

Setup

Setup instructions

This training depends on `oc`, the OpenShift command-line interface.

You have the choice of either using OpenShift's web terminal or installing `oc` locally.

If you prefer to not install anything on your computer, follow the instructions on the *1. Web terminal* page.

The *2. Local usage* chapter explains how to install `oc` for the respective operating system.

Also have a look at the *3. More tools to work with OpenShift*, which is, however, totally optional.

Warning

In case you've already installed `oc`, please make sure you have an up-to-date version.

1. Web terminal

Using OpenShift's web terminal might be more convenient for you as it doesn't require you to install `oc` locally on your computer.

Note

If you do change your mind, head right over to *2. Local usage*.

Task 1.1: Login on the web console

First of all, open your browser. Then, log in on OpenShift's web console using the URL and credentials provided by your trainer.

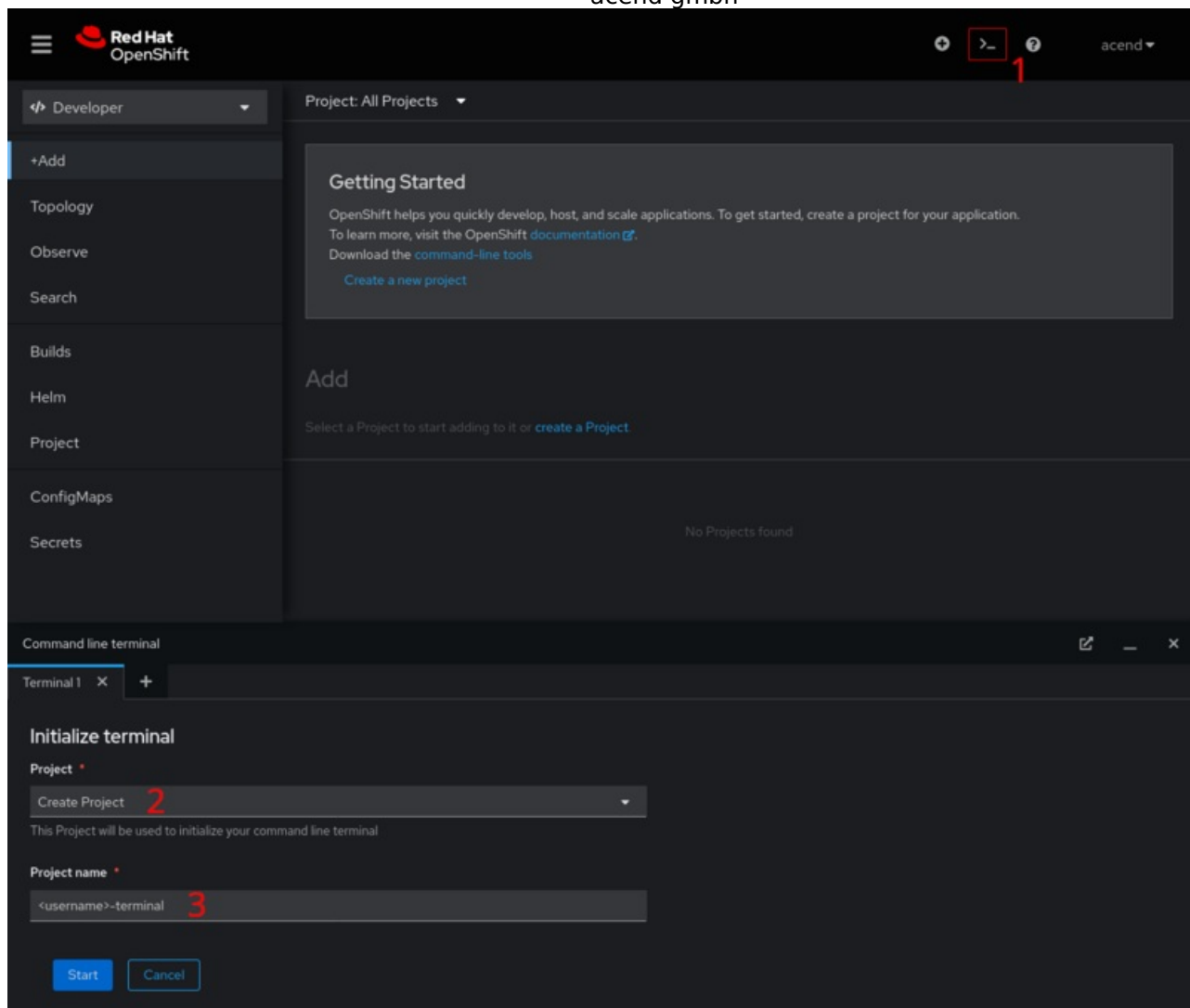
Task 1.2: Initialize terminal

Warning

Make sure to create a dedicated project for the web terminal!

In OpenShift's web console:

1. Click on the terminal icon on the upper right
2. Choose to create a new project
3. Name your project `<username>-terminal` where `<username>` is the username given to you during this training
4. Click **Start**



Task 1.3: Verification

After the initial setup, you're presented with a web terminal. Tools like `oc` are already installed and you're also already logged in.

You can check this by executing the following command:

```
oc whoami
```

You're now ready to go!

Warning

The terminal project is only meant to be used for the web terminal resources. Always check that you do not use the terminal namespace for the other labs!

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Next steps

If you're interested, have a look at the *3. More tools to work with OpenShift*, which is however totally optional.

When you're ready to go, head on over to the [labs](#) and begin with the training!

2. Local usage

Please follow the instructions on the *2.1. cli installation* page to install `oc`.

