ns/project_name/sa/service_account_name`, and is encoded into the certificate as the X509v3 Subject Alternative Name parameter.

The role of SPIFFE is to mitigate the attack surface for identity theft. For example, if a malicious user gains access to the certificate-key pair of the *frontend* microservice, and finds an exploit to execute arbitrary code in the *gateway* microservice, then SPIFFE checks might stop the attack. Because the service account name is encoded in each certificate, setting a unique service account for both the microservices ensures that the SPIFFE check fails and the Envoy proxy fails to complete the TLS handshake.

OpenShift Service Mesh provides additional security checks, referred to as secure naming. At run time, the Pilot component checks whether a service uses the correct service account before SPIFFE is checked. Consequently, the Pilot expects a response from one service but receives a response from a different service. If you set a different service account for each service, then the Envoy proxy rejects the request because it originated from a service other than the expected (mapped) one.

Secure naming is useful when an attacker compromises network routing in your OpenShift cluster and can reroute traffic from one service to another service.



### References

#### **What is DevSecOps?**

<https://www.redhat.com/en/topics/devops/what-is-devsecops>

#### **Understanding Red Hat OpenShift Service Mesh**

[https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.6/html-single/service\\_mesh/index#understanding-service-mesh](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.6/html-single/service_mesh/index#understanding-service-mesh)

#### **Istio High-level architecture**

<https://archive.istio.io/v1.6/docs/concepts/security/#high-level-architecture>

#### **Istio PKI**

<https://archive.istio.io/v1.6/docs/concepts/security/#pki>

#### **Secret Discovery Service**

<https://www.envoyproxy.io/docs/envoy/v1.14.5/configuration/security/secret>

#### **Istio Secure Naming**

<https://archive.istio.io/v1.6/docs/concepts/security/#secure-naming>

#### **Understanding and creating service accounts**

[https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.6/html-single/authentication\\_and\\_authorization/index#understanding-and-creating-service-accounts](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.6/html-single/authentication_and_authorization/index#understanding-and-creating-service-accounts)

## ► Quiz

# Describing the Role of Citadel in OpenShift Service Mesh

Choose the correct answers to the following questions:

► 1. Which two of the following statements about issuing certificate-key pair identity are correct? (Choose two.)

- a. Each service must be aware of the certificate-key identity in order to request a new identity before the expiration date.
- b. The Pilot agent inside of the Envoy proxy requests a new certificate based on the service account of the service.
- c. The generated certificate-key pair is usually stored in the configuration of the Envoy process.
- d. The developers must first inject a certificate authority to the Service Mesh before requesting any identities.

► 2. Which of the following two statements about microservice security with OpenShift Service Mesh are recommended practices? (Choose two.)

- a. Enable traffic encryption in each project. For example, by using TLS and unique service accounts for each pod.
- b. Deploy each pod into a unique project so that malicious pods cannot decrypt internal traffic of other pods.
- c. Encode a custom SVID into each pod identity so that malicious containers are easily spotted.
- d. Enable deny-by-default practices, and refuse communication with any pods with identities that you cannot cryptographically verify.

► **3. An application consists of four services: a front end service, a gateway service, and two back end services. The front end service serves a web page to the end user. The web page then sends requests to the gateway service, which communicates with back end services and replies directly to the web page. Assuming that Red Hat OpenShift Service Mesh manages all of the services, how many service accounts should be created in the application project?**

- a. One, only for the front end service, because no other pod is directly exposed to the end user.
- b. Two, for both the front end and gateway services, because they are exposed to the end user.
- c. Two, for both of the back end services, because they might contain sensitive information.
- d. Four, one for each of the services because requests from every service must be cryptographically verifiable.

► **4. Which of the following two statements are true about the public key infrastructure (PKI) in Service Mesh? (Choose two.)**

- a. Developers can use the PKI to encrypt service communications within the service mesh by using TLS without changing application code.
- b. Developers must redeploy all services within the service mesh after any change to the PKI configuration.
- c. Developers can use the PKI to configure authorization settings for services within the service mesh without changing the application code.
- d. Developers must modify the application code before they can use the PKI.

## ► Solution

# Describing the Role of Citadel in OpenShift Service Mesh

Choose the correct answers to the following questions:

► 1. **Which two of the following statements about issuing certificate-key pair identity are correct? (Choose two.)**

- a. Each service must be aware of the certificate-key identity in order to request a new identity before the expiration date.
- b. The Pilot agent inside of the Envoy proxy requests a new certificate based on the service account of the service.
- c. The generated certificate-key pair is usually stored in the configuration of the Envoy process.
- d. The developers must first inject a certificate authority to the Service Mesh before requesting any identities.

► 2. **Which of the following two statements about microservice security with OpenShift Service Mesh are recommended practices? (Choose two.)**

- a. Enable traffic encryption in each project. For example, by using TLS and unique service accounts for each pod.
- b. Deploy each pod into a unique project so that malicious pods cannot decrypt internal traffic of other pods.
- c. Encode a custom SVID into each pod identity so that malicious containers are easily spotted.
- d. Enable deny-by-default practices, and refuse communication with any pods with identities that you cannot cryptographically verify.

- **3. An application consists of four services: a front end service, a gateway service, and two back end services. The front end service serves a web page to the end user. The web page then sends requests to the gateway service, which communicates with back end services and replies directly to the web page. Assuming that Red Hat OpenShift Service Mesh manages all of the services, how many service accounts should be created in the application project?**
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  - c. Two, for both of the back end services, because they might contain sensitive information.
  - d. Four, one for each of the services because requests from every service must be cryptographically verifiable.
- **4. Which of the following two statements are true about the public key infrastructure (PKI) in Service Mesh? (Choose two.)**
- a. Developers can use the PKI to encrypt service communications within the service mesh by using TLS without changing application code.
  - b. Developers must redeploy all services within the service mesh after any change to the PKI configuration.
  - c. Developers can use the PKI to configure authorization settings for services within the service mesh without changing the application code.
  - d. Developers must modify the application code before they can use the PKI.

# Configuring Mutual TLS

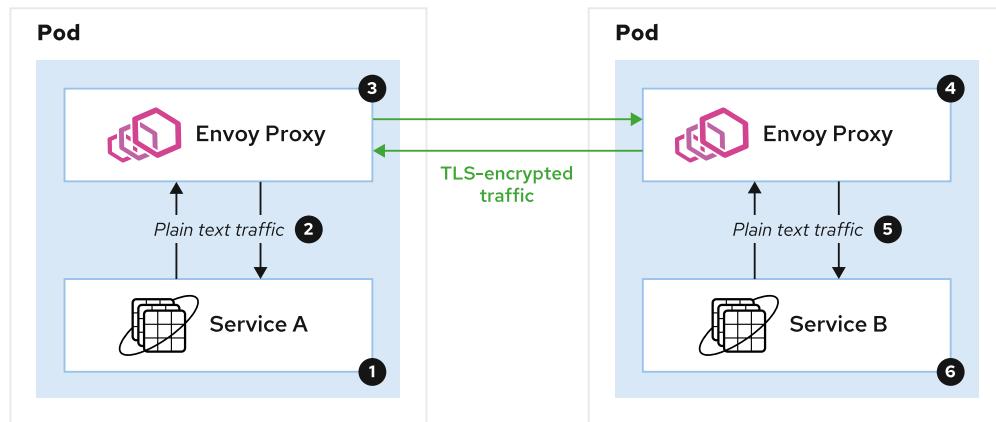
## Objectives

After completing this section, you should be able to configure Mutual TLS to secure intra-service communication.

## Describing Mutual TLS in OpenShift Service Mesh

*Mutual TLS* (mTLS) is a security feature provided by OpenShift Service Mesh. Enabling mTLS results in encrypted traffic between Envoy proxy containers. This means that traffic between services is encrypted.

Every service injected with an Envoy proxy can perform plain text as well as TLS-encrypted requests.



- ① The application sends plain text traffic.
- ② The Envoy proxy intercepts the traffic.
- ③ The origin Envoy proxy encrypts the traffic.
- ④ The destination Envoy proxy intercepts TLS traffic.
- ⑤ The destination Envoy proxy decrypts TLS traffic into plain text traffic.
- ⑥ The destination service receives and responds via plain text traffic.

Enabling mTLS reduces the attack surface of your Red Hat OpenShift cluster. For example, mTLS mitigates man-in-the-middle attacks between the Red Hat OpenShift nodes by securing internal (also called east-west) traffic.

If an attacker injects a malicious container into your service mesh, for example due to a compromised external container registry, this container cannot decrypt the encrypted network packets.

Red Hat OpenShift does not provide any mechanism to enable encryption for internal communication. Cloud administrators who want to adhere to the DevSecOps principles, such as implementing zero-trust network perimeters, must manually provision and maintain a Public Key Infrastructure (PKI). The application developers must adjust the application code to communicate by using TLS protocols.

OpenShift Service Mesh enables you to utilize a managed PKI infrastructure. The deployed microservice application uses plain text protocol to communicate with other services. The Envoy proxy performs TLS encryption at the request origin and decryption at the request destination.

Because Envoy proxies start and terminate the TLS traffic, the application code requires no modifications to utilize TLS communication.

## Describing Mutual Authentication Workflow

In mTLS, both the origin and target Envoy proxies authenticate each request.

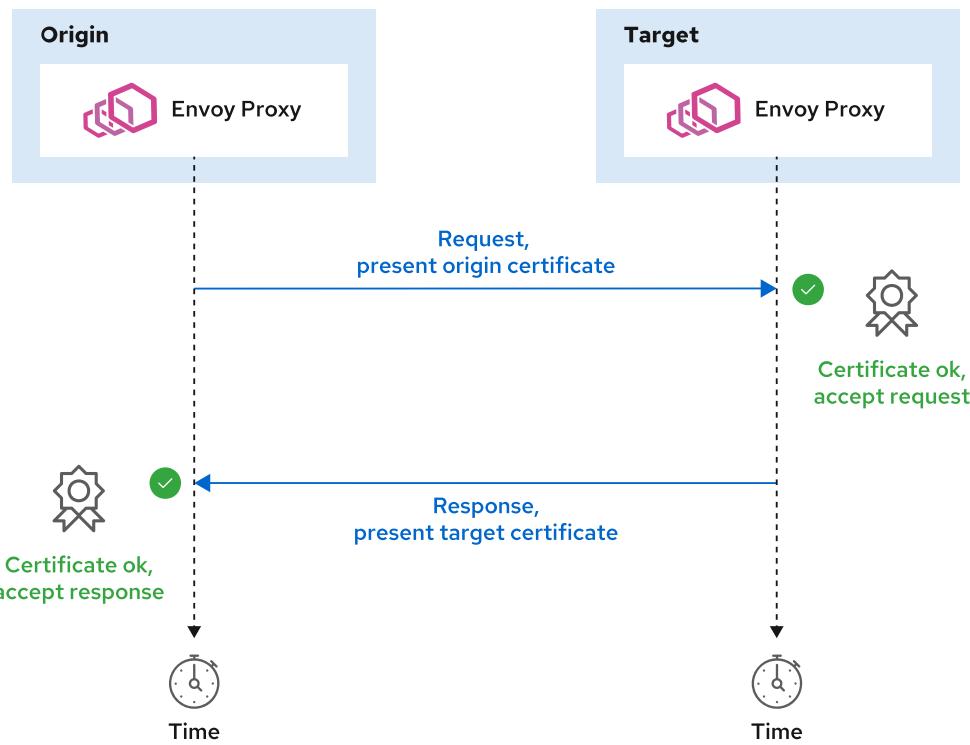


Figure 8.1: Successful mTLS exchange

The origin Envoy proxy attaches a certificate-backed identity to its request. The target Envoy proxy verifies the certificate attached to the request. In the response, the target Envoy proxy attaches its certificate-backed identity to the response. Finally, the origin Envoy proxy accepts only responses with a valid and trusted identity.

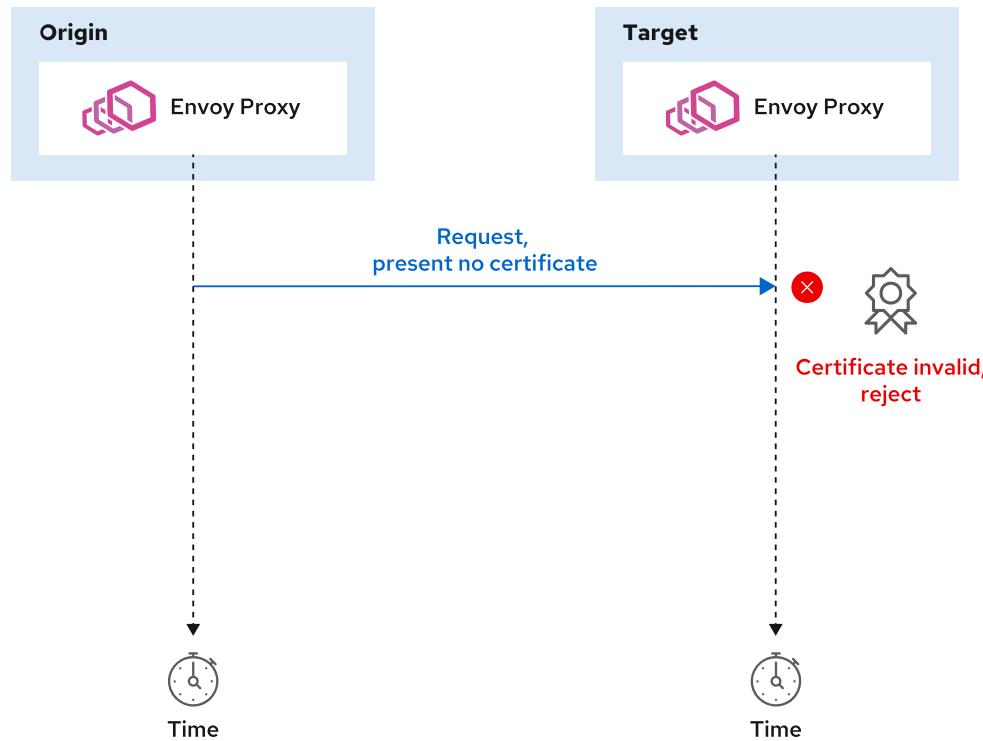


Figure 8.2: Failed mTLS exchange

## Mutual TLS Modes

You can enable mTLS in one of two modes:

- Permissive (default)
- Strict

The *permissive* mode allows Envoy proxies to accept either plain text or mTLS-encrypted traffic. The permissive mode is the default mTLS mode because it enables communication with services that are not injected with Envoy proxies.

The permissive mode enables you to configure services that must use mTLS. If you specify that a service must use mTLS, then the Envoy proxy rejects plain text requests from such service.

The *strict* mode forbids Envoy proxies to accept plain text traffic. Consequently, services that use plain text requests are unable to communicate with services in OpenShift Service Mesh.

## Choosing Mutual TLS Mode

Use the strict mode when you want to enforce a zero-trust perimeter, and when your services have no dependencies on services that do not have the Envoy proxy sidecar container.

Permissive mode is especially useful when you are migrating some of your services to OpenShift Service Mesh, or for testing. Even when OpenShift Service Mesh uses the permissive mode, you can set services with the Envoy proxy container to communicate by using mTLS.

## Configuring Mutual TLS

### Configuring Mutual TLS Globally

You can configure global strict enforcement of mTLS by modifying the `servicemeshcontrolplane` resource:

```
[student@demo ~]$ oc edit servicemeshcontrolplane basic-install -n istio-system
apiVersion: maistra.io/v2
kind: ServiceMeshControlPlane
metadata:
  creationTimestamp: "2021-05-31T10:34:24Z"
  finalizers:
  - maistra.io/istio-operator
  generation: 2
  name: basic
  namespace: istio-system
spec:
  security:
    dataPlane:
      mtls: true ①
    controlPlane:
      mtls: true ②
    grafana:
      enabled: true
  version: v2.0
  ...

```

- ① The `.spec.security.dataPlane.mtls` property configures strict mTLS for Envoy proxies in the data plane.
- ② The `.spec.security.controlPlane.mtls` property configures strict mTLS for Envoy proxies in the control plane.

### Configuring Mutual TLS per Project

At the project level, OpenShift Service Mesh uses two custom resources to configure mTLS:

#### DestinationRule Resource

The DestinationRule (DR) resource configures how an Envoy proxy sends origin requests.

#### PeerAuthentication Resource

The PeerAuthentication (PA) resource configures the policies for receiving requests.

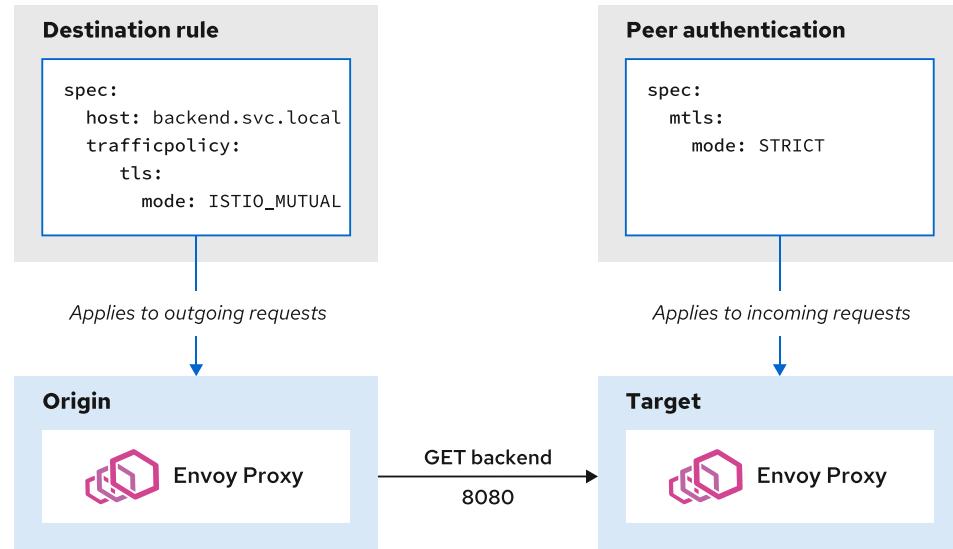


Figure 8.3: Configuring origin and destination Envoy proxy behavior

## Configuring Origin Request Policies with DestinationRule

The following destination rule explicitly configures the Envoy proxy to use mutual TLS:

```

apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: dr-mtls
  namespace: mTLS ❶
spec:
  host: * ❷
  trafficPolicy:
    tls:
      mode: ISTIO_MUTUAL ❸

```

- ❶ The destination rule configures Envoy proxies in the `mtls` project.
- ❷ This destination rule applies to requests for all hosts.
- ❸ Originating requests use strictly mutual TLS.