If you already have successfully installed `oc`, please verify that your installed version is current. Then, head over to *2.2. Console login* to log in.

2.1. cli installation

The `oc` command is the command-line interface to work with one or several OpenShift clusters.

The client is written in Go and you can run the single binary on the following operating systems:

- *2.1.1. Windows*
- *2.1.2. macOS*
- *2.1.3. Linux*

2.2. Console login

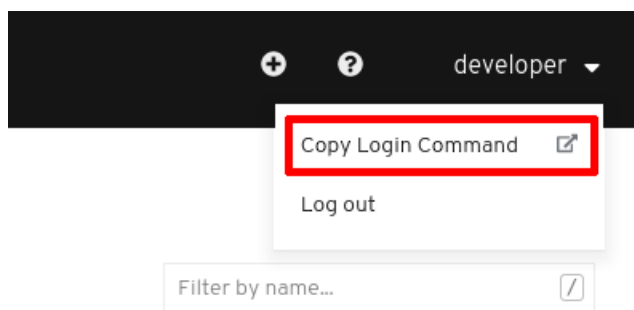
Task 2.2.1: Login on the web console

First of all, open your browser. Then, log in on OpenShift's web console using the URL and credentials provided by your trainer.

Task 2.2.2: Login on the command line

In order to log in on the command line, copy the login command from the web console.

To do that, open the Web Console and click on your username that you see at the top right, then choose **Copy Login Command**.



A new tab or window will open in your browser.

Note

You might need to log in again.

The page now displays a link **Display token**. Click on it and copy the command under **Log in with this token**.

Now paste the copied command on the command line.

Task 2.2.3: Verify login

If you now execute `oc version` you should see something like this (your output may vary):

```
Client Version: 4.11.2
Kustomize Version: v4.5.4
Kubernetes Version: v1.24.0+dc5a2fd
```

First steps with oc

The `oc` binary has many subcommands. Invoke `oc --help` (or simply `-h`) to get a list of all subcommands; `oc <subcommand> --help` gives you detailed help about a subcommand.

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Next steps

If you're interested, have a look at the *3. More tools to work with OpenShift*, which is however totally optional.

When you're ready to go, head on over to the [labs](#) and begin with the training!

3. More tools to work with OpenShift

More tools to work with OpenShift

- [Red Hat OpenShift Local](#)
- [Red Hat OpenShift Dev Spaces](#)

Next steps

When you're ready to go, head on over to the [labs](#) and begin with the training!

Labs

The purpose of these labs is to convey OpenShift basics by providing hands-on tasks for people. OpenShift will allow you to deploy and deliver your software packaged as containers in an easy, straightforward way.