The preceding destination rule configures Envoy proxies such that:

- Pods in the `mtls` project use only mTLS to originate requests. Consequently, any Envoy proxy in the `mtls` project cannot originate request with microservices that are not managed by OpenShift Service Mesh.

If you specify the host, for example `*.mtls.svc.local`, the Envoy proxies use strict mTLS only for the configured host. Consequently, the Envoy proxies can fall back to plain text traffic when originating requests to other hosts.

- The destination rule does not configure incoming requests. Consequently, microservices that are not managed by OpenShift Service Mesh can send plain text requests to services in the

mtls project. The Envoy proxies in the mtls project successfully fall back to plain text traffic for outgoing requests.

## Configuring Target Request Policies with PeerAuthentication

The PeerAuthentication resource enables you to configure what types of incoming traffic you want to allow in a project.

The following PeerAuthentication resource is the simplest way to refuse any incoming plain text requests:

```
apiVersion: security.istio.io/v1beta1
kind: PeerAuthentication
metadata:
  name: default
  namespace: foo
spec:
  mtls:
    mode: STRICT
```

If you want to enforce mTLS-only traffic in a project, configure Envoy proxies with both the destination rule as well as PeerAuthentication resources.

The preceding peer authentication does not specify the `.spec.selector` field. Consequently, it configures all Envoy proxies in the project.

You can specify selectors to target specific workloads in a project, for example:

```
apiVersion: security.istio.io/v1beta1
kind: PeerAuthentication
metadata:
  name: default
  namespace: foo
spec:
  selector:
    matchLabels:
      app: backend ①
  mtls:
    mode: STRICT
```

① This peer authentication policy matches only pods with the `app=backend` label.

## Classifying mTLS Traffic Types

Services deployed on OpenShift Service Mesh can use a number of different protocols to expose their APIs and communicate with other services. OpenShift Service Mesh supports a number of such protocols, for example:

- http
- http2
- grpc
- mongo

- mysql
- TCP

When a service uses an unknown protocol, the Envoy proxy treats the traffic as an opaque TCP connection and wraps the connection for mTLS.

In some cases, you might need to disable specific ports from mTLS wrapping. Disabling mTLS wrapping can be useful, for example, when:

- A protocol already uses some form of encryption.
- An application is location aware in terms of routing and cannot use Envoy proxy routing.

You can use peer authentication to configure mTLS on a port level, for example:

```
apiVersion: security.istio.io/v1beta1
kind: PeerAuthentication
metadata:
  name: default
  namespace: foo
spec:
  mtls:
    mode: STRICT ①
    portLevelMtls:
      3333:
        mode: DISABLE ②
```

- ① Configure strict mTLS.
- ② Envoy proxies can accept plain text traffic on port 3333.

Additionally, you can configure the Envoy proxy to not redirect and wrap traffic by using annotations, for example:

- `traffic.sidecar.istio.io/excludeInboundPorts`: a list of inbound ports excluded from redirection
- `traffic.sidecar.istio.io/excludeOutboundPorts`: a list of outbound ports excluded from redirection
- `traffic.sidecar.istio.io/excludeOutboundIPRanges`: a list of IP address ranges in the CIDR form excluded from redirection

The preceding annotations apply to pods and configure Envoy proxy not to intercept traffic on the configured ports or IP ranges.

## Verifying State of Mutual TLS

You can both verify the mTLS configuration by using the `istioctl` command-line utility. You can use the `istioctl experimental authz check POD_NAME` command to verify Envoy proxy mTLS settings.

Additionally, you can examine the configuration of the Envoy proxy. This can be useful in examining chain filters that manipulate each request, or the transport socket.

For example, in the following `customer-5fc9f6d46f-mq4f7` pod, find the virtual inbound port:

```
[student@demo ~]$ istioctl proxy-config listener customer-5fc9f6d46f-mq4f7 \
| jq '.[25].name'
"virtualInbound"
```

Examine transport socket configuration:

```
[student@demo ~]$ istioctl proxy-config listener customer-5fc9f6d46f-mq4f7 \
| jq '.[25].transportSocket'
{
  "name": "envoy.transport_sockets.tls",
  "typedConfig": {
    "@type": "type.googleapis.com/envoy.api.v2.auth.DownstreamTlsContext",
    "commonTlsContext": {
      "tlsParams": {},
      "tlsCertificateSdsSecretConfigs": [
        {
          "name": "default",
          "sdsConfig": {
            "apiConfigSource": {
              "apiType": "GRPC",
              "grpcServices": [
                {
                  "envoyGrpc": {
                    "clusterName": "sds-grpc"
                  }
                }
              ],
              "initialFetchTimeout": "0s"
            }
          }
        },
        ...
      ],
      ...
    }
  }
}
...output omitted...
```

See the Envoy Proxy documentation [[https://www.envoyproxy.io/docs/envoy/v1.14.5/api-v3/extensions/transport\\_sockets/tls/v3/cert.proto.html](https://www.envoyproxy.io/docs/envoy/v1.14.5/api-v3/extensions/transport_sockets/tls/v3/cert.proto.html)] for more information about the TLS transport socket extension.

## Verifying Service Identity

Services that use mTLS use a set of X.509 certificates to establish request identity. The certificate is commonly stored in the Envoy proxy configuration.

You can parse a certificate from the Envoy proxy configuration, for example:

```
[student@demo ~]$ oc exec POD_NAME -c istio-proxy -- \
curl -s http://127.0.0.1:15000/config_dump | \
jq -r .configs[5].dynamic_active_secrets[0].secret | \
jq -r .tls_certificate.certificate_chain.inline_bytes | \
base64 --decode > certificate-chain.pem
```

You can examine the parsed certificate by using the `openssl` utility:

```
[student@demo ~]$ cat certificate-chain.pem | openssl x509 -text -noout
Certificate:
Data:
    Version: 3 (0x2)
    Serial Number:
        8e:e5:1b:99:76:cc:47:7e:0c:3b:5e:8a:50:08:a2:03
    Signature Algorithm: sha256WithRSAEncryption
    Issuer: O = cluster.local
    Validity
        Not Before: Jun 1 11:17:13 2021 GMT
        Not After : Jun 2 11:17:13 2021 GMT
    Subject:
        Subject Public Key Info:
...output omitted...
```

Verifying the service identity is useful, for example, when you change the OpenShift Service Mesh certificate authority to your organization's certificate authority, or when troubleshooting lower-level network issues, such as failure to perform TLS handshake between two services. You can also verify the SPIFFE identity encoded in the certificate.

## End-to-end TLS

Configuring end-to-end TLS means the communication between an external client and a service is fully encrypted. However, to get routed to applications managed by OpenShift Service Mesh, you must use the `ingressgateway` pods.

Configuring one route to expose multiple different services is difficult because a single route can have only one set of certificates.

You can solve the issue by deploying a separate ingress gateway for each service that you want to expose to external clients. Alternatively, you can create a passthrough-terminated TLS route for each exposed service and mount the certificates for each route into the default `ingressgateway` pod.

For example, consider an application that consists of the `customer`, `preference`, and `recommendation` services. The application is deployed and responds to requests. The following procedure describes how to secure traffic from outside of the service mesh to the `customer` pod.

To secure your application by using a passthrough-terminated TLS route:

1. Create a `tls` secret with the contents of your certificate-key pair.

```
[student@demo ~]$ oc -n istio-system create secret tls
istio-ingressgateway-customer-certs --key customer.key --cert customer.crt
secret/istio-ingressgateway-customer-certs created
```

2. Mount the certificates into the `istio-ingressgateway` pod.

- a. Prepare a patch that mounts the `istio-ingressgateway-customer-certs` secret into the `istio-ingressgateway` pod.

```
[student@demo ~]$ cat > gateway-patch.json << EOF
[{
  "op": "add",
  "path": "/spec/template/spec/containers/0/volumeMounts/0",
  "value": {
    "mountPath": "/etc/istio/customer-certs",
    "name": "customer-certs",
    "readOnly": true
  }
},
{
  "op": "add",
  "path": "/spec/template/spec/volumes/0",
  "value": {
    "name": "customer-certs",
    "secret": {
      "secretName": "istio-ingressgateway-customer-certs",
      "optional": true
    }
  }
}]
EOF
```

3. Apply the patch.

```
[student@demo ~]$ oc -n istio-system patch --type=json deploy istio-ingressgateway
-p "$(cat gateway-patch.json)"
deployment.apps/istio-ingressgateway patched
```

4. Verify certificates are mounted in the ingressgateway container.

```
[student@demo ~]$ INGRESS_POD=$(oc -n istio-system get pods -l
istio=ingressgateway -o jsonpath='{.items..metadata.name}')
[student@demo ~]$ oc -n istio-system exec $INGRESS_POD --
ls /etc/istio/customer-certs
tls.crt
tls.key
```

5. Create a gateway that accepts connections by using the host of your exposed application, that is, the resolvable host name used for ingress on the HTTPS port

- a. Prepare the gateway yaml file:

```
[student@demo ~]$ cat > gateway.yml <<EOF
apiVersion: networking.istio.io/v1beta1
kind: Gateway
metadata:
  name: customer-gateway
spec:
  selector:
    istio: ingressgateway ①
  servers:
    - port:②
      number: 443
      name: https-customer
      protocol: HTTPS
    tls:
      mode: SIMPLE ③
      serverCertificate: /etc/istio/customer-certs/tls.crt ④
      privateKey: /etc/istio/customer-certs/tls.key
  hosts:
    - "customer.com" ⑤
EOF
```

- ①** The gateway targets the `istio-ingressgateway` pod by the label `istio=ingressgateway`. The `istio-ingressgateway` pod contains the mounted certificate-key pair.
- ②** The gateway accepts connections on the HTTPS port 443 with the HTTPS protocol.
- ③** The SIMPLE TLS mode means the server does not verify client certificates. Only the client verifies the server authority.
- ④** Provide path to the mounted certificate-key pair. The route presents this certificate to clients.
- ⑤** The host of the path. This path responds to `https://customer.com`. Ensure clients can correctly resolve this domain.

b. Apply the gateway:

```
[student@demo ~]$ oc create -f gateway.yml
gateway.networking.istio.io/customer-gateway created
```

6. Create a virtual service that responds to the `customer-gateway` gateway.

a. Prepare the virtual service yaml file:

```
[student@demo ~]$ cat > vservice.yml << EOF
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: customer-virtualservice
spec:
  hosts:
  - "customer.com"
  gateways:
  - customer-gateway
  http:
  - match:
    - uri:
      prefix: /
    route:
    - destination:
      host: customer
      port:
        number: 8080
EOF
```

- b. Apply the virtual service:

```
[student@demo ~]$ oc create -f vservice.yml
virtualservice.networking.istio.io/customer-virtualservice created
```

7. Create a passthrough-terminated TLS route in the `istio-system` project that listens to the domain that you selected earlier. The route redirects requests to the `istio-ingressgateway` service.

- a. Prepare the route yaml file:

```
[student@demo ~]$ cat > route.yml << EOF
apiVersion: route.openshift.io/v1
kind: Route
metadata:
  labels:
    app: istio-ingressgateway
  name: customer-https-route
  namespace: istio-system
spec:
  host: customer.com
  port:
    targetPort: https
  tls:
    insecureEdgeTerminationPolicy: None
    termination: passthrough
  to:
    kind: Service
    name: istio-ingressgateway
    weight: 100
  wildcardPolicy: None
EOF
```

b. Apply the route:

```
[student@demo ~]$ oc create -f route.yml
route.route.openshift.io/customer-https-route created
```

8. Verify the secure ingress:

```
[student@demo ~]$ curl https://customer.com/
customer => preference => recommendation v1 from 'f11b097f1dd0': 2
```



## References

### **Authentication Policy**

<https://istio.io/v1.6/docs/tasks/security/authentication/authn-policy/>

### **Mutual TLS Migration**

<https://istio.io/v1.6/docs/tasks/security/authentication/mtls-migration/>

### **Peer Authentication**

[https://istio.io/v1.6/docs/reference/config/security/peer\\_authentication/](https://istio.io/v1.6/docs/reference/config/security/peer_authentication/)

### **Destination Rule**

<https://istio.io/v1.6/docs/reference/config/networking/destination-rule/>

### **Gateway**

<https://istio.io/v1.6/docs/reference/config/networking/gateway/>

#ServerTLSSettings

### **Configuring Routes**

<https://access.redhat.com/documentation/en-us/>

openshift\_container\_platform/4.6/html-single/networking#configuring-routes

## ► Guided Exercise

# Configuring Mutual TLS

In this exercise, you will configure OpenShift Service Mesh to use mutual TLS (mTLS).

## Outcomes

You should be able to:

- Verify mTLS state in the OpenShift Service Mesh cluster.
- Enable mTLS in a specific project using the *Policy* and *DestinationRule* resources.
- Validate mTLS state using the *istioctl* command-line client.

## Before You Begin

To perform this exercise, ensure you have:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

As the **student** user on the **workstation** machine, use the **lab** command to prepare your system for this exercise.

This command ensures that:

- Your OpenShift cluster meets the requirements.
- Microservices used in this guided exercise are present on your cluster, and ready to use.
- You have access to the solution files on the **workstation** machine.

```
[student@workstation ~]$ lab secure-mtls start
```

## Instructions

- 1. Log in to OpenShift and verify that the sample project has been successfully deployed.

- 1.1. Run the following command to load the environment variables created in the first guided exercise:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

- 1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

1.3. Change to project `mtls`:

```
[student@workstation ~]$ oc project mTLS
Now using project "mtls" on server ...
```

1.4. Verify that the pods are ready:

```
[student@workstation ~]$ oc get pods
NAME                      READY   STATUS    RESTARTS   AGE
customer-6948b8b959-cl5zf  2/2     Running   0          11s
preference-6d5d86cb79-9cjkv 2/2     Running   0          11s
recommendation-69db8d6c48-wrkc6 2/2     Running   0          11s
```

1.5. Save the `ingress-gateway` route host name with the `/mtls` endpoint into a variable:

```
[student@workstation ~]$ INGRESS_HOST=$(oc get route -n istio-system \
istio-ingressgateway -o jsonpath='{.spec.host}'/mtls)
```

1.6. Verify that the service responds by using the `INGRESS_HOST` variable:

```
[student@workstation ~]$ curl $INGRESS_HOST
customer => preference => recommendation v1 from 'f11b097f1dd0': 1
```

The start script deploys the `customer`, `preference`, and `recommendation` services into your Red Hat OpenShift cluster. The source code is in the Git repository at <https://github.com/RedHatTraining/D0328-apps/> in the `customer`, `preference`, and `recommendation` directories.

## ► 2. Verify the state of mTLS in your service mesh by using the `istioctl` utility.

2.1. Save the customer pod name into a variable:

```
[student@workstation ~]$ CUSTOMER_POD=$(oc get pods -l app=customer \
-o jsonpath='{.items..metadata.name}')
```

2.2. Examine the `istioctl` output by using the `CUSTOMER_POD` variable:

```
[student@workstation ~]$ istioctl experimental authz check $CUSTOMER_POD
LISTENER[FilterChain]      CERTIFICATE      mTLS (MODE)      AuthZ (RULES)
0.0.0.0_80                 none            no (none)        no (none)
0.0.0.0_3000                none            no (none)        no (none)
0.0.0.0_5778                none            no (none)        no (none)
0.0.0.0_8080                none            no (none)        no (none)
0.0.0.0_9090                none            no (none)        no (none)
0.0.0.0_9411                none            no (none)        no (none)
```

```
0.0.0.0_14267      none        no (none)      no (none)
0.0.0.0_14268      none        no (none)      no (none)
...output omitted...
virtualInbound[6]   noneSDS: default yes (PERMISSIVE) no (none)
virtualInbound[7]   none        no (PERMISSIVE) no (none)
virtualInbound[8]   noneSDS: default yes (PERMISSIVE) no (none)
virtualInbound[9]   none        no (PERMISSIVE) no (none)
...output omitted...
```

Mutual TLS is in permissive mode for each inbound port. Consequently, the Envoy proxy in the customer pod accepts unsigned (plain text) requests.

► 3. Enforce use of mTLS in the `mtls` project.

3.1. Create the `policy.yml` file:

```
[student@workstation ~]$ cat > policy.yml << EOF
apiVersion: security.istio.io/v1beta1
kind: PeerAuthentication
metadata:
  name: default
spec:
  mtls:
    mode: STRICT
EOF
```

You can see the complete resource at `~/D0328/solutions/secure-mtls/policy.yml`.

3.2. Apply the Policy resource:

```
[student@workstation ~]$ oc create -f policy.yml
peerauthentication.security.istio.io/default created
```

► 4. Recheck the mTLS status in the `mtls` project.

4.1. Check the state of mTLS in your service mesh:

```
[student@workstation ~]$ istioctl experimental authz check $CUSTOMER_POD | grep
  virtual
virtualOutbound[0]      none        no (none)      no (none)
virtualOutbound[1]      none        no (none)      no (none)
virtualInbound[0]       none        no (none)      no (none)
virtualInbound[1]       noneSDS: default yes (none)      no (none)
virtualInbound[2]       noneSDS: default yes (none)      no (none)
virtualInbound[3]       none        no (none)      no (none)
virtualInbound[4]     noneSDS: default yes (STRICT) no (none)
virtualInbound[5]     noneSDS: default yes (STRICT) no (none)
```

Because the `default` policy is now in the `STRICT` mode, all services within the `mtls` project accept only TLS requests.

► 5. Check that the service no longer responds to plain text requests. Service responds to mTLS requests.

- 5.1. Deploy the `sleep` application that is not injected with an Envoy proxy:

```
[student@workstation ~]$ oc create -f ~/DO328/labs/secure-mtls/sleep.yml
service/sleep created
deployment.apps/sleep created
```

The `sleep` pod is a container with the `sleep` command as its execution command. You can view the source code in the Git repository at <https://github.com/RedHatTraining/DO328-apps> in the `sleep` directory.

- 5.2. After the `sleep` pod changes into the `Running` status, issue a request from the `sleep` pod to the customer service:

```
[student@workstation ~]$ oc exec \
$(oc get pods -o name | grep sleep) -- curl customer:8080
...output omitted...
curl: (56) Recv failure: Connection reset by peer
command terminated with exit code 56
```

- 5.3. Verify that the `customer` pod responds at the `/mtls` endpoint:

```
[student@workstation ~]$ curl $INGRESS_HOST
customer => preference => recommendation v1 from 'f11b097f1dd0': 2
```

- 6. Secure communication between pods so that each pod can only decrypt its own communication.

- 6.1. Create a service account for each pod:

```
[student@workstation ~]$ oc create serviceaccount customer
serviceaccount/customer created
[student@workstation ~]$ oc create serviceaccount recommendation
serviceaccount/recommendation created
[student@workstation ~]$ oc create serviceaccount preference
serviceaccount/preference created
```

- 6.2. Assign the service accounts to pod deployments:

```
[student@workstation ~]$ oc set serviceaccount deployment customer customer
deployment.apps/customer serviceaccount updated
[student@workstation ~]$ oc set serviceaccount deployment recommendation \
recommendation
deployment.apps/recommendation serviceaccount updated
[student@workstation ~]$ oc set serviceaccount deployment preference preference
deployment.apps/preference serviceaccount updated
```

- 6.3. Assigning a service account to a deployment terminates the current pod and creates a new pod. Wait until all pods become ready.

```
[student@workstation ~]$ oc get pods
NAME                      READY   STATUS    RESTARTS   AGE
customer-5c7b87c6c5-55vrz  2/2     Running   0          22s
preference-6d98556fc5-vzk7v 2/2     Running   0          23s
recommendation-6b886bd8d8-8r6xq 2/2     Running   0          24s
sleep-55965958d6-vntwd    1/1     Running   0          28m
```

6.4. Save the new pod name into a variable:

```
[student@workstation ~]$ CUSTOMER_POD=$(oc get pods -l app=customer -o name)
```

6.5. Verify the customer pod uses a unique SVID:

```
[student@workstation ~]$ oc exec $CUSTOMER_POD -c istio-proxy -- \
curl -s http://127.0.0.1:15000/config_dump | \
jq -r .configs[5].dynamic_active_secrets[0].secret | \
jq -r .tls_certificate.certificate_chain.inline_bytes | \
base64 --decode | \
openssl x509 -text -noout | \
grep "X509v3 Subject" -A 1
X509v3 Subject Alternative Name: critical
URI:spiffe://cluster.local/ns/mtls/sa/customer
```

- ❶ Execute the following commands in the `istio-proxy` container, which contains the certificates.
  - ❷ Print the full Envoy proxy configuration.
  - ❸ Select TLS certificates.
  - ❹ Decode the base64-encoded string.
  - ❺ Decode the certificate by using the `openssl` utility.
  - ❻ Find the `Subject Alternative Name`, and then print the line following it.
- Repeat the step to verify the SVID for the `preference` and `recommendation` pods.

6.6. Verify that pods can communicate using the unique identities:

```
[student@workstation ~]$ curl $INGRESS_HOST
customer => preference => recommendation v1 from 'f11b097f1dd0': 1
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab secure-mls finish
```

This concludes the guided exercise.

# Defining Service to Service Authorization

## Objectives

After completing this section, you should be able to configure restriction on services communication in OpenShift Service Mesh.

## Defining Authorization in Zero-trust Perimeters

Previously, you learned about the concepts of zero-trust networks and using mutual TLS to encrypt your internal traffic.

OpenShift Service Mesh also provides an authorization mechanism, which uses the service identity and provides developers fine-grained control over services communication.

In OpenShift Service Mesh, you can configure a deny-by-default communication pattern with targeted exceptions. For example, consider that you want to expose the front end and gateway services to end users, but exposing the database directly would be a security risk.

Without OpenShift Service Mesh, you can choose not to configure ingress for services that should not be exposed.

However, if an attacker injects a malicious container into your cluster, for example due to a compromised container registry, the database is directly accessible from within the cluster. In the worst case scenario, the malicious container is deployed into the cluster with its own Envoy proxy and a valid cryptographic identity.

OpenShift Service Mesh enables you to mitigate such a breach by using the deny-by-default communication pattern. Developers can configure the OpenShift Service Mesh to allow connections to the database service only from pods with a specified identity. Any other communication is forbidden and the malicious container cannot communicate with the database pod.

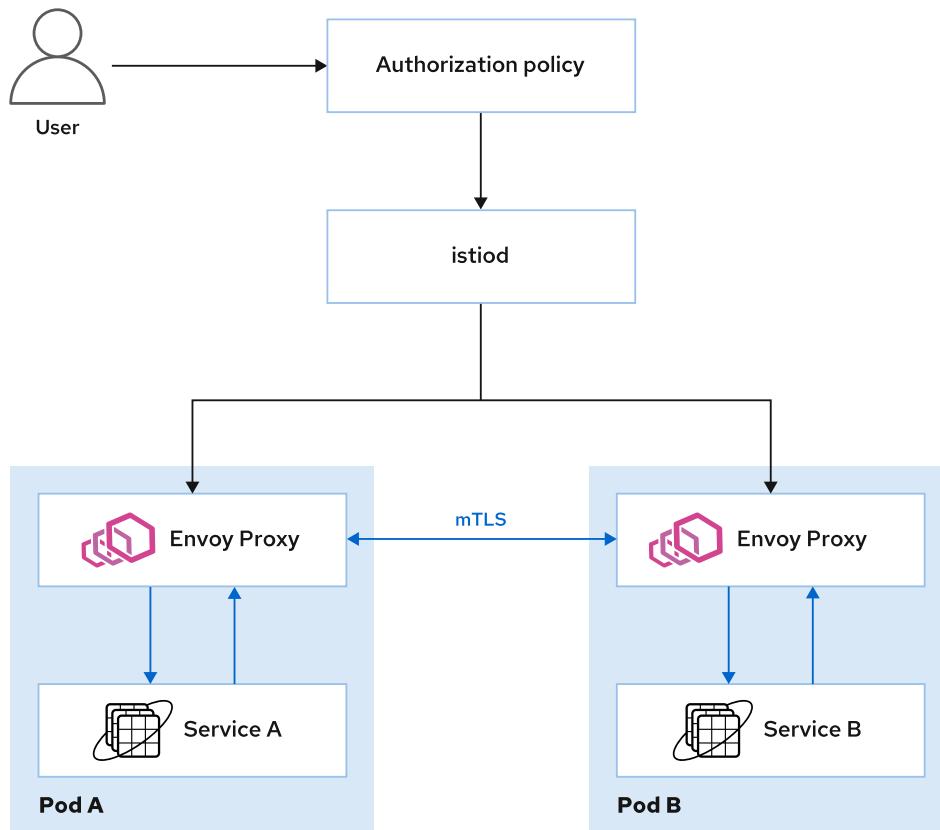
Enabling authorization in OpenShift Service Mesh requires no modifications to the application code. Envoy proxies ensure that authorization configuration is enforced.

Additionally, OpenShift Service Mesh enables you to control egress calls. If you configure OpenShift Service Mesh to deny unknown egress requests, a potential malicious container is unable to make any calls outside of OpenShift Service Mesh.

Service to service authorization is another tool in the toolbox of a DevSecOps organization that enables you to minimize security vectors and mitigate security breaches.

## Describing Authorization Workflow

Use the `AuthorizationPolicy` custom resource definition to configure authorization. When you create a new authorization policy, `istiod` generates an Envoy RBAC policy configuration. This policy configuration is propagated into Envoy proxy containers. Envoy proxies apply the authorization policies at run time, when another service sends a request.



**Figure 8.4: OpenShift Service Mesh authorization workflow**

Mutual TLS is required for authorization policies that use identity, such as principals, namespaces, or server name indication (SNI). If you disable mutual TLS, then the request contains no identity and identity-based policies deny the request.

## Configuring Service Authorization

To configure OpenShift Service Mesh authorization policies, use the `AuthorizationPolicy` custom resource definition (CRD). The `AuthorizationPolicy` CRD specifies the following attributes:

- *Subject*, matched by the `.spec.selector` field. This is the target Envoy proxy that enforces the policy.
- *Action*, matched by the `.spec.action` field, specifies an allowlist (ALLOW) or a denylist (DENY) action. The default value is ALLOW.
- *Rule set*, matched by the `spec.rules` field, specifies the trigger for this policy, for example communication on a specified port. Each rule set has the following attributes:
  - `source` field, specifies the origin of the request, for example, a service identity.
  - `to` field, specifies the HTTP method, port, path, or other properties of the request.
  - `when` field, specifies additional conditions, such as the presence of an HTTP header.

For example:

```

apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "test-policy"
spec:
  selector: ①
    matchLabels:
      app: test
  action: ALLOW ②
  rules: ③
  - from:
    - source:
        namespaces: ["test"]
    to:
    - operation:
        methods: ["GET"]
        ports: ["8080"]
        paths: ["/"]

```

- ① This authorization policy targets all pods that match the `app=test` label. The Envoy proxy in matching pods will enforce this authorization policy.
- ② Action is explicitly set to `ALLOW`. Requests that trigger this policy are permitted. Any other requests to the matching pods will be denied, unless you specify another authorization policy.
- ③ This policy matches requests from the `test` namespace with the `GET` HTTP method to the `8080` port matching the `/` endpoint.

Note the following:

- If you create no authorization policy, then all requests are permitted. However, when you specify at least one authorization policy, you enable deny-by-default behavior for the Envoy proxy of the matching workload.
- If you create a single `DENY` policy, all requests are permitted except for the requests that match the policy.
- You can create multiple authorization policies for one workload.

Creating multiple policies for a single workload is useful for designing atomic, easy-to-maintain policies. Creating multiple policies for a single workload also enables other patterns, such as temporary permit requests used for testing or development.

Each Envoy proxy contains a list of authorization policies. When an Envoy proxy receives a request, each policy is evaluated separately. The first policy that matches is applied. This results in a logical OR behavior.



### Warning

Do not rely on the policy order of your envoy proxy.

- The scope of authorization policies is a project. The previous `test-policy` example policy will not match workloads with the `app=test` label in a different project.

## Configuring Traffic Type

You can specify authorization policies to match parameters that are not available in all protocols. For example, consider the following matching parameters:

- Match requests to host `example`.
- Match requests for path `/example`
- Match requests for the `GET` method.

The preceding matching is specific to the HTTP protocol, and does not work for protocols like TCP.

If you create authorization policies with HTTP-based matching, then you must specify your traffic type in the `Service` object.

Consider the following service:

```
kind: Service
apiVersion: v1
metadata:
  labels:
    app: exchange
  name: exchange
spec:
  ports:
    - port: 8080
      protocol: TCP
      targetPort: 8080
  selector:
    app: exchange
```

The service does not name the port it uses. Service Mesh treats the traffic as opaque TCP traffic. Consequently, Envoy proxies do not match HTTP-based authorization policies as expected.

To set the traffic type, provide the port name, for example:

```
kind: Service
apiVersion: v1
metadata:
  labels:
    app: exchange
  name: exchange
spec:
  ports:
    - port: 8080
      protocol: TCP
      targetPort: 8080
      name: http
  selector:
    app: exchange
```

## Using Authorization Policies with Rewriting Rules

The virtual service object enables you to rewrite paths. For example, consider the following virtual service:

```

kind: VirtualService
apiVersion: networking.istio.io/v1beta1
metadata:
  name: example
spec:
  ...spec omitted...
  http:
    - match:
      - uri:
          prefix: /path
        rewrite:
          uri: /
    route:
      - destination:
          host: exchange
          port:
            number: 8080

```

The example virtual service rewrites the request path from `/path` to `/` and then redirects the request to the `exchange:8080` host. However, when the request targets other paths, such as `/path/example`, the rewriting rule rewrites the path to `//example`. If you create an authorization policy that targets the `/example` path, then it does not match the `//example` path.

You can solve the issue in one of the following ways:

- Change the authorization policy to match the `//example` path.
- Use the built-in path normalization to remove double slashes from rewritten paths.
- Change the rewriting rules from `/path` to `/path/`. This change provides an additional security benefit of not matching paths such as `/pathABC` by the virtual service.

You can set the path normalization setting on your control plane file:

```

spec:
  techPreview:
    global:
      pathNormalization: MERGE_SLASHES

```

Learn more about normalization options in the Service Mesh Documentation [[https://access.redhat.com/documentation/en-us/openshift\\_container\\_platform/4.6/html/service\\_mesh/service-mesh-2-x#updating-the-path-normalization-configuration](https://access.redhat.com/documentation/en-us/openshift_container_platform/4.6/html/service_mesh/service-mesh-2-x#updating-the-path-normalization-configuration)].

Rewriting traffic can lead to unexpected authorization policy matches. If you rewrite your traffic and use authorization policies, then carefully test your authorization policy matching before relying on the authorization policies in production environments.

## Combining Authorization Policy Rule Parameters

You can specify multiple rule parameters, such as the `.spec.rules.from.source` or `.spec.rules.to.operation` parameters. Specifying multiple matching parameters results in the logical OR behavior.

This is useful for specifying multiple trigger conditions for the policy. However, large authorization policies with multiple rule parameters are difficult to understand and maintain. It is a best

practice to keep your authorization policies as small and atomic as possible in the context of your environment.

The following policy example combines multiple `.spec.rules.from.source` fields:

```
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "test-policy-multiple-sources"
spec:
  selector:
    matchLabels:
      app: test
  rules:
  - from:
    - source:
        namespaces: ["test"]
    - source:
        principals: ["cluster.local/ns/test2/sa/test2-service-account"]
    - source:
        ipBlocks: ["10.128.0.0/14"]
```

The example `test-policy-multiple-sources` authorization policy specifies no `.spec.action` field value. Consequently, the default `ALLOW` value is applied. The policy permits any requests that match at least one of the following conditions:

- Requests originate from the `test` namespace.
- Requests identified by the `test2-service-account` service account in project `test2`.
- Requests originating from an IP in the `10.128.0.0/14` range.

Because the preceding policy did not specify any `to` field, all requests from the allowed sources are allowed.

The following policy example combines multiple `.spec.rules.to.operation` fields:

```
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "test-policy-multiple-operation"
spec:
  selector:
    matchLabels:
      app: test
  rules:
  - to:
    - operation:
        methods: ["GET"]
        ports: ["8080"]
    - operation:
        methods: ["POST"]
        ports: ["8080"]
        paths: ["/api/v2/createEmployee/*"]
    - operation:
```

```
methods: ["PUT"]
ports: ["8080"]
paths: ["/api/v2/updateEmployee"]
```

The `test-policy-multiple-operation` authorization policy permits any requests that match at least one of the following conditions:

- Any GET requests on the 8080 port.
- POST requests on the 8080 port to the `/api/v2/createEmployee/*` endpoints.
- PUT requests on the 8080 port to the `/api/v2/updateEmployee` endpoint.



## References

### **Authorization Policy (Reference)**

<https://istio.io/v1.6/docs/reference/config/security/authorization-policy/>

### **Authorization Policy Conditions**

<https://istio.io/v1.6/docs/reference/config/security/conditions/>

### **Authorization Policy (Concept)**

<https://istio.io/v1.6/docs/concepts/security/#authorization-policies>

### **Envoy Proxy HTTP filters**

[https://www.envoyproxy.io/docs/envoy/latest/configuration/http/http\\_filters/http\\_filters](https://www.envoyproxy.io/docs/envoy/latest/configuration/http/http_filters/http_filters)

## ► Guided Exercise

# Configuring Service to Service Authorization

In this exercise, you will restrict service-to-service communication within a project and across projects.

At the start of the exercise, the `lab` command deploys the `customer`, `preference`, and `recommendation` services into your Red Hat OpenShift cluster. The `customer` service sends requests to the `preference` service. The `preference` service sends requests to the `recommendation` service.

Each service deployment uses a unique service account. You can examine the full deployment file in the `~/DO328/labs/secure-authc/app-deployment.yaml` file. In the `app-deployment.yaml` file, note that each Deployment resource specifies a unique service account.

You will:

- Restrict each service to accept incoming requests from one and only one other service, as per the service workflow.
- Relax the restriction by enabling the `customer` service to accept incoming requests from an external project, to simulate developer environment.
- Disable mTLS to demonstrate that Envoy proxies deny any identity-based policies with disabled mTLS.

## Outcomes

You should be able to configure OpenShift Service Mesh to restrict access to services based on service parameters, such as namespace or service account.

## Before You Begin

To perform this exercise, ensure you have:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (`/usr/local/bin/oc`).

On the `workstation` machine, use the `lab` command to prepare your system for this exercise.