Goals of these labs:

- Help you get started with this modern technology
- Explain the basic concepts to you
- Show you how to deploy your first applications on Kubernetes

Additional Docs

- [OpenShift Docs](#)

Additional Tutorials

- [OpenShift Interactive Learning Portal](#)

1. Introduction

In this lab, we will introduce the core concepts of OpenShift.

All explanations and resources used in this lab give only a quick and not detailed overview. As OpenShift is based on Kubernetes, its concepts also apply to OpenShift which you can find in [the official Kubernetes documentation](#).

Core concepts

With the open source software OpenShift, you get a platform to build and deploy your application in a container as well as operate it at the same time. Therefore, OpenShift is also called a *Container Platform*, or the term *Container-as-a-Service* (CaaS) is used.

Depending on the configuration the term *Platform-as-a-Service* (PaaS) works as well.

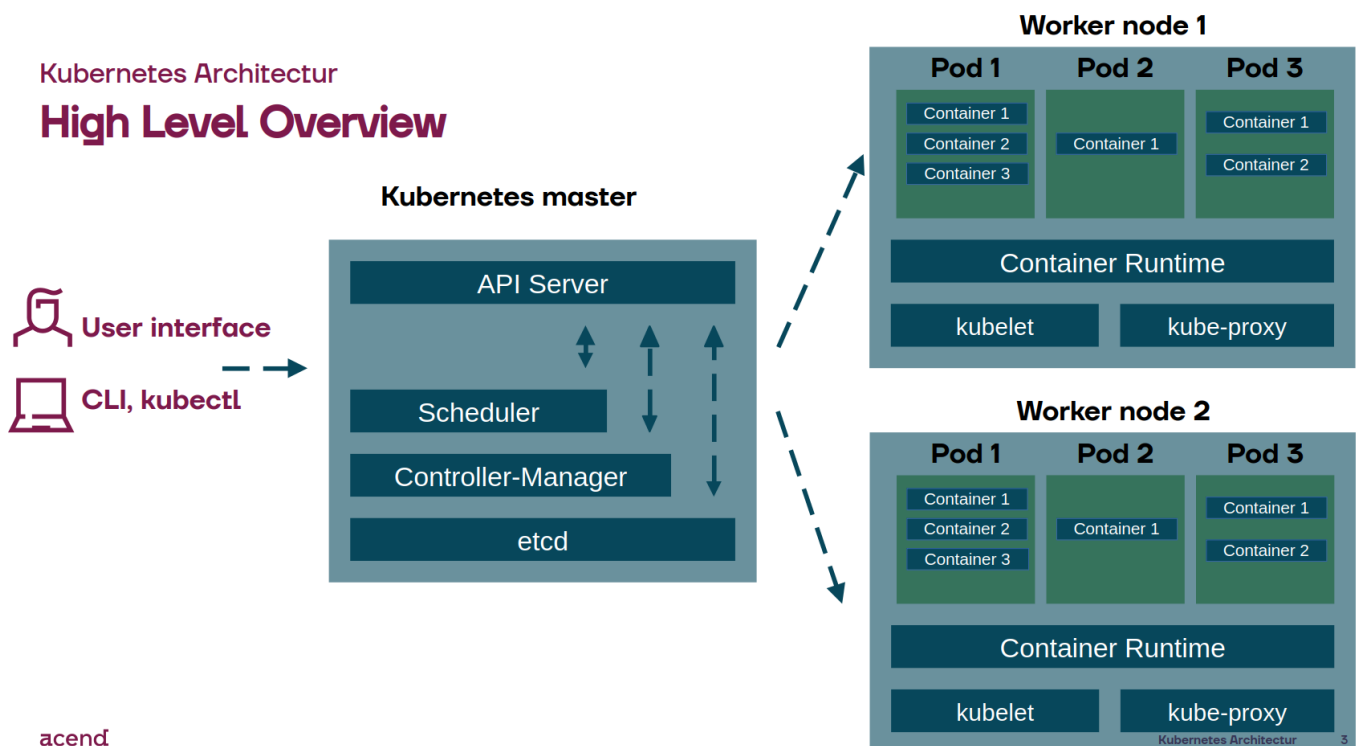
Container engine

OpenShift's underlying container engine is [CRI-O](#). Earlier releases used [Docker](#).