The `lab` command deploys the `customer`, `preference`, and `recommendation` services into your Red Hat OpenShift cluster. The source code is in the Git repository at <https://github.com/RedHatTraining/DO328-apps> in the `customer`, `preference`, and `recommendation` directories.

```
[student@workstation ~]$ lab secure-authc start
```

## Instructions

- 1. Log in to OpenShift and verify that the application is ready.
- 1.1. Run the following command to load the environment variables created in the first guided exercise:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

- 1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

- 1.3. Change to project secure-authc:

```
[student@workstation ~]$ oc project secure-authc
Now using project "secure-authc" on server ...
```

- 1.4. Verify that pods are in the Running state:

```
[student@workstation ~]$ oc get pods
NAME                  READY   STATUS    RESTARTS   AGE
customer-5f9bb4676-2g4f6   2/2     Running   0          11s
preference-748787ff89-fnxt8  2/2     Running   0          11s
recommendation-78588b5ff9-wx52s  2/2     Running   0          11s
```

- 1.5. Save the ingress-gateway route host name with the /secure-authc endpoint into a variable:

```
[student@workstation ~]$ INGRESS_HOST=$(oc get route -n istio-system \
istio-ingressgateway -o jsonpath='{.spec.host}'/secure-authc)
```

- 1.6. Verify that the service responds by using the INGRESS\_HOST variable:

```
[student@workstation ~]$ curl $INGRESS_HOST
customer => preference => recommendation v1 from 'f11b097f1dd0': 1
```

- 2. Verify that there is no restriction on pod communication. Any pod in the mesh can communicate with any other pod in the secure-authc project.

- 2.1. Create a new project named curl:

```
[student@workstation ~]$ oc new-project curl
Now using project "curl" on server ...
```

- 2.2. Add the curl project into the servicemeshmemberroll resource:

```
[student@workstation ~]$ oc patch smmr default -n istio-system \
--type='json' -p='[{"op": "add", "path": "/spec/members/0", "value":"curl"}]'
```

Alternatively, use the ~/D0328/labs/secure-authc/patch-smmr.sh script.

### 2.3. Deploy the sleep application into the curl project:

```
[student@workstation ~]$ oc create -f ~/D0328/labs/secure-authc/sleep.yml
service/sleep created
deployment.apps/sleep created
```

The sleep pod is a container with the sleep command as its execution command. You can view the source code in the Git repository at <https://github.com/RedHatTraining/D0328-apps/blob/master/sleep/Dockerfile>.

### 2.4. After the sleep pod changes into the Ready state, issue a request from the sleep pod to the customer service:

```
[student@workstation ~]$ oc exec $(oc get pods -o name) \
-- curl -s customer.secure-authc.svc.cluster.local:8080
Defaulting container name to sleep.
Use 'oc describe pod/sleep-556b5fc57c-725w7 -n curl' to see all of the containers
in this pod.
customer => preference => recommendation v1 from 'f11b097f1dd0': 2
```

The sleep pod can reach the customer service in a different namespace.

### 2.5. Change to the secure-authc project:

```
[student@workstation ~]$ oc project secure-authc
Now using project "secure-authc" on server ...
...output omitted...
```

### 2.6. Issue a request from the recommendation pod to the customer pod:

```
[student@workstation ~]$ oc exec $(oc get pod -l app=recommendation -o name) \
-- curl -s customer:8080
Defaulting container name to recommendation.
Use 'oc describe pod/recommendation-78588b5ff9-wx52s -n secure-authc' to see all
of the containers in this pod.
customer => preference => recommendation v1 from 'f11b097f1dd0': 3
```

The recommendation pod can reach the customer pod. However, the recommendation pod should never query the customer pod.

## ► 3. Restrict access to the customer pod by using the following information:

- The customer pod is accessible only by the istio-ingressgateway-service-account service account.
- The customer pod is accessible only at the port 8080.
- The customer pod is accessible only using the GET method.

- 3.1. Prepare the `AuthorizationPolicy` resource. You can view the prepared policy `customer-policy.yaml` in the `~/D0328/solutions/secure-authc` directory.

```
[student@workstation ~]$ cat > customer-policy.yaml << EOF
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "get-customer"
spec:
  selector:
    matchLabels:
      app: customer①
  rules:
  - from:
    - source:
      principals:
        ["cluster.local/ns/istio-system/sa/istio-ingressgateway-service-account"]②
      to:
      - operation:③
        methods: ["GET"]
        ports: ["8080"]
EOF
```

- ① This policy targets all pods with the label `app=customer`.
- ② Requests from the `istio-ingressgateway-service-account` identity are permitted.
- ③ Requests from the permitted source are restricted to method `GET` on port `8080`.

- 3.2. Create the policy:

```
[student@workstation ~]$ oc create -f customer-policy.yaml
authorizationpolicy.security.istio.io/get-customer created
```

- 3.3. Issue a request from the `recommendation` pod to the `customer` pod to test the policy enforcement:

```
[student@workstation ~]$ oc exec $(oc get pod -l app=recommendation -o name) \
-- curl -s customer:8080
Defaulting container name to recommendation.
Use 'oc describe pod/recommendation-78588b5ff9-wx52s -n secure-authc' to see all
of the containers in this pod.
RBAC: access denied
```



### Note

It takes a couple seconds before the authorization policy settings propagate into the Envoy proxy of the `customer` pod.

If the request succeeds, then try to issue the same request again after 5-10 seconds.

- ▶ 4. Repeat the previous step to restrict communication for the preference and recommendation pods.
- 4.1. Restrict communication for the preference pod by using the following information:
    - The preference pod is accessible only by the customer pod with identity `customer-sa`.
    - The preference pod is accessible only at the 8080 port.
    - The preference pod is accessible only using the GET method.
 The solution file is provided at `~/D0328/solutions/secure-authc/preference-policy.yaml`.
  - 4.2. Restrict communication for the recommendation pod by using the following information:
    - The recommendation pod is accessible only by the preference pod with identity `preference-sa`.
    - The recommendation pod is accessible only at the 8080 port.
    - The recommendation pod is accessible only using the GET method.
 The solution file is provided at `~/D0328/solutions/secure-authc/recommendation-policy.yaml`.
- ▶ 5. For development and testing, make the customer pod accessible from any other pod in the curl project.

5.1. Change into the curl project:

```
[student@workstation ~]$ oc project curl
Now using project "curl" on server ...
...output omitted
```

5.2. Verify that pods in the curl project cannot communicate with the customer pod.

```
[student@workstation ~]$ oc exec $(oc get pods -o name) \
-- curl -s customer.secure-authc.svc.cluster.local:8080
Defaulting container name to sleep.
Use 'oc describe pod/sleep-556b5fc57c-jvm9b -n curl' to see all of the containers
in this pod.
RBAC: access denied
```

5.3. Prepare the AuthorizationPolicy resource:

```
[student@workstation ~]$ cat > curl-customer-policy.yaml << EOF
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "curl-get-customer"
  namespace: "secure-authc"
spec:
  selector:
    matchLabels:
      app: customer
  rules:
  - from:
    - source:
      namespaces: ["curl"]
```

The curl-customer-policy.yaml file is available in the ~/D0328/solutions/secure-authc directory.

#### 5.4. Create the policy:

```
[student@workstation ~]$ oc create -f curl-customer-policy.yaml
authorizationpolicy.security.istio.io/curl-get-customer created
```

#### 5.5. Verify that pods in the curl project can now communicate with the customer pod:

```
[student@workstation ~]$ oc exec $(oc get pods -o name) \
-- curl -s customer.secure-authc.svc.cluster.local:8080
Defaulting container name to sleep.
Use 'oc describe pod/sleep-556b5fc57c-jvm9b -n curl' to see all of the containers
in this pod.
customer => preference => recommendation v1 from 'f11b097f1dd0': 4
```

#### 5.6. Verify that pods in the curl project cannot communicate with other pods in the secure-authc project:

```
[student@workstation ~]$ oc exec $(oc get pods -o name) \
-- curl -s preference.secure-authc.svc.cluster.local:8080
Defaulting container name to sleep.
Use 'oc describe pod/sleep-556b5fc57c-jvm9b -n curl' to see all of the containers
in this pod.
RBAC: access denied
```

- ▶ 6. Disable mTLS in the secure-authc project to verify that identity-based authorization policies rely on mTLS.

#### 6.1. Prepare the PeerAuthentication resource:

```
[student@workstation ~]$ cat > disable-mtls.yaml << EOF
apiVersion: security.istio.io/v1beta1
kind: PeerAuthentication
metadata:
  name: default
  namespace: secure-authc
spec:
  mtls:
    mode: DISABLE
EOF
```

The disable-mtls.yaml file is available in the ~/D0328/solutions/secure-authc directory.

6.2. Create the resource:

```
[student@workstation secure-authc]$ oc create -f ./disable-mtls.yaml
peerauthentication.security.istio.io/default created
```

6.3. Verify that the application no longer responds on the INGRESS\_HOST URL:

```
[student@workstation ~]$ curl $INGRESS_HOST
RBAC: access denied
```

## Finish

On the workstation machine, use the lab command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab secure-authc finish
```

This concludes the guided exercise.

## ► Lab

# Securing an OpenShift Service Mesh

### Performance Checklist

In this lab, you will secure the provided application by using the OpenShift Service Mesh authorization policies.

### Outcomes

You should be able to:

- Enable and verify mutual TLS.
- Configure authorization policies based on service identity.
- Restrict service communication using authorization policies based on HTTP attributes, such as HTTP verbs and ports.

### Before You Begin

To perform this exercise, ensure you have:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.

As the student user on the workstation machine, use the `lab` command to prepare your system for this lab.

The `lab` command deploys the exchange application into your Red Hat OpenShift cluster. The source code is in the Git repository at <https://github.com/RedHatTraining/DO328-apps> in the `exchange-application` directory.

The exchange application consists of the following services:

- Frontend
- Currency
- Exchange
- History

You can examine the services in the `secure-mesh` project. The application is available on the `istio-ingressgateway` route at the `/frontend` endpoint.

Additionally, the `lab` command also deploys the dashboard application into your Red Hat OpenShift cluster. The dashboard application provides information about availability of the exchange application services in the service mesh.

The dashboard source code is in the Git repository at <https://github.com/RedHatTraining/DO328-apps> in the `dashboard` directory.

The dashboard application consists of the following services:

- Frontend

- Backend

You can examine the services in the `dashboard` project. The application is available by using the `istio-ingressgateway` route at the `/dashboard` endpoint.

```
[student@workstation ~]$ lab secure-mesh start
```

## Instructions

Secure the exchange application according to the following specifications:

- The `frontend` service is accessible only from the `istio-ingressgateway` service with only GET requests on port 3000.
- The `exchange` service is accessible only from the `istio-ingressgateway` service on port 8080 on the following endpoints:
  - GET `/currencies`
  - POST `/exchangeRate/singleCurrency`
  - POST `/exchangeRate/historicalData`
- The `currency` and `history` services are accessible only from the `secure-mesh` project.

After you secure the exchange application, it should be accessible on the `/frontend` endpoint of the `istio-ingressgateway` route. However, it should not be accessible to any other services in the service mesh. Consequently, the dashboard application should mark all services with status `Down`, and unavailable.

1. Log in to OpenShift and verify that the application is ready.
2. Restrict access to the `frontend` service.
3. Restrict access to the `exchange` service.
4. Restrict access to the `currency` and `history` services.

## Evaluation

Grade your work by running the `lab secure-mesh grade` command from your `workstation` machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab secure-mesh grade
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab secure-mesh finish
```

This concludes the lab.

## ► Solution

# Securing an OpenShift Service Mesh

### Performance Checklist

In this lab, you will secure the provided application by using the OpenShift Service Mesh authorization policies.

### Outcomes

You should be able to:

- Enable and verify mutual TLS.
- Configure authorization policies based on service identity.
- Restrict service communication using authorization policies based on HTTP attributes, such as HTTP verbs and ports.

### Before You Begin

To perform this exercise, ensure you have:

- A configured and running OpenShift cluster.
- A installed and running OpenShift Service Mesh in the OpenShift cluster.

As the student user on the `workstation` machine, use the `lab` command to prepare your system for this lab.

The `lab` command deploys the exchange application into your Red Hat OpenShift cluster. The source code is in the Git repository at <https://github.com/RedHatTraining/DO328-apps> in the `exchange-application` directory.

The exchange application consists of the following services:

- Frontend
- Currency
- Exchange
- History

You can examine the services in the `secure-mesh` project. The application is available on the `istio-ingressgateway` route at the `/frontend` endpoint.

Additionally, the `lab` command also deploys the dashboard application into your Red Hat OpenShift cluster. The dashboard application provides information about availability of the exchange application services in the service mesh.

The dashboard source code is in the Git repository at <https://github.com/RedHatTraining/DO328-apps> in the `dashboard` directory.

The dashboard application consists of the following services:

- Frontend
- Backend

You can examine the services in the `dashboard` project. The application is available by using the `istio-ingressgateway` route at the `/dashboard` endpoint.

```
[student@workstation ~]$ lab secure-mesh start
```

## Instructions

Secure the exchange application according to the following specifications:

- The `frontend` service is accessible only from the `istio-ingressgateway` service with only GET requests on port 3000.
- The `exchange` service is accessible only from the `istio-ingressgateway` service on port 8080 on the following endpoints:
  - GET `/currencies`
  - POST `/exchangeRate/singleCurrency`
  - POST `/exchangeRate/historicalData`
- The `currency` and `history` services are accessible only from the `secure-mesh` project.

After you secure the exchange application, it should be accessible on the `/frontend` endpoint of the `istio-ingressgateway` route. However, it should not be accessible to any other services in the service mesh. Consequently, the dashboard application should mark all services with status Down, and unavailable.

1. Log in to OpenShift and verify that the application is ready.

- 1.1. Run the following command to load the environment variables created in the first guided exercise:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

- 1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

- 1.3. Change to project `secure-mesh`:

```
[student@workstation ~]$ oc project secure-mesh
Now using project "secure-mesh" on server ...
```

- 1.4. Verify that pods are in the `Running` state:

```
[student@workstation ~]$ oc get pods
NAME           READY   STATUS    RESTARTS   AGE
currency-566cdcc8c6-jtd5g  2/2     Running   0          13s
exchange-66b78bf65c-s72gv  2/2     Running   0          13s
frontend-5648fbb85f-td5dg  2/2     Running   0          13s
history-54b5c9d476-rk4pd   2/2     Running   0          13s
```

15. Save the ingress-gateway route host name with the /frontend endpoint into a variable:

```
[student@workstation ~]$ FRONTEND=$(oc get route -n istio-system \
istio-ingressgateway -o jsonpath='{.spec.host}'/frontend)
```

16. Verify that the application responds by using the FRONTEND variable:

```
[student@workstation ~]$ firefox $FRONTEND
```

17. Save the ingress-gateway route hostname with the /dashboard endpoint into a variable:

```
[student@workstation ~]$ DASHBOARD=$(oc get route -n istio-system \
istio-ingressgateway -o jsonpath='{.spec.host}'/dashboard)
```

18. Verify that all the services are accessible by using the DASHBOARD variable:

```
[student@workstation ~]$ firefox $DASHBOARD
```

2. Restrict access to the frontend service.

- 2.1. Prepare the authorization policy. You can view the complete `get-frontend.yaml` file in the `~/D0328/solutions/secure-mesh` directory.

```
[student@workstation ~]$ cat > get-frontend.yaml << EOF
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "get-frontend"
spec:
  selector:
    matchLabels:
      app: frontend
  rules:
  - from:
    - source:
      principals:
        ["cluster.local/ns/istio-system/sa/istio-ingressgateway-service-account"]
    to:
    - operation:
      methods: ["GET"]
      ports: ["3000"]
EOF
```

2.2. Apply the authorization policy:

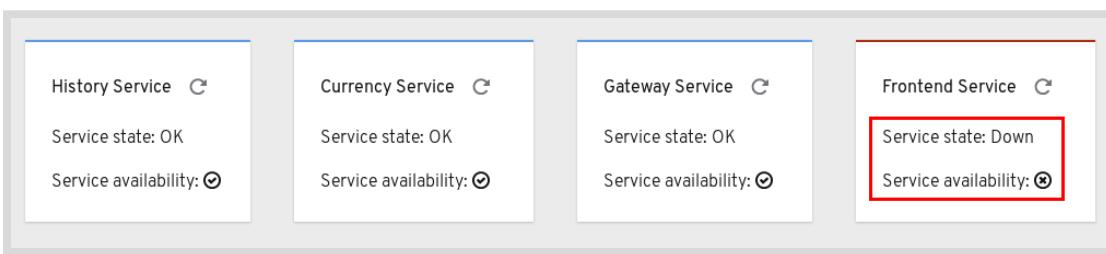
```
[student@workstation ~]$ oc create -f get-frontend.yaml
authorizationpolicy.security.istio.io/get-frontend created
```

2.3. Verify that the application responds by using the FRONTEND variable:

```
[student@workstation ~]$ firefox $FRONTEND
```

2.4. Verify that the Frontend Service service is unavailable in the dashboard application:

```
[student@workstation ~]$ firefox $DASHBOARD
```



3. Restrict access to the exchange service.

3.1. Prepare the authorization policy. You can view the complete `exchange.yaml` file in the `~/D0328/solutions/secure-mesh` directory.

```
[student@workstation ~]$ cat > exchange.yaml << EOF
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "exchange"
spec:
  selector:
    matchLabels:
      app: exchange
  rules:
  - from:
    - source:
      principals:
        ["cluster.local/ns/istio-system/sa/istio-ingressgateway-service-account"]
    to:
    - operation:
      methods: ["POST", "GET"]
      ports: ["8080"]
      paths: ["/currencies", "/exchangeRate/singleCurrency",
              "/exchangeRate/historicalData"]
EOF
```

3.2. Apply the authorization policy:

```
[student@workstation ~]$ oc create -f exchange.yaml
authorizationpolicy.security.istio.io/exchange created
```

3.3. Verify that the `Historical Data` page of the application works. Open the page:

```
[student@workstation ~]$ firefox $FRONTEND/history
```

On the `Historical Data` page, click `Submit`.

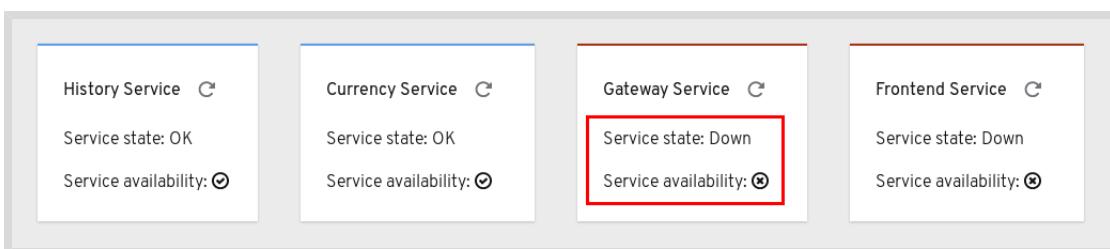
3.4. Verify that the `Exchange` page of the application works. Open the page:

```
[student@workstation ~]$ firefox $FRONTEND/exchange
```

On the `Exchange` page, click `Submit`.

3.5. Verify that the `Gateway Service` service is unavailable in the dashboard application:

```
[student@workstation ~]$ firefox $DASHBOARD
```



4. Restrict access to the currency and history services.

- 4.1. Add a new label, `ns-restricted`, to each of the service deployments. Alternatively, you can use the `add-labels.sh` script in the `~/D0328/solutions/secure-mesh` directory.

```
[student@workstation ~]$ oc patch deployment history --type='json' \
-p='[{"op": "add", "path": "/spec/template/metadata/labels/ns-restricted",
"value":"true"}]'
deployment.apps/history patched
[student@workstation ~]$ oc patch deployment currency --type='json' \
-p='[{"op": "add", "path": "/spec/template/metadata/labels/ns-restricted",
"value":"true"}]'
deployment.apps/currency patched
```

- 4.2. Verify that both `currency` and `history` pods are labeled by using the `ns-restricted` label, and are in the `Running` state:

```
[student@workstation ~]$ oc get pods -l ns-restricted
NAME           READY   STATUS    RESTARTS   AGE
currency-65b7dbdc75-2smhv   2/2     Running   0          28s
history-64bf7cf7d5-mnmr6   2/2     Running   0          44s
```

- 4.3. Prepare the authorization policy. You can view the complete `ns-restricted.yaml` file in the `~/D0328/solutions/secure-mesh` directory.

```
[student@workstation ~]$ cat > ns-restricted.yaml << EOF
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "ns-restricted"
spec:
  selector:
    matchLabels:
      "ns-restricted": "true"
  rules:
  - from:
    - source:
      namespaces: ["secure-mesh"]
EOF
```

- 4.4. Apply the authorization policy:

```
[student@workstation ~]$ oc create -f ns-restricted.yaml
authorizationpolicy.security.istio.io/ns-restricted created
```

- 4.5. Verify that the `Historical Data` page of the application works. Open the page:

```
[student@workstation ~]$ firefox $FRONTEND/history
```

On the `Historical Data` page, click `Submit`.

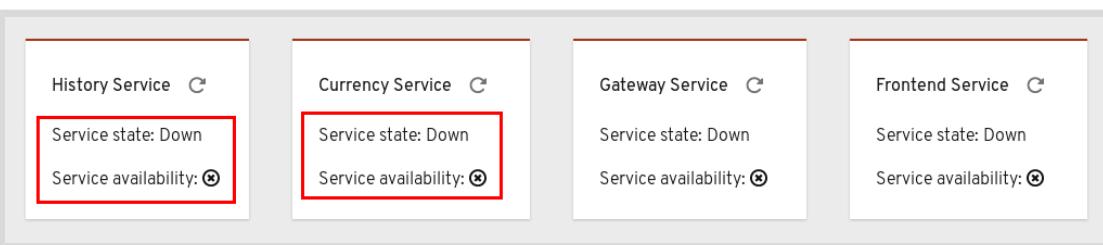
- 4.6. Verify that the `Exchange` page of the application works. Open the page:

```
[student@workstation ~]$ firefox $FRONTEND/exchange
```

On the Exchange page, click Submit.

- 4.7. Verify that the **History Service** and **Currency Service** services are unavailable in the dashboard application:

```
[student@workstation ~]$ firefox $DASHBOARD
```



## Evaluation

Grade your work by running the `lab secure-mesh grade` command from your workstation machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab secure-mesh grade
```

## Finish

On the **workstation** machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab secure-mesh finish
```

This concludes the lab.

# Summary

---

In this chapter, you learned:

- How OpenShift Service Mesh enables you to adopt DevSecOps practices.
- How to configure and troubleshoot mutual TLS (mTLS).
- How to secure microservices by restricting service-to-service communication using the deny-by-default pattern.



## Chapter 9

# Comprehensive Review

### Goal

Review tasks from *Building Resilient Microservices with Istio and Red Hat OpenShift Service Mesh*

### Objectives

Review tasks from *Building Resilient Microservices with Istio and Red Hat OpenShift Service Mesh*

### Sections

Comprehensive Review of Red Hat OpenShift Service Mesh (and Lab)

### Lab

Building Resilient Microservices

# Comprehensive Review

---

## Objectives

After completing this section, you should be able to demonstrate knowledge and skills learned in *Building Resilient Microservices with Istio and Red Hat OpenShift Service Mesh*.

### Reviewing Building Resilient Microservices with Istio and Red Hat OpenShift Service Mesh

Before beginning the comprehensive review for this course, you should be comfortable with the topics covered in each chapter.

You can refer to earlier sections in the textbook for extra study.

#### **Chapter 1, Introducing Red Hat OpenShift Service Mesh**

Describe the basic concepts of microservice architecture and Red Hat OpenShift Service Mesh.

- Describe the basic concepts behind a distributed architecture and Red Hat OpenShift Service Mesh.
- Describe the fundamental architecture of OpenShift Service Mesh components.

#### **Chapter 2, Installing Red Hat OpenShift Service Mesh**

Deploy Red Hat OpenShift Service Mesh on OpenShift Container Platform.

Install Red Hat OpenShift Service Mesh on Red Hat OpenShift Container Platform.

#### **Chapter 3, Observing a Service Mesh**

Trace and visualize an OpenShift Service Mesh with Jaeger and Kiali.

- Configure distributed tracing to track service traffic.
- Collect and inspect critical metrics with Prometheus and Grafana.
- Monitor and visualize service interactions with Kiali.

#### **Chapter 4, Controlling Service Traffic**

Manage and route traffic with Red Hat OpenShift Service Mesh

- Manage and route traffic with Red Hat OpenShift Service Mesh.
- Route traffic to services in a mesh, based on request headers.
- Control egress traffic to access external services.

#### **Chapter 5, Releasing Applications with OpenShift Service Mesh**

Release applications with canary and mirroring release strategies.

- Release application services with a safe canary rollout.
- Deploy a "mirror" service to test a new service with a realistic load.

## **Chapter 6, Testing Service Resilience with Chaos Testing**

Test the resilience of an OpenShift Service Mesh with Chaos Testing.

- Create test errors to identify weaknesses in your application.
- Create a delay in your services to test for weaknesses in your application.

## **Chapter 7, Building Resilient Services**

Leverage OpenShift Service Mesh strategies for creating resilient services.

- Describe the strategies for creating resilient services with Service Mesh.
- Configure time-outs to maintain service reliability.
- Configure a service retry to maintain service reliability.
- Configure a circuit breaker pattern to maintain service reliability.

## **Chapter 8, Securing an OpenShift Service Mesh**

Secure and encrypt service communication in your application with Red Hat OpenShift Service Mesh.

- Describe how OpenShift Service Mesh manages cryptographic identities.
- Configure Mutual TLS to secure intra-service communication.
- Configure restriction on services communication in OpenShift Service Mesh.

## ► Lab

# Building Resilient Microservices

### Performance Checklist

In this review, you will deploy the "Adopt a Pup" application to OpenShift and configure Red Hat OpenShift Service Mesh to manage the traffic and security aspects of the application. You will also configure the service mesh to be more resilient against delays, timeouts, and failures.

### Outcomes

You should be able to:

- Deploy the "Adopt a Pup" application to OpenShift and enable Red Hat OpenShift Service Mesh to control the incoming and outgoing traffic.
- Secure the application by configuring access control and allowing only encrypted communication between microservices.
- Configure the service mesh to perform canary releases and dark launches for testing new features of the application.
- Configure the service mesh to make the application more resilient by using timeouts, retries, and circuit breakers.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- An installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

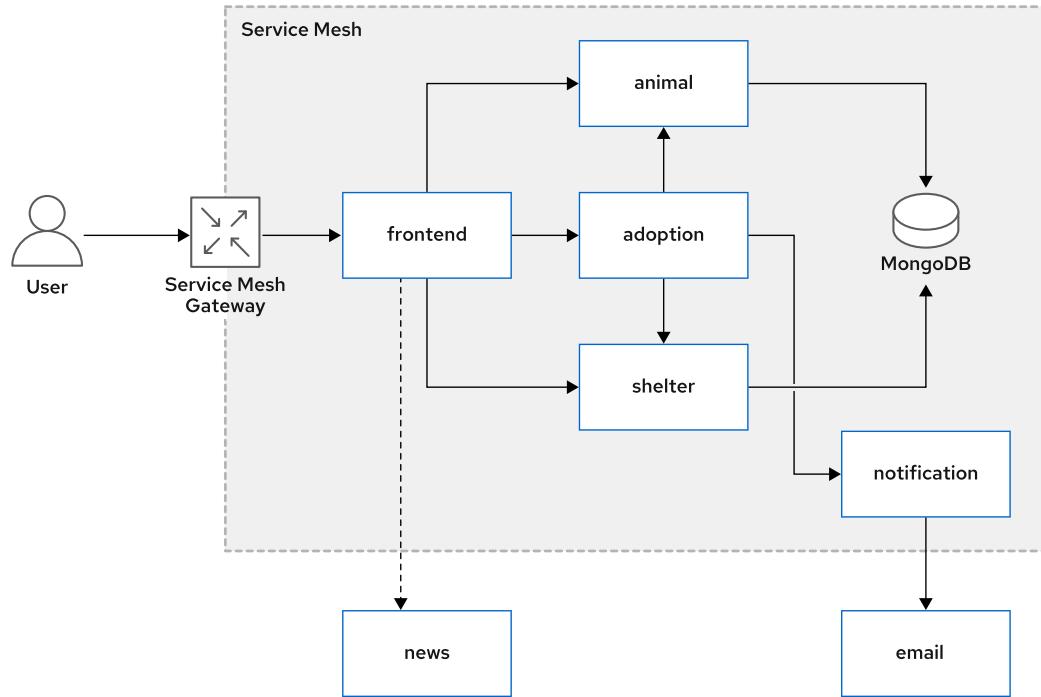
As the student user on the workstation machine, use the lab command to validate the prerequisites for this exercise, and prepare the lab:

```
[student@workstation ~]$ lab comprehensive-review start
```

### Instructions

The start script creates a new project named adoptapup and deploys all services except the adoption service. The news service deploys in a separate project named adoptapup-news.

The architecture of the "Adopt a Pup" application is as follows:



The application consists of the following microservices:

### **animal**

Manages a set of pups that can be adopted. Each pup belongs to a particular animal shelter.

### **shelter**

Manages several animal shelters that take care of pups until they are adopted. A shelter can have one or more pups.

### **notification**

Manages notifications that are sent to potential owners of pups. The notification service handles multiple notifications, such as emails and text messages. Currently, only notifications by email are supported.

### **email**

Sends emails to users. The service mesh does not manage this service.

### **adoption**

This service processes user requests for adoption. It is responsible for data validation and verifying that the user is eligible to adopt a pup.

### **news**

This service periodically informs users about news regarding shelters and animals. This service is deployed in a separate project. The service mesh does not manage this service.

### **frontend**

This service provides the web user interface for the application.

### **mongodb**

The details for pups, shelters, and adoptions are stored in this MongoDB database.

The start script deployed these services by using YAML files located in the /home/student/D0328/labs/comprehensive-review folder.

The start script deployed the MongoDB database and preloaded shelter and animal data into the database.



### Note

Name all virtual service resources created in the adoptapup project as service -vs, where service is the service name, for example, adoption-vs and animal-vs.

Name all destination rule resources created in the adoptapup project as service -dr, where service is the service name, for example adoption-dr and animal-dr.

Name all service accounts created in the adoptapup project as service -sa, where service is the service name, for example adoption-sa and animal-sa.

Perform the following tasks:

1. Log in to OpenShift as the developer user and inspect the deployed microservices in the adoptapup and adoptapup-news projects. Verify that all the microservices, except the adoption microservice, are deployed and running.

- 1.1. Source the environment variables in the /usr/local/etc/ocp4.config file:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

- 1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

- 1.3. Set the current project to adoptapup:

```
[student@workstation ~]$ oc project adoptapup
Now using project "adoptapup" on server ...output omitted...
```

- 1.4. Verify that the microservices deployed by the start script are Running:

```
[student@workstation ~]$ oc get pods
NAME                      READY   STATUS    RESTARTS   AGE
animal-v1-588956cfb5-88k9r   2/2     Running   0          30m
email-65bbdb599b-f75k8       1/1     Running   0          30m
frontend-v1-5f4965ff7d-ngfjz  2/2     Running   0          30m
mongodb-574f8ccb9c-98fpq    2/2     Running   0          30m
notification-5c7fd8bccf-nwndv 2/2     Running   0          30m
shelter-76dccc9cbc-rws47    2/2     Running   0          30m
[student@workstation ~]$ oc get pods -n adoptapup-news
NAME                      READY   STATUS    RESTARTS   AGE
news-6f7c8d4486-sn2pb      1/1     Running   0          32m
```

2. Verify that the data has been successfully loaded into MongoDB using the check-mongo.sh script in the /home/student/D0328/labs/comprehensive-review folder. If data is successfully loaded, you will see the raw JSON data from the database as follows:

```
[student@workstation ~]$ sh ~/D0328/labs/comprehensive-review/check-mongo.sh
...output omitted...

Checking if animal data is loaded into MongoDB...

{ "id" : "d52a8d58-9024-49dd-92b6-d443c6049ffe", "animalName" : "Gus" } ...output
omitted...

Checking if shelter data is loaded into MongoDB...

{ "id" : "e038ae3c-592f-403e-9233-4b6eeab30e3c", "shelterName" : "Denver Doggos" }
...output omitted...
```

If the data is not loaded, then run the `load-mongo.sh` script in the `/home/student/D0328/labs/comprehensive-review` folder, and then rerun the `check-mongo.sh` script to verify success.

3. Create a service mesh gateway named `adoptapup-gateway` to allow external traffic to flow into the service mesh. Configure the gateway to listen for HTTP requests on port 80.
4. Deploy the `adoption` service in the `adoptapup` project. Ensure that it is managed by Red Hat OpenShift Service Mesh.

Name the OpenShift deployment and service resource as `adoption`, and then add a label `app: adoption` to the relevant resources. This service listens on port 8080.

Name the virtual service as `adoption-vs`. Configure the virtual service so that all requests to the `/adoption` endpoint, relative to the service mesh gateway URL, are routed to the `adoption` service.

Using a web browser, access the front end user interface at the `/frontend` endpoint relative to the gateway URL. Verify that you can browse shelters and animals from the navigation pane.



### Warning

If you have restarted your classroom VMs, or redeployed the MongoDB database pod after running the start script, then you must run the `load-mongo.sh` script as discussed in a previous step. You must do this because the MongoDB pod uses ephemeral storage and it does not persist data between restarts.

5. Click `News` in the navigation panel. The front end fails to fetch data from the `news` service (external to the service mesh).  
Configure the service mesh to allow the front end service to fetch the latest news from the `news` service. The name of the resource must be `news`.

6. Version 2 of the **frontend** service introduces some user interface changes. The container image for version 2 is available at `quay.io/redhattraining/ossm-adopt-a-pup-webapp:2.0`.

Deploy version 2 of the **frontend** service as follows:

- Configure service mesh to route 80% of traffic to version 1 and the remainder to version 2.
- The container name and deployment name should be called **frontend-v2**. Add the label `version: v2` to the relevant resources.

Verify that the navigation panel background color is red in version 2, but not in version 1.

Copy and modify the deployment from the `/home/student/D0328/labs/comprehensive-review/frontend-service-v1.yaml` file to create a verion 2 of the application.



#### Note

You might have to refresh your browser several times before you can see the user interface changes. It can take some time for the page from version 2 to render as it loads the static assets (CSS and JavaScript files) for the first time.

7. Version 2 of the **animal** service focuses on improving performance. The container image for version 2 is available at `quay.io/RedHatTraining/ossm-animal-service:2.0`.

Deploy version 2 of the **animal** service as follows:

- The container name and deployment name should be called **animal-v2**. Add the label `version: v2` to the relevant resources.
- Configure service mesh to mirror traffic from version 1 to version 2. Version 2 is not yet ready for production deployment, so responses to clients must still be sent exclusively from version 1.
- Verify that traffic is mirrored and that you see the output from version 2 in the generated logs.

Copy and modify the deployment from the `/home/student/D0328/labs/comprehensive-review/animal-service-v1.yaml` file to create a verion 2 of the application.

8. Introduce a 3-second delay for all responses from the **shelter** service. Verify that you see delayed responses when you click **Our Shelters** in the navigation panel.

9. Configure network connections for the **adoption** service to retry failed requests consistent with the following policies:

- Configure the service mesh to allow 3 retry attempts. Each retry waits at most 5 seconds before timing out.
- Retries must be triggered only when the response contains an HTTP status code of 500 and above.