Docker was originally created to help developers test their applications in their continuous integration environments. Nowadays, system admins also use it. CRI-O doesn't exist as long as Docker does. It is a "lightweight container runtime for Kubernetes" and is fully [OCI-compliant](#).

Overview

OpenShift basically consists of control plane and worker nodes.



Control plane and worker nodes

The control plane components are the *API server*, the *scheduler* and the *controller manager*. The API server itself represents the management interface. The scheduler and the controller manager decide how applications should be deployed on the cluster. Additionally, the state and configuration of the cluster itself are controlled in the control plane components.

Worker nodes are also known as compute nodes, application nodes or minions, and are responsible for running the container workload (applications). The *control plane* for the worker nodes is implemented in the control plane components. The hosts running these components were historically called masters.

Containers and images

The smallest entities in Kubernetes and OpenShift are Pods, which resemble your containerized application.

Using container virtualization, processes on a Linux system can be isolated up to a level where only the predefined resources are available. Several containers can run on the same system without “seeing” each other (files, process IDs, network). One container should contain one application (web server, database, cache, etc.). It should be at least one part of the application, e.g. when running a multi-service middleware. In a container itself any process can be started that runs natively on your operating system.

Containers are based on images. An image represents the file tree, which includes the binary, shared libraries and other files which are needed to run your application.

A container image is typically built from a `Containerfile` or `Dockerfile`, which is a text file filled with instructions. The end result is a hierarchically layered binary construct. Depending on the backend, the implementation uses overlay or copy-on-write (COW) mechanisms to represent the image.

Layer example for a Tomcat application:

1. Base image (CentOS 7)
2. Install Java
3. Install Tomcat
4. Install App

The pre-built images under version control can be saved in an image registry and can then be used by the container platform.

Namespaces and Projects

Namespaces in Kubernetes represent a logical segregation of unique names for entities (Pods, Services, Deployments, ConfigMaps, etc.).

In OpenShift, users do not directly create Namespaces, they create Projects. A Project is a Namespace with additional annotations.

Note

OpenShift’s concept of a Project does not coincide with Rancher’s.

Permissions and roles can be bound on a per-project basis. This way, a user can control his own resources inside a Project.

Note

Some resources are valid cluster-wise and cannot be set and controlled on a namespace basis.

Pods

A Pod is the smallest entity in Kubernetes and OpenShift.

It represents one instance of your running application process. The Pod consists of at least two containers, one for your application itself and another one as part of the Kubernetes design, to keep the network namespace. The so-called infrastructure container (or pause container) is therefore automatically added by Kubernetes.

The application ports from inside the Pod are exposed via Services.

Services

A service represents a static endpoint for your application in the Pod. As a Pod and its IP address typically are considered dynamic, the IP address of the Service does not change when changing the application inside the Pod. If you scale up your Pods, you have an automatic internal load balancing towards all Pod IP addresses.

There are different kinds of Services:

- `ClusterIP` : Default virtual IP address range
- `NodePort` : Same as `ClusterIP` plus open ports on the nodes
- `LoadBalancer` : An external load balancer is created, only works in cloud environments, e.g. AWS ELB
- `ExternalName` : A DNS entry is created, also only works in cloud environments

A Service is unique inside a Namespace.

Deployment

Have a look at the [official documentation](#) .

Volume

Have a look at the [official documentation](#) .

Job

Have a look at the [official documentation](#) .

History

There is a official Kubernetes Documentary available on Youtube.

- [Kubernetes: The Documentary \[PART 1\]](#)
- [Kubernetes: The Documentary \[PART 2\]](#)

Inspired by the open source success of Docker in 2013 and seeing the need for innovation in the area of large-scale cloud computing, a handful of forward-thinking Google engineers set to work on the container orchestrator that would come to be known as Kubernetes- this new tool would forever change the way the internet is built.

These engineers overcome technical challenges, resistance to open source from within, naysayers, and intense competition from other big players in the industry.

Most engineers know about “The Container Orchestrator Wars” but most people would not be able to

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explain exactly what happened, and why it was Kubernetes that ultimately came out on top.