10. Configure a circuit breaker for the **adoption** service as follows:

- Allow 3 consecutive errors within 10 seconds before breaking the circuit.
- Allow 1 minute of recovery after the circuit breaks before activating the service to receive requests.

11. Configure connection pooling for the **notification** service as follows:
  - Allow only 5 concurrent connections at any given time to prevent overloading this service.
  - Allow only 1 request per connection.
12. Secure the services in the service mesh as follows:
  - Create the **animal-sa** and **shelter-sa** service accounts.
  - Configure the service mesh so that only the **shelter** service and version 1 of the **animal** service are authorized to communicate with the MongoDB database on the port 27017.

Name your resource **mongodb-auth-policy**.

## Evaluation

Grade your work by running the **lab comprehensive-review grade** command from your **workstation** machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab comprehensive-review grade
```

## Finish

On the **workstation** machine, use the **lab** command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab comprehensive-review finish
```

This concludes the lab.

## ► Solution

# Building Resilient Microservices

### Performance Checklist

In this review, you will deploy the "Adopt a Pup" application to OpenShift and configure Red Hat OpenShift Service Mesh to manage the traffic and security aspects of the application. You will also configure the service mesh to be more resilient against delays, timeouts, and failures.

### Outcomes

You should be able to:

- Deploy the "Adopt a Pup" application to OpenShift and enable Red Hat OpenShift Service Mesh to control the incoming and outgoing traffic.
- Secure the application by configuring access control and allowing only encrypted communication between microservices.
- Configure the service mesh to perform canary releases and dark launches for testing new features of the application.
- Configure the service mesh to make the application more resilient by using timeouts, retries, and circuit breakers.

### Before You Begin

To perform this exercise, ensure you have access to:

- A configured and running OpenShift cluster.
- An installed and running OpenShift Service Mesh in the OpenShift cluster.
- The OpenShift CLI (/usr/local/bin/oc).

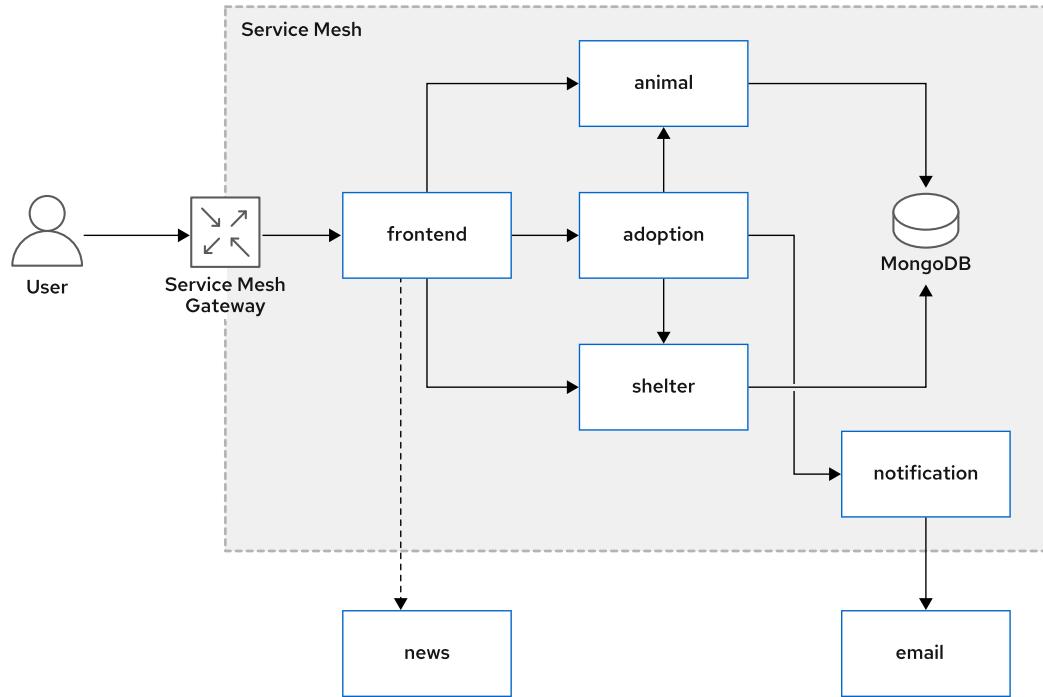
As the student user on the workstation machine, use the lab command to validate the prerequisites for this exercise, and prepare the lab:

```
[student@workstation ~]$ lab comprehensive-review start
```

### Instructions

The start script creates a new project named adoptapup and deploys all services except the adoption service. The news service deploys in a separate project named adoptapup-news.

The architecture of the "Adopt a Pup" application is as follows:



The application consists of the following microservices:

### animal

Manages a set of pups that can be adopted. Each pup belongs to a particular animal shelter.

### shelter

Manages several animal shelters that take care of pups until they are adopted. A shelter can have one or more pups.

### notification

Manages notifications that are sent to potential owners of pups. The notification service handles multiple notifications, such as emails and text messages. Currently, only notifications by email are supported.

### email

Sends emails to users. The service mesh does not manage this service.

### adoption

This service processes user requests for adoption. It is responsible for data validation and verifying that the user is eligible to adopt a pup.

### news

This service periodically informs users about news regarding shelters and animals. This service is deployed in a separate project. The service mesh does not manage this service.

### frontend

This service provides the web user interface for the application.

### mongodb

The details for pups, shelters, and adoptions are stored in this MongoDB database.

The start script deployed these services by using YAML files located in the `/home/student/D0328/labs/comprehensive-review` folder.

The start script deployed the MongoDB database and preloaded shelter and animal data into the database.

**Note**

Name all virtual service resources created in the adoptapup project as service -vs, where service is the service name, for example, adoption-vs and animal-vs.

Name all destination rule resources created in the adoptapup project as service -dr, where service is the service name, for example adoption-dr and animal-dr.

Name all service accounts created in the adoptapup project as service -sa, where service is the service name, for example adoption-sa and animal-sa.

Perform the following tasks:

1. Log in to OpenShift as the developer user and inspect the deployed microservices in the adoptapup and adoptapup-news projects. Verify that all the microservices, except the adoption microservice, are deployed and running.

- 1.1. Source the environment variables in the /usr/local/etc/ocp4.config file:

```
[student@workstation ~]$ source /usr/local/etc/ocp4.config
```

- 1.2. Log in to OpenShift:

```
[student@workstation ~]$ oc login -u ${RHT_OCP4_DEV_USER} \
-p ${RHT_OCP4_DEV_PASSWORD} ${RHT_OCP4_API}
Login successful.
...output omitted...
```

- 1.3. Set the current project to adoptapup:

```
[student@workstation ~]$ oc project adoptapup
Now using project "adoptapup" on server ...output omitted...
```

- 1.4. Verify that the microservices deployed by the start script are Running:

```
[student@workstation ~]$ oc get pods
NAME                      READY   STATUS    RESTARTS   AGE
animal-v1-588956cfb5-88k9r   2/2     Running   0          30m
email-65bbdb599b-f75k8       1/1     Running   0          30m
frontend-v1-5f4965ff7d-ngfjz  2/2     Running   0          30m
mongodb-574f8ccb9c-98fpq    2/2     Running   0          30m
notification-5c7fd8bccf-nwndv 2/2     Running   0          30m
shelter-76dccc9cbc-rws47    2/2     Running   0          30m
[student@workstation ~]$ oc get pods -n adoptapup-news
NAME                      READY   STATUS    RESTARTS   AGE
news-6f7c8d4486-sn2pb      1/1     Running   0          32m
```

2. Verify that the data has been successfully loaded into MongoDB using the check-mongo.sh script in the /home/student/D0328/labs/comprehensive-review folder. If data is successfully loaded, you will see the raw JSON data from the database as follows:

```
[student@workstation ~]$ sh ~/D0328/labs/comprehensive-review/check-mongo.sh
...output omitted...

Checking if animal data is loaded into MongoDB...

{ "id" : "d52a8d58-9024-49dd-92b6-d443c6049ffe", "animalName" : "Gus" } ...output omitted...

Checking if shelter data is loaded into MongoDB...

{ "id" : "e038ae3c-592f-403e-9233-4b6eeab30e3c", "shelterName" : "Denver Doggos" } ...output omitted...
```

If the data is not loaded, then run the `load-mongo.sh` script in the `/home/student/D0328/labs/comprehensive-review` folder, and then rerun the `check-mongo.sh` script to verify success.

3. Create a service mesh gateway named `adoptapup-gateway` to allow external traffic to flow into the service mesh. Configure the gateway to listen for HTTP requests on port 80.
  - 3.1. Create a `gateway.yaml` file with the following contents. You can also copy the content from the `/home/student/D0328/solutions/comprehensive-review/gateway.yaml` file.

```
apiVersion: networking.istio.io/v1beta1
kind: Gateway
metadata:
  name: adoptapup-gateway
spec:
  selector:
    istio: ingressgateway
  servers:
    - port:
        number: 80
        name: http
        protocol: HTTP
      hosts:
        - "*"
```

- 3.2. Create the gateway using the `oc create` command.

```
[student@workstation ~]$ oc create -f gateway.yaml
gateway.networking.istio.io/adoptapup-gateway created
```

4. Deploy the adoption service in the `adoptapup` project. Ensure that it is managed by Red Hat OpenShift Service Mesh.  
The container image for the adoption service is available at `quay.io/redhattraining/ossm-adoption-service:1.0`. The container serves requests on port 8080.  
Name the OpenShift deployment and service resource as `adoption`, and then add a label `app: adoption` to the relevant resources. This service listens on port 8080.

Name the virtual service as `adoption-vs`. Configure the virtual service so that all requests to the `/adoption` endpoint, relative to the service mesh gateway URL, are routed to the `adoption` service.

Using a web browser, access the front end user interface at the `/frontend` endpoint relative to the gateway URL. Verify that you can browse shelters and animals from the navigation pane.



### Warning

If you have restarted your classroom VMs, or redeployed the MongoDB database pod after running the start script, then you must run the `load-mongo.sh` script as discussed in a previous step. You must do this because the MongoDB pod uses ephemeral storage and it does not persist data between restarts.

- 4.1. Create a YAML file named `adoption-service.yaml` with the following contents. You can also copy the YAML snippets from the `/home/student/D0328/solutions/comprehensive-review/adoption-service.yaml` file.

Start by creating the deployment resource:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: adoption
spec:
  selector:
    matchLabels:
      app: adoption
  replicas: 1
  template:
    metadata:
      labels:
        app: adoption
      annotations:
        sidecar.istio.io/inject: "true"
    spec:
      containers:
        - name: adoption
          image: quay.io/redhattraining/ossm-adoption-service:1.0
          imagePullPolicy: Always
          ports:
            - containerPort: 8080
...

```

Add the YAML snippet for creating a service:

```
apiVersion: v1
kind: Service
metadata:
  labels:
    app: adoption
    name: adoption
spec:
  ports:
```

```
- port: 8080
  name: http
  targetPort: 8080
selector:
  app: adoption
---
```

Finally, create the virtual service as follows:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: adoption-vs
spec:
  hosts:
    - "*"
  gateways:
    - adoptapup-gateway
  http:
    - match:
        - uri:
            prefix: /adoption
      route:
        - destination:
            host: adoption
            port:
              number: 8080
```

Save your changes.

#### 4.2. Create deployment, service, and virtual service resources.

```
[student@workstation ~]$ oc create -f adoption-service.yaml
deployment.apps/adoption created
service/adoption created
virtualservice.networking.istio.io/adoption-vs created
```

#### 4.3. Verify that the adoption service pod is Running.

```
[student@workstation ~]$ oc get pods
NAME                               READY   STATUS    RESTARTS   AGE
adoption-658c6fbcb4-jnnrm        2/2     Running   0          15m
...output omitted...
```

#### 4.4. Run the `oc get route` command to get the service mesh gateway URL.

```
[student@workstation ~]$ GW_URL=$(oc get route istio-ingressgateway \
-n istio-system -o jsonpath='{.spec.host}')
```

#### 4.5. Access the front end for the "Adopt a Pup" application by using the Firefox browser.

```
[student@workstation ~]$ firefox http://${GW_URL}/frontend &
```

- 4.6. Click Adoptable Animals to see a list of pups that are available for adoption.

The screenshot shows the 'Adoptable Animals' page of the 'Adopt A Pup' application. The left sidebar has 'Our Shelters' selected. The main content area displays two dogs: 'Theo' (a brown curly-haired dog) and 'Winston' (a brown dog wearing a red vest). Each dog has a 'Details' button below its image.

Click Our Shelters to see a list of shelters. Click Details on the Our Shelters page to see details about the shelter, and to view the list of pups available in the shelter.

The screenshot shows the 'Our Shelters' page of the 'Adopt A Pup' application. The left sidebar has 'Our Shelters' selected. The main content area lists two shelters: 'Denver Doggos' and 'Minneapolis Mutts', each with a 'Details' button.

5. Click News in the navigation panel. The front end fails to fetch data from the news service (external to the service mesh).

Configure the service mesh to allow the front end service to fetch the latest news from the news service. The name of the resource must be news.

- 5.1. Get the route URL for the news service.

```
[student@workstation ~]$ oc get route news -n adoptapup-news
NAME    HOST/PORT          ...output omitted...
news   news-adoptapup-news.apps.ocp4.example.com  ...output omitted...
```

- 5.2. The front end is unable to fetch news items from the news service, which runs outside the service mesh in a separate project. Create a service entry resource named news to allow service mesh to fetch data from the external news service.

Create a file named news-serviceentry.yaml with the following content. Add the host name that you gathered from the oc get route command in the previous step.

You can also copy the YAML content from the /home/student/D0328/solutions/comprehensive-review/news-serviceentry.yaml file.

```
apiVersion: networking.istio.io/v1beta1
kind: ServiceEntry
metadata:
  name: news
spec:
  hosts:
    - news-adoptapup-news.apps.ocp4.example.com
  ports:
    - name: http-80
      number: 80
      protocol: http
```

- 5.3. Create a service entry resource.

```
[student@workstation ~]$ oc create -f news-serviceentry.yaml
serviceentry.networking.istio.io/news created
```

- 5.4. Wait for a few seconds for the configuration to propagate. Refresh the News page from the navigation panel. You should now see news items fetched from the news service.

The screenshot shows the Animal Adoption application's navigation bar on the left with options like Home, Adoptable Animals, Our Shelters, Notifications, News (which is selected), Your messages, Management, Create Shelter, and Create Animal. The main content area is titled "Animal News" and displays "Latest animal news!". Below this, there is a table titled "Latest News" with columns for "Timestamp" and "Story". Three news items are listed:

| Timestamp  | Story                                                                                                                |
|------------|----------------------------------------------------------------------------------------------------------------------|
| 1578454302 | At this time, there is no evidence that animals play a significant role in spreading the virus that causes COVID-19. |
| 1582278201 | Dogs are being taught to smell coronavirus in patients.                                                              |
| 1583351796 | Vaccinate your pup regularly.                                                                                        |



### Note

The news items are displayed randomly. Your list of items may differ from the example.

6. Version 2 of the frontend service introduces some user interface changes. The container image for version 2 is available at quay.io/redhattraining/ossm-adopt-a-pup-webapp:2.0.

Deploy version 2 of the frontend service as follows:

- Configure service mesh to route 80% of traffic to version 1 and the remainder to version 2.
- The container name and deployment name should be called `frontend-v2`. Add the label `version: v2` to the relevant resources.

Verify that the navigation panel background color is red in version 2, but not in version 1.

Copy and modify the deployment from the `/home/student/D0328/labs/comprehensive-review/frontend-service-v1.yaml` file to create a verion 2 of the application.



### Note

You might have to refresh your browser several times before you can see the user interface changes. It can take some time for the page from version 2 to render as it loads the static assets (CSS and JavaScript files) for the first time.

- The finished deployment is in the `/home/student/D0328/solutions/comprehensive-review/frontend-service-v2.yaml` file.

To create the file manually, make a copy of the `/home/student/D0328/labs/comprehensive-review/frontend-service-v1.yaml` file.

```
[student@workstation ~]$ cp  
~/D0328/labs/comprehensive-review/frontend-service-v1.yaml \  
~/frontend-service-v2.yaml
```

- Delete the Service and VirtualService resource definitions from the `frontend-service-v2.yaml` file. Version 2 includes only the Deployment resource.

- Change the `frontend-service-v2.yaml` file for deploying version 2 as follows:

```
apiVersion: apps/v1  
kind: Deployment  
metadata:  
  labels:  
    app: frontend  
    version: v2  
  name: frontend-v2  
spec:  
  selector:  
    matchLabels:  
      app: frontend  
      version: v2  
  replicas: 1  
  template:  
    metadata:  
      labels:  
        app: frontend  
        version: v2  
    annotations:  
      sidecar.istio.io/inject: "true"  
  spec:  
    containers:
```

```
- name: frontend-v2
  image: quay.io/redhattraining/ossm-adopt-a-pup-webapp:2.0
...output omitted...
```

6.4. Deploy version 2 of the `frontend` service.

```
[student@workstation ~]$ oc create -f frontend-service-v2.yaml
deployment.apps/frontend-v2 created
```

6.5. Verify that the pod for version 2 is `Running` before continuing to the next step.

```
[student@workstation ~]$ oc get pods
NAME                               READY   STATUS    RESTARTS   AGE
...output omitted...
frontend-v1-5f4965ff7d-ngfjz     2/2     Running   0          2h
frontend-v2-5449f5d8bc-c2fl8     2/2     Running   0          74s
...output omitted...
```

6.6. Create the destination rule resource for the `frontend` service. Create a file named `frontend-dest-rule.yaml` with YAML content as follows. You can also copy the YAML from the `/home/student/D0328/solutions/comprehensive-review/frontend-dest-rule.yaml` file.

```
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: frontend-dr
spec:
  host: frontend
  subsets:
    - name: v1
      labels:
        version: v1
    - name: v2
      labels:
        version: v2
```

6.7. Create the destination rule resource.

```
[student@workstation ~]$ oc create -f frontend-dest-rule.yaml
destinationrule.networking.istio.io/frontend-dr created
```

6.8. Edit the virtual service resource for the `frontend` service.

You can apply the solution file: `oc apply -f /home/student/D0328/solutions/comprehensive-review/frontend-vs-v2.yaml`.