There is no topic more relevant to the current open source landscape. This film captures the story directly from the people who lived it, featuring interviews with prominent engineers from Google, Red Hat, Twitter and others.

1.1. YAML

YAML Ain't Markup Language (YAML) is a human-readable data-serialization language. YAML is not a programming language. It is mostly used for storing configuration information.

Note

Data serialization is the process of converting data objects, or object states present in complex data structures, into a stream of bytes for storage, transfer, and distribution in a form that can allow recovery of its original structure.

As you will see a lot of YAML in our Kubernetes basics course, we want to make sure you can read and write YAML. If you are not yet familiar with YAML, this introduction is waiting for you. Otherwise, feel free to skip it or come back later if you meet some less familiar YAML stuff.

This introduction is based on the [YAML Tutorial from cloudbees.com](https://cloudbees.com/yaml-tutorial/).

For more information and the full spec have a look at <https://yaml.org/>

A simple file

Let's look at a YAML file for an overview:

```
---
foo: "foo is not bar"
bar: "bar is not foo"
pi: 3.14159
awesome: true
kubernetes-birth-year: 2015
cloud-native:
  - scalable
  - dynamic
  - cloud
  - container
kubernetes:
  version: "1.22.0"
  deployed: true
  applications:
    - name: "My App"
      location: "public cloud"
```

The file starts with three dashes. These dashes indicate the start of a new YAML document. YAML supports multiple documents, and compliant parsers will recognize each set of dashes as the beginning of a new one.

Then we see the construct that makes up most of a typical YAML document: a key-value pair. `foo` is a key that points to a string value: `foo is not bar`

YAML knows four different data types:

- `foo` & `bar` are strings.
- `pi` is a floating-point number

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- `awesome` is a boolean
- `kubernetes-birth-year` is an integer

You can enclose strings in single or double-quotes or no quotes at all. YAML recognizes unquoted numerals as integers or floating point.

The `cloud-native` item is an array with four elements, each denoted by an opening dash. The elements in `cloud-native` are indented with two spaces. Indentation is how YAML denotes nesting. The number of spaces can vary from file to file, but tabs are not allowed.

Finally, `kubernetes` is a dictionary that contains a string `version`, a boolean `deployed` and an array `applications` where the item of the array contains two strings.

YAML supports nesting of key-values, and mixing types.

Indentation and Whitespace

Whitespace is part of YAML's formatting. Unless otherwise indicated, newlines indicate the end of a field. You structure a YAML document with indentation. The indentation level can be one or more spaces. The specification forbids tabs because tools treat them differently.

Comments

Comments begin with a pound sign. They can appear after a document value or take up an entire line.

```
---  
# This is a full line comment  
foo: bar # this is a comment, too
```

YAML data types

Values in YAML's key-value pairs are scalar. They act like the scalar types in languages like Perl, Javascript, and Python. It's usually good enough to enclose strings in quotes, leave numbers unquoted, and let the parser figure it out. But that's only the tip of the iceberg. YAML is capable of a great deal more.

Key-Value Pairs and Dictionaries

The key-value is YAML's basic building block. Every item in a YAML document is a member of at least one dictionary. The key is always a string. The value is a scalar so that it can be any datatype. So, as we've already seen, the value can be a string, a number, or another dictionary.

Numeric types

YAML recognizes numeric types. We saw floating point and integers above. YAML supports several other numeric types. An integer can be decimal, hexadecimal, or octal.

```
---  
foo: 12345  
bar: 0x12d4  
plop: 023332
```

YAML supports both fixed and exponential floating point numbers.

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```
---  
foo: 1230.15  
bar: 12.3015e+05
```

Finally, we can represent not-a-number (NAN) or infinity.

```
---  
foo: .inf  
bar: -.Inf  
plop: .NAN
```

Foo is infinity. Bar is negative infinity, and plop is NAN.

Strings

YAML strings are Unicode. In most situations, you don't have to specify them in quotes.

```
---  
foo: this is a normal string
```

But if we want escape sequences handled, we need to use double quotes.