Alternatively, edit the file manually:

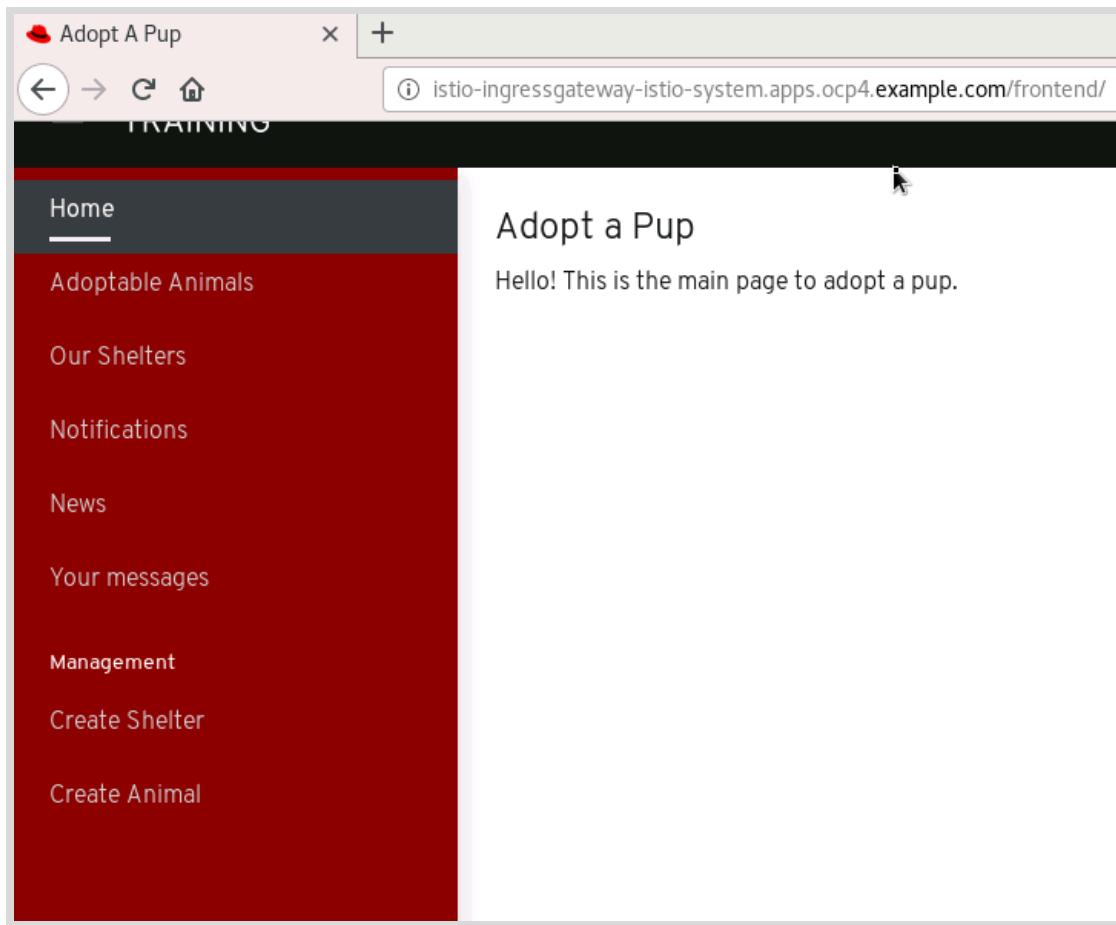
```
[student@workstation ~]$ oc edit vs frontend-vs
```

Configure weighted routing as follows:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: frontend-vs
  namespace: adoptapup
spec:
  gateways:
    - adoptapup-gateway
  hosts:
    - '*'
  http:
    - match:
        - uri:
            prefix: /frontend
      route:
        - destination:
            host: frontend
            subset: v1
            port:
              number: 3000
              weight: 80
        - destination:
            host: frontend
            subset: v2
            port:
              number: 3000
              weight: 20
```

Save your changes to the virtual service. Wait approximately 30 seconds while the deployment changes propagate through the service mesh.

- 6.9. Click **Home** in the navigation panel, and then refresh the page multiple times until you see the background color change to red.



7. Version 2 of the `animal` service focuses on improving performance. The container image for version 2 is available at `quay.io/RedHatTraining/ossm-animal-service:2.0`.

Deploy version 2 of the `animal` service as follows:

- The container name and deployment name should be called `animal-v2`. Add the label `version: v2` to the relevant resources.
- Configure service mesh to mirror traffic from version 1 to version 2. Version 2 is not yet ready for production deployment, so responses to clients must still be sent exclusively from version 1.
- Verify that traffic is mirrored and that you see the output from version 2 in the generated logs.

Copy and modify the deployment from the `/home/student/D0328/labs/comprehensive-review/animal-service-v1.yaml` file to create a verion 2 of the application.

- 7.1. The finished deployment is in the `/home/student/D0328/solutions/comprehensive-review/animal-service-v2.yaml` file.

To create the deployment manually, make a copy of the `/home/student/D0328/labs/comprehensive-review/animal-service-v1.yaml` file.

```
[student@workstation ~]$ cp
~/DO328/labs/comprehensive-review/animal-service-v1.yaml \
~/animal-service-v2.yaml
```

- 7.2. Delete the Service and VirtualService resource definitions (lines 28–60) from the animal-service-v2.yaml file. Version 2 includes only the Deployment resource.
- 7.3. Make changes to the animal-service-v2.yaml file for deploying version 2 as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app: animal
    version: v2
  name: animal-v2
spec:
  selector:
    matchLabels:
      app: animal
      version: v2
  replicas: 1
  template:
    metadata:
      labels:
        app: animal
        version: v2
      annotations:
        sidecar.istio.io/inject: "true"
    spec:
      containers:
        - name: animal-v2
          image: quay.io/redhattraining/ossm-animal-service:2.0
...output omitted...
```

- 7.4. Deploy version 2 of the animal service.

```
[student@workstation ~]$ oc create -f animal-service-v2.yaml
deployment.apps/animal-v2 created
```

- 7.5. Verify that the pod for version 2 is Running before continuing to the next step.

```
[student@workstation ~]$ oc get pods
NAME                      READY   STATUS    RESTARTS   AGE
...output omitted...
animal-v1-588956cfb5-88k9r   2/2     Running   0          3h
animal-v2-7c8fff7686-zlhfs   2/2     Running   0          10m
...output omitted...
...output omitted...
```

- 7.6. Create the destination rule resource for the `animal` service. Create a file named `animal-dest-rule.yaml` with YAML content as follows. You can also copy the YAML from the `/home/student/D0328/solutions/comprehensive-review/animal-dest-rule.yaml` file.

```
apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: animal-dr
spec:
  host: animal
  subsets:
    - name: v1
      labels:
        version: v1
    - name: v2
      labels:
        version: v2
```

- 7.7. Create the destination rule resource.

```
[student@workstation ~]$ oc create -f animal-dest-rule.yaml
destinationrule.networking.istio.io/animal-dr created
```

- 7.8. Edit the virtual service resource for the `animal` service.

Apply the solution file: `oc apply -f /home/student/D0328/solutions/comprehensive-review/animal-vs-v2.yaml`

Alternatively, edit the resource manually:

```
[student@workstation ~]$ oc edit vs animal-vs
```

Configure mirroring for the `animal` service as follows:

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: animal-vs
  namespace: adoptapup
spec:
  gateways:
    - adoptapup-gateway
  hosts:
    - '*'
  http:
    - match:
        - uri:
            prefix: /animals
      route:
        - destination:
            host: animal
            subset: v1
            port:
```

```

number: 8080
weight: 100
mirror:
  host: animal
  subset: v2

```

Save your changes to the virtual service. Wait approximately 30 seconds while the deployment changes propagate through the service mesh.

- 7.9. Click **Adoptable Animals** in the navigation panel, and then refresh the page multiple times to verify that the list of adoptable animals displays without errors.
- 7.10. Inspect the logs for version 2 and verify that requests sent to version 1 of the **animal** service are mirrored. You should see logs for incoming requests.

```

[student@workstation ~]$ oc get pods -o name | \
grep animal-v2 | xargs oc logs -c animal-v2
...output omitted..._animalservice.AnimalController : Getting 5 adoptable animals
through animal-v2...
...output omitted..._animalservice.AnimalController : Getting 5 adoptable animals
through animal-v2...
...output omitted..._animalservice.AnimalController : Getting 5 adoptable animals
through animal-v2...
...output omitted...

```

8. Introduce a 3-second delay for all responses from the **shelter** service. Verify that you see delayed responses when you click **Our Shelters** in the navigation panel.
  - 8.1. Edit the virtual service resource for the **shelter** microservice.  
Apply the solution file: `oc apply -f /home/student/D0328/solutions/comprehensive-review/shelter-vs-v2.yaml`  
Alternatively, edit the resource manually:

```
[student@workstation ~]$ oc edit vs shelter-vs
```

- 8.2. Add a 3-second delay to all responses as follows:

```

apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  annotations:
  name: shelter-vs
  namespace: adoptapup
spec:
  gateways:
  - adoptapup-gateway
  hosts:
  - '*'
  http:
  - match:
    - uri:
        prefix: /shelters
  route:

```

```

- destination:
  host: shelter
  port:
    number: 8080
fault:
delay:
  percentage:
    value: 100
  fixedDelay: 3000ms

```

Save your changes. Wait approximately 30 seconds for the service mesh to propagate the changes.

- 8.3. Click **Our Shelters** in the navigation panel, and then refresh the page multiple times. Verify that the list of shelters displays after a 3-second delay.  
Click **Details** next to one of the shelters. Verify that shelter details display after a 3-second delay.
  9. Configure network connections for the adoption service to retry failed requests consistent with the following policies:
    - Configure the service mesh to allow 3 retry attempts. Each retry waits at most 5 seconds before timing out.
    - Retries must be triggered only when the response contains an HTTP status code of 500 and above.
- 9.1. Edit the virtual service resource for the `adoption` microservice.  
Apply the solution file: `oc apply -f /home/student/D0328/solutions/comprehensive-review/adoption-vs-v2.yaml`  
Alternatively, edit the resource manually:

```
[student@workstation ~]$ oc edit vs adoption-vs
```

- 9.2. Add configuration for retries as follows:

```

apiVersion: networking.istio.io/v1beta1
kind: VirtualService
metadata:
  name: adoption-vs
  namespace: adoptapup
spec:
  gateways:
    - adoptapup-gateway
  hosts:
    - '*'
  http:
    - match:
        - uri:
            prefix: /adoption
      route:
        - destination:
            host: adoption

```

```

  port:
    number: 8080
  retries:
    attempts: 3
    perTryTimeout: 5s
    retryOn: 5xx

```

Save your changes.

**10.** Configure a circuit breaker for the adoption service as follows:

- Allow 3 consecutive errors within 10 seconds before breaking the circuit.
  - Allow 1 minute of recovery after the circuit breaks before activating the service to receive requests.
- 10.1. Create the destination rule resource for the adoption microservice in a file named `adoption-dr.yaml` as follows. You can also copy the YAML snippet from the `/home/student/D0328/solutions/comprehensive-review/adoption-dr.yaml` file.

```

apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: adoption-dr
spec:
  host: adoption
  trafficPolicy:
    outlierDetection:
      consecutiveErrors: 3
      interval: 10s
      baseEjectionTime: 1m

```

Save your changes.

10.2. Create the destination rule resource.

```
[student@workstation ~]$ oc create -f adoption-dr.yaml
destinationrule.networking.istio.io/adoption-dr created
```

**11.** Configure connection pooling for the notification service as follows:

- Allow only 5 concurrent connections at any given time to prevent overloading this service.
  - Allow only 1 request per connection.
- 11.1. Create the destination rule resource for the notification microservice in a file named `notification-pool.yaml` as follows. You can also copy the YAML snippet from the `/home/student/D0328/solutions/comprehensive-review/notification-pool.yaml` file.

```

apiVersion: networking.istio.io/v1beta1
kind: DestinationRule
metadata:
  name: notification-dr
spec:

```

```

host: notification
trafficPolicy:
  connectionPool:
    tcp:
      maxConnections: 5
    http:
      maxRequestsPerConnection: 1
  
```

Save your changes.

#### 11.2. Create the destination rule resource.

```
[student@workstation ~]$ oc create -f notification-pool.yaml
destinationrule.networking.istio.io/notification-dr created
```

### 12. Secure the services in the service mesh as follows:

- Create the `animal-sa` and `shelter-sa` service accounts.
- Configure the service mesh so that only the `shelter` service and version 1 of the `animal` service are authorized to communicate with the MongoDB database on the port 27017.

Name your resource `mongodb-auth-policy`.

#### 12.1. Create service accounts for the `shelter` and `animal` services.

```
[student@workstation ~]$ oc create serviceaccount animal-sa
serviceaccount/animal-sa created
[student@workstation ~]$ oc create serviceaccount shelter-sa
serviceaccount/shelter-sa created
```

#### 12.2. Assign the service accounts to pod deployments.

```
[student@workstation ~]$ oc set serviceaccount deployment animal-v1 animal-sa
deployment.apps/animal-v1 serviceaccount updated
[student@workstation ~]$ oc set serviceaccount deployment shelter shelter-sa
deployment.apps/shelter serviceaccount updated
```

#### 12.3. Assigning a service account to a deployment terminates the current pod and creates a new pod. Verify that the pods for the `shelter` and `animal` services are Running.

| NAME                       | READY | STATUS  | RESTARTS | AGE |
|----------------------------|-------|---------|----------|-----|
| ...output omitted...       |       |         |          |     |
| animal-v1-7b6487966f-d5gdb | 2/2   | Running | 0        | 54s |
| ...output omitted...       |       |         |          |     |
| shelter-84fcc987c9-n8n5t   | 2/2   | Running | 0        | 21s |

#### 12.4. Configure authorization policies to allow only the `animal` and `shelter` services to communicate with MongoDB.

Create a file named `mongodb-security-policy.yaml` with the following contents. You can also copy the YAML content from the `/home/student/D0328/solutions/comprehensive-review/mongodb-security-policy.yaml` file.

```
apiVersion: "security.istio.io/v1beta1"
kind: "AuthorizationPolicy"
metadata:
  name: "mongodb-auth-policy"
spec:
  selector:
    matchLabels:
      app: mongodb
  rules:
  - from:
    - source:
        principals: ["cluster.local/ns/adoptapup/sa/animal-sa"]
    - source:
        principals: ["cluster.local/ns/adoptapup/sa/shelter-sa"]
    to:
    - operation:
        ports: ["27017"]
```

- 12.5. Create the authorization policy resources.

```
[student@workstation ~]$ oc create -f mongodb-security-policy.yaml
authorizationpolicy.security.istio.io/mongodb-auth-policy created
```

- 12.6. Verify that the `animal` and `shelter` services can fetch data from MongoDB. Click `Adoptable Animals` and `Our Shelters` in the navigation pane and verify that the list of animals and shelters is displayed.

## Evaluation

Grade your work by running the `lab comprehensive-review grade` command from your `workstation` machine. Correct any reported failures and rerun the script until successful.

```
[student@workstation ~]$ lab comprehensive-review grade
```

## Finish

On the `workstation` machine, use the `lab` command to complete this exercise. This is important to ensure that resources from previous exercises do not impact upcoming exercises.

```
[student@workstation ~]$ lab comprehensive-review finish
```

This concludes the lab.

## Appendix A

# Installing OpenShift Service Mesh with the CLI

# Installing Red Hat OpenShift Service Mesh with the CLI

---

## Objectives

After completing this section, you should be able to install OpenShift Service Mesh on Red Hat OpenShift Container Platform with the CLI

## Installing OpenShift Service Mesh Using the CLI

You can also install OpenShift Service Mesh using the `oc` CLI. To install operators, you must have `cluster-admin` privileges.

Log in Red Hat OpenShift using an account with `cluster-admin` privileges.

```
[user@host ~]$ oc login -u USER -p PASSWORD OCP4_API
```

## Installing the Elasticsearch Operator

The installation of the Elasticsearch Operator involves the following steps:

1. Create a Subscription object YAML file to subscribe the `openshift-operators` namespace to the Elasticsearch Operator, for example, `elasticsearch.yaml`.

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: elasticsearch-operator
  namespace: openshift-operators①
spec:
  channel: "4.6"②
  name: elasticsearch-operator③
  source: redhat-operators④
  sourceNamespace: openshift-marketplace
  installPlanApproval: Automatic
```

- ① Namespace used to install the operator.
  - ② Stream of operator versions.
  - ③ Name of the operator to subscribe.
  - ④ Source that provides the operator.
2. Create the Subscription object applying the YAML file.

```
[user@host ~]$ oc apply -f elasticsearch.yaml
subscription.operator.coreos.com/elasticsearch-operator created
```

3. Check the status of the Operator installation.

```
[user@host ~]$ oc describe sub elasticsearch-operator \
-n openshift-operators
Name:      elasticsearch-operator
Namespace:  openshift-operators
...output omitted...
Message:    all available catalogsources are healthy
...output omitted...
```

## Installing the Jaeger Operator

Installing the Jaeger Operator involves the following steps:

1. Create a Subscription object YAML file to subscribe the `openshift-operators` namespace to the Jaeger Operator, for example, `jaeger.yaml`.

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: jaeger-product
  namespace: openshift-operators
spec:
  name: jaeger-product
  source: redhat-operators
  sourceNamespace: openshift-marketplace
  channel: "stable"
  installPlanApproval: Automatic
```

2. Create the Subscription object applying the YAML file.