```
---  
foo: "this is not a normal string\n"  
bar: this is not a normal string\n
```

YAML processes the first value as ending with a carriage return and linefeed. Since the second value is not quoted, YAML treats the `\n` as two characters.

```
foo: this is not a normal string  
bar: this is not a normal string\n
```

YAML will not escape strings with single quotes, but the single quotes do avoid having string contents interpreted as document formatting. String values can span more than one line. With the fold (greater than) character, you can specify a string in a block.

```
bar: >  
  this is not a normal string it  
  spans more than  
  one line  
  see?
```

But it's interpreted without the newlines: bar : this is not a normal string it spans more than one line see?

The block (pipe) character has a similar function, but YAML interprets the field exactly as is.

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```
---
bar: |
  this is not a normal string it
  spans more than
  one line
  see?
```

So, we see the newlines where they are in the document.

```
bar : this is not a normal string it
spans more than
one line
see?
```

Nulls

You enter nulls with a tilde or the unquoted null string literal.

```
---
foo: ~
bar: null
```

Booleans

YAML indicates boolean values with the keywords True, On and Yes for true. False is indicated with False, Off, or No.

```
---
foo: True
bar: False
light: On
TV: Off
```

Arrays

You can specify arrays or lists on a single line.

```
---
items: [ 1, 2, 3, 4, 5 ]
names: [ "one", "two", "three", "four" ]
```

Or, you can put them on multiple lines.

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```
---
items:
  - 1
  - 2
  - 3
  - 4
  - 5
names:
  - "one"
  - "two"
  - "three"
  - "four"
```

The multiple line format is useful for lists that contain complex objects instead of scalars.

```
---
items:
  - things:
      thing1: huey
      things2: dewey
      thing3: louie
  - other things:
      key: value
```

An array can contain any valid YAML value. The values in a list do not have to be the same type.

Dictionaries

We covered dictionaries above, but there's more to them. Like arrays, you can put dictionaries inline. We saw this format above.

```
---
foo: { thing1: huey, thing2: louie, thing3: dewey }
```

We've seen them span lines before.

```
---
foo: bar
bar: foo
```

And, of course, they can be nested and hold any value.

```
---
foo:
  bar:
    - bar
    - rab
    - plop
```

2. First steps

In this lab, we will interact with the OpenShift cluster for the first time.

Warning

Please make sure you completed *Setup* before you continue with this lab. If you do this training in our acend web based environment, no setup is required.

Projects

As a first step on the cluster, we are going to create a new Project.

A Project is a logical design used in OpenShift to organize and separate your applications, Deployments, Pods, Ingresses, Services, etc. on a top-level basis. Authorized users inside a Project are able to manage those resources. Project names have to be unique in your cluster.

Task 2.2: Create a Project

Create a new Project in the lab environment. The `oc help` output can help you figure out the right command.

Note

Please choose an identifying name for your Project, e.g. your initials or name as a prefix. We are going to use `<namespace>` as a placeholder for your created Project.

Solution

To create a new Project on your cluster use the following command:

```
oc new-project <namespace>
```

Note

In order to declare what Project to use, you have several possibilities:

- Some prefer to explicitly select the Project for each `oc` command by adding `--namespace <namespace>` or `-n <namespace>`
- By using the following command, you can switch into another Project instead of specifying it for each `oc` command

```
oc project <namespace>
```

Task 2.3: Discover the OpenShift web console

Discover the different menu entries in the two views, the **Developer** and the **Administrator** view.

Display all existing Pods in the previously created Project with `oc` (there shouldn't yet be any):

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```
oc get pod --namespace <namespace>
```

Note

With the command `oc get` you can display all kinds of resources.

3. Deploying a container image

In this lab, we are going to deploy our first container image and look at the concepts of Pods, Services, and Deployments.