```
[user@host ~]$ oc apply -f jaeger.yaml
subscription.operator.coreos.com/jaeger-product created
```

3. Check the status of the Operator installation.

```
[user@host ~]$ oc describe sub jaeger-product \
-n openshift-operators
Name:      jaeger-product
Namespace:  openshift-operators
...output omitted...
Message:    all available catalogsources are healthy
...output omitted...
```

## Installing the Kiali Operator

Installing the Kiali Operator involves the following steps:

1. Create a Subscription object YAML file to subscribe the `openshift-operators` namespace to the Kiali Operator, for example, `kiali.yaml`.

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
```

```
name: kiali-ossm
namespace: openshift-operators
spec:
  name: kiali-ossm
  source: redhat-operators
  sourceNamespace: openshift-marketplace
  channel: "stable"
  installPlanApproval: Automatic
```

2. Create the Subscription object applying the YAML file.

```
[user@host ~]$ oc apply -f kiali.yaml
subscription.operator.coreos.com/kiali-ossm created
```

3. Check the status of the Operator installation.

```
[user@host ~]$ oc describe sub kiali-ossm \
-n openshift-operators
Name:      kiali-ossm
Namespace:  openshift-operators
...output omitted...
Message:    all available catalogsources are healthy
...output omitted...
```

## Installing the OpenShift Service Mesh Operator Using the CLI

Installing the OpenShift Service Mesh Operator involves the following steps:

1. Create a Subscription object YAML file to subscribe the `openshift-operators` namespace to the Red Hat OpenShift Service Mesh Operator, for example, `service-mesh-subscription.yaml`.

```
apiVersion: operators.coreos.com/v1alpha1
kind: Subscription
metadata:
  name: servicemeshoperator
  namespace: openshift-operators
spec:
  channel: '1.0'
  name: servicemeshoperator
  source: redhat-operators
  sourceNamespace: openshift-marketplace
  installPlanApproval: Automatic
```

2. Create the Subscription object applying the YAML file.

```
[user@host ~]$ oc apply -f service-mesh-subscription.yaml
subscription.operator.coreos.com/servicemeshoperator created
```

3. Check the status of the Operator installation.

## Appendix A | Installing OpenShift Service Mesh with the CLI

```
[user@host ~]$ oc describe sub servicemeshoperator \
-n openshift-operators
Name:          servicemeshoperator
Namespace:     openshift-operators
...output omitted...
Message:           all available catalogsources are healthy
...output omitted...
```

## Creating the OpenShift Service Mesh Control Plane

Red Hat recommends that you deploy the control plan in a separate project.

The following describes how to deploy the control plane using the CLI.

1. Log in Red Hat OpenShift as a developer user.

```
[user@host ~]$ oc login -u USER -p PASSWORD RHT_OCP4_API
```

2. Create a project, for example, `istio-system`.

```
[user@host ~]$ oc new-project istio-system
Now using project "istio-system" on server "https://api.ocp4.example.com:6443".
...output omitted...
```

3. Create a `ServiceMeshControlPlane` object YAML file, for example, `istio-basic-installation.yaml`.

```
apiVersion: maistra.io/v2
kind: ServiceMeshControlPlane
metadata:
  name: basic ①
  namespace: istio-system ②
spec:
  gateways: ③
    egress:
      enabled: true
      runtime:
        deployment:
          autoScaling:
            enabled: false
    ingress:
      enabled: true
      runtime:
        deployment:
          autoScaling:
            enabled: false
  tracing: ④
    sampling: 10000
    type: Jaeger
  telemetry:
```

```

type: Istiod

policy:
  type: Istiod

addons:
  grafana: ⑤
    enabled: true
  jaeger: ⑥
    install:
      storage:
        type: Memory
  kiali: ⑦
    enabled: true

```

- ① Name assigned to the Control Plane.
- ② Namespace where the Control Plane is deployed.
- ③ Istio gateways configuration. Disables autoscaling on the ingress and egress gateways.
- ④ Tracing configuration. Selects Jaeger and the sampling rate.
- ⑤ Grafana configuration. Enables Grafana to analyze and monitor the Service Mesh.
- ⑥ Jaeger configuration. Enables the in-memory storage. ElasticSearch should be used in a production environment.
- ⑦ Kiali configuration. Enables Kiali to visualize traffic in the Service Mesh.

The full control plane configuration is available in GitHub. See the source code [[https://github.com/maistra/istio-operator/blob/maistra-2.1/pkg/apis/maistra/v2/smcp\\_new.yaml](https://github.com/maistra/istio-operator/blob/maistra-2.1/pkg/apis/maistra/v2/smcp_new.yaml)].

1. Deploy the control plane.

```
[user@host ~]$ oc create -n istio-system \
-f istio-basic-installation.yaml
servicemeshcontrolplane.maistra.io/basic created
```

2. Check the status of the control plane installation.

```
[user@host ~]$ oc get smcp -n istio-system
NAME      READY
basic     True
```

You must create a new `ServiceMeshMemberRoll` for each new control plane installation.

To create a new `ServiceMeshMemberRoll`:

1. Create a `ServiceMeshControlPlane` object YAML file, for example, `service-mesh-member-roll.yaml`.

```
apiVersion: maistra.io/v1
kind: ServiceMeshMemberRoll
metadata:
  name: default
  namespace: istio-system
spec:
  members:
    - a-project
```

The control plane manages projects listed as `members`.

2. Deploy the `ServiceMeshMemberRoll`.

```
[user@host ~]$ oc create -n istio-system \
-f service-mesh-member-roll.yaml
servicemeshmemberroll.maistra.io/default created
```

## Adding or Removing a Project from the Control Plane

Only projects listed on the `ServiceMeshMemberRoll` are managed by the service mesh. To add or remove a project from the control plane:

1. Log in Red Hat OpenShift Container.
2. Edit the `ServiceMeshMemberRoll` resource.

```
[user@host ~]$ oc edit smmr -n istio-system
```

3. Modify the YAML to add or remove project `members` and save the changes.



## Appendix B

# Creating a Quay account

# Creating a Quay Account

## Objectives

After completing this section, you should be able to describe how to create a Quay account, and public container image repositories for labs in the course.

## Creating a Quay Account

You need a Quay account to create one or more *public* container image repositories for the labs in this course. If you already have a Quay account, you can skip the steps to create a new account listed in this appendix.



### Important

If you already have a Quay account, ensure that you only create *public* container image repositories for the labs in this course. The lab grading scripts and instructions require unauthenticated access to pull container images from the repository.

To create a new Quay account, perform the following steps:

1. Navigate to <https://quay.io> using a web browser.
2. Click **Sign in** in the upper-right corner (next to the search bar).
3. On the **Sign in** page, you can log in by using your Red Hat, Google or GitHub credentials.

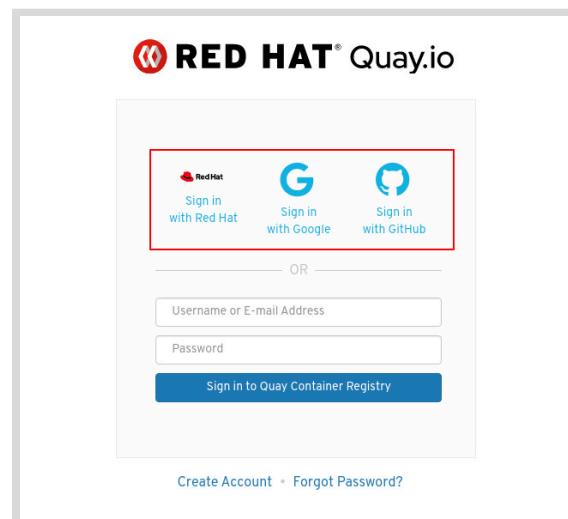
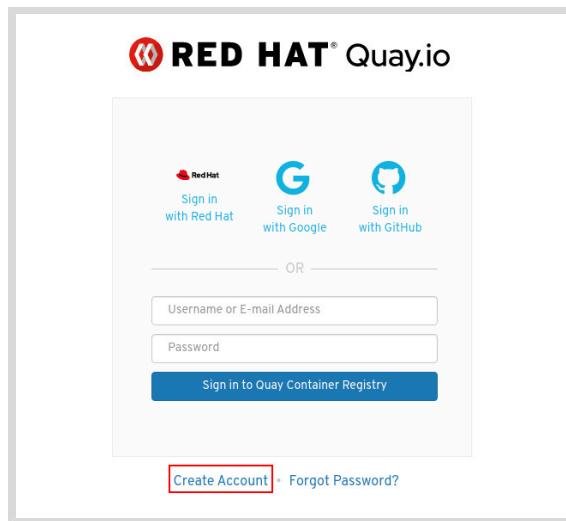


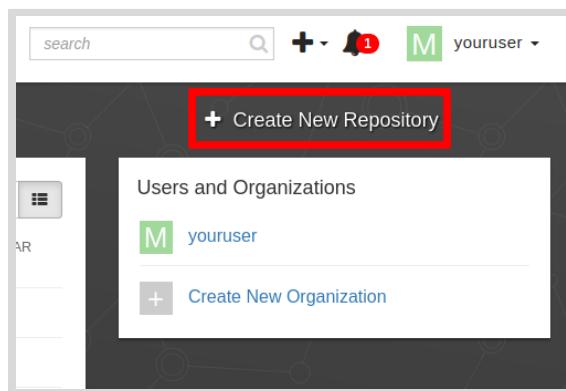
Figure B.1: Sign in using Red Hat, Google or GitHub credentials.

Alternatively, click **Create Account**.



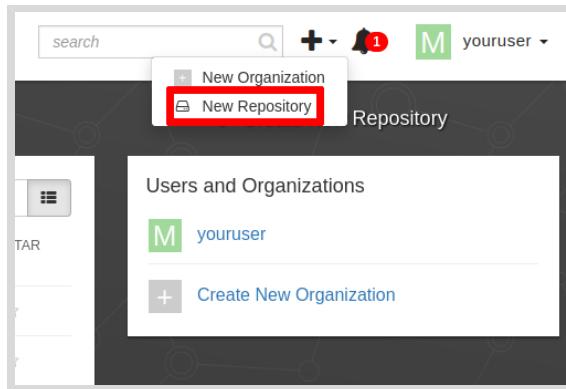
**Figure B.2: Creating a new account**

4. If you chose to skip the Red Hat, Google or GitHub log-in method and instead opted to create a new account, you will receive an email with instructions on how to activate your Quay account. Verify your email address and then sign in to the Quay website with the username and password you provided during account creation.
5. After you have logged in to Quay you can create new image repositories by clicking **Create New Repository** on the **Repositories** page.



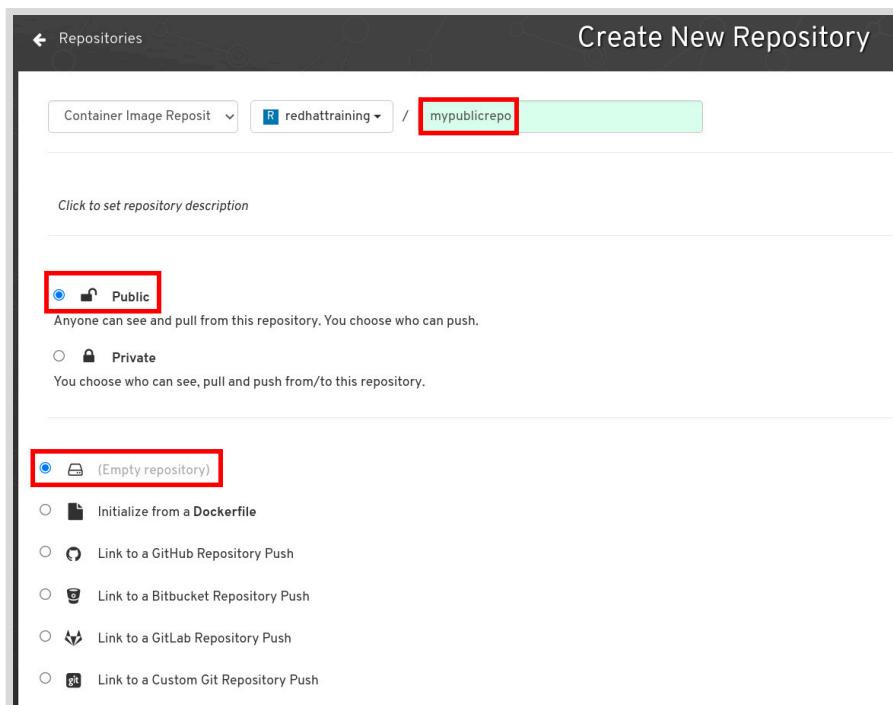
**Figure B.3: Creating a new image repository**

Alternatively, click the plus icon (+) in the upper-right corner (to the left of the bell icon), and then click **New Repository**.



**Figure B.4: Creating a new image repository**

6. Enter a name for the repository as per your lab instructions. Ensure that you select the **Public**, and **Empty Repository** options.



**Figure B.5: Creating a new image repository**

Click **Create Public Repository** to create the repository.



## References

### Getting Started with Quay.io

<https://docs.quay.io/solution/getting-started.html>

## Appendix C

# Troubleshooting Tips

# Troubleshooting Tips

---

## Objectives

After completing this section, you should be able to troubleshoot and resolve general issues for labs in the course.

## Red Hat OpenShift Container Platform Log In Failure

Logging in as the RHOCP developer or admin user might sometimes fail with the following errors:

- error: EOF
- error: net/http: TLS handshake timeout
- Error from server (InternalError): Internal error occurred: unexpected response: 503

You might also see a lab start script printing a FAIL message when it tries to log in to OpenShift.

- If you experience this issue after you started your VMs, then wait a few minutes until all the OpenShift services are started and ready, and then try logging in again.
- Log in to the utility VM as the lab user, and inspect the status of your OpenShift nodes using the oc get nodes command.

```
[student@workstation ~]$ ssh lab@utility
[lab@utility ~]$ oc get nodes
NAME      STATUS    ROLES          AGE     VERSION
master01   Ready     master,worker  97d    v1.19.0+2f3101c
master02   Ready     master,worker  97d    v1.19.0+2f3101c
master03   Ready     master,worker  97d    v1.19.0+2f3101c
```

All your nodes should be in Ready state.

## Red Hat OpenShift Service Mesh Installation Issues

Your Red Hat OpenShift Service Mesh installation might fail due to transient network issues, or timeouts. If this happens, then you can try the following:

- Run the lab uninstall-mesh start script to clean up the failed install, and retry your installation. You can also run the lab install-mesh solve script to perform an automated install of service mesh.
- Verify that a service mesh control plane named basic exists by running the oc get smcp -n istio-system command.

| NAME  | READY | STATUS          | PROFILES    | VERSION | AGE  |
|-------|-------|-----------------|-------------|---------|------|
| basic | 9/9   | ComponentsReady | ["default"] | 2.0.5.1 | 160m |

## Appendix C | Troubleshooting Tips

The status of the control plane must be **ComponentsReady**.

- Verify that a service mesh member roll resource named **default** is created by running the `oc get smmr -n istio-system` command.

| NAME    | READY | STATUS     | AGE   |
|---------|-------|------------|-------|
| default | 0/0   | Configured | 4m46s |

The number in the **READY** column must match the number of projects joined the service mesh.

- The `oc get pods -n istio-system` command should show all pods in running state.

| NAME                                   | READY | STATUS  | RESTARTS | AGE  |
|----------------------------------------|-------|---------|----------|------|
| grafana-78967ddf56-z8vtn               | 2/2   | Running | 0        | 161m |
| istio-egressgateway-595fdddf798-nfk17  | 1/1   | Running | 0        | 161m |
| istio-ingressgateway-5cf698d99f-ljvvda | 1/1   | Running | 0        | 161m |
| istiod-basic-57d58c7598-xcb5q          | 1/1   | Running | 0        | 162m |
| jaeger-6d5b4d58c8-695g9                | 2/2   | Running | 0        | 161m |
| kiali-868fd7c6ff-7f9mn                 | 1/1   | Running | 0        | 71m  |
| prometheus-65b75bc97-rddwl             | 3/3   | Running | 0        | 162m |

If the control plane disabled some features, then some pods will not show in the list.

## Envoy Proxy Sidecar Injection Failures

Run the `oc get pods` command in your project, and verify that you can see two containers (2/2) per replica, and all the replicas in Running state. If you see only one container for service mesh managed applications, it means proxy sidecar injection failed.

If you do not see the Envoy proxy sidecar injected into applications deployed on service mesh, then verify the following:

- You have added your project to the service mesh member roll resource.
- Run the `oc get smmr default -n istio-system -o yaml` command and verify that your project appears in the member list.
- You have added the `sidecar.istio.io/inject` annotation in the applications deployment resource and set its value to "true".
  - Run the `oc delete pod pod_name` to delete the pod. OpenShift will spawn a new pod and re-inject the sidecar proxy.

## Project Deletion Failure in Lab Scripts

You are asked to run the lab finish script after you complete each lab. This script might sometimes fail to delete the OpenShift project due to timeouts, and you will see a FAIL message being displayed.

You can safely ignore this message. Verify if the project still exists, and then manually delete the project using the `oc delete project` command.

When deleting the `istio-system` project, it sometimes gets stuck in `Terminating` state. This is caused by the finalization hooks trying to delete non-created resources.

To fix this issue, disable the `finalize` hook for the namespace using the following command:

```
[student@workstation ~]$ oc get namespace istio-system -o  
json | sed -e 's/"kubernetes"//' | kubectl replace --raw  
"/api/v1/namespaces/istio-system/finalize" -f -
```

This is a known Kubernetes issue, reported here [<https://github.com/kubernetes/kubernetes/issues/60807>]. Nevertheless this solution must not be applied to production clusters, as it will leave non-deleted resources, polluting the cluster.