Task 3.1: Start and stop a single Pod

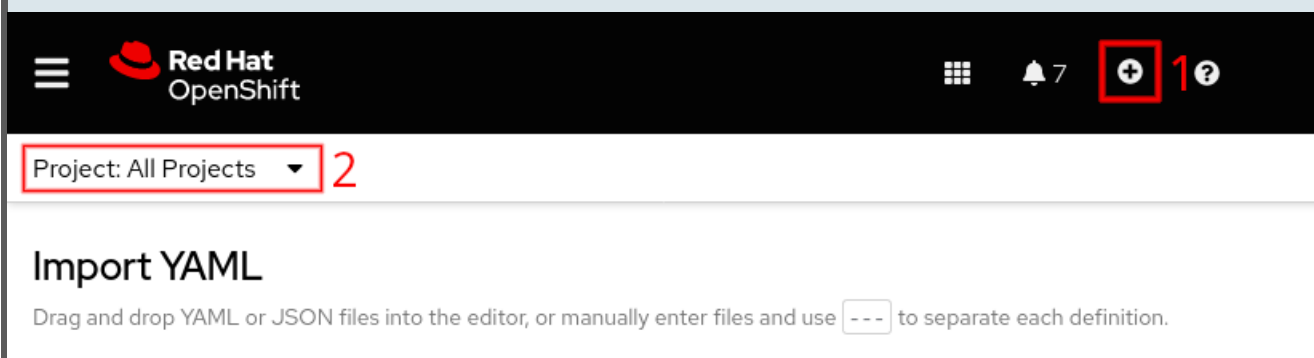
After we've familiarized ourselves with the platform, we are going to have a look at deploying a pre-built container image from Quay.io or any other public container registry.

In OpenShift we have used the `<project>` identifier to select the correct project. Please use the same identifier in the context `<namespace>` to do the same for all upcoming labs. Ask your trainer if you want more information on that.

First, we are going to directly start a new Pod. For this we have to define our Kubernetes Pod resource definition. Create a new file `pod_awesome-app.yaml` with the content below.

Note

Alternatively, you can create the Pod definition on the web console. Simply click on the **plus sign button** on the upper right (1), make sure you've selected the correct **Project** (2) and paste the content.



```
apiVersion: v1
kind: Pod
metadata:
  name: awesome-app
spec:
  containers:
  - image: quay.io/acend/example-web-go:latest
    imagePullPolicy: Always
    name: awesome-app
  resources:
    limits:
      cpu: 20m
      memory: 32Mi
    requests:
      cpu: 10m
      memory: 16Mi
```

Note

If you used the web console to import the Pod's YAML definition, don't execute the following command.

Now we can apply this with:

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```
oc apply -f pod_awesome-app.yaml --namespace <namespace>
```

The output should be:

```
pod/awesome-app created
```

Use `oc get pods --namespace <namespace>` in order to show the running Pod:

```
oc get pods --namespace <namespace>
```

Which gives you an output similar to this:

NAME	READY	STATUS	RESTARTS	AGE
awesome-app	1/1	Running	0	1m24s

Have a look at your awesome-app Pod inside the OpenShift web console.

Now delete the newly created Pod:

```
oc delete pod awesome-app --namespace <namespace>
```

Task 3.2: Create a Deployment

In some use cases it can make sense to start a single Pod. But this has its downsides and is not really a common practice. Let's look at another concept which is tightly coupled with the Pod: the so-called *Deployment*. A Deployment ensures that a Pod is monitored and checks that the number of running Pods corresponds to the number of requested Pods.

To create a new Deployment we first define our Deployment in a new file `deployment_example-web-go.yaml` with the content below.

Note

You could, of course, again import the YAML on the web console as described above.

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```
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app: example-web-go
  name: example-web-go
spec:
  replicas: 1
  selector:
    matchLabels:
      app: example-web-go
  template:
    metadata:
      labels:
        app: example-web-go
    spec:
      containers:
        - image: quay.io/acend/example-web-go:latest
          name: example-web-go
          resources:
            requests:
              cpu: 10m
              memory: 16Mi
            limits:
              cpu: 20m
              memory: 32Mi
```

And with this we create our Deployment inside our already created namespace:

Note

If you used the web console to import the Deployment's YAML definition, don't execute the following command.

```
oc apply -f deployment_example-web-go.yaml --namespace <namespace>
```

The output should be:

```
deployment.apps/example-web-go created
```

We're using a simple sample application written in Go, which you can find built as an image on [Quay.io](https://quay.io/repository/acend/example-web-go) or as source code on [GitHub](https://github.com/acend/example-web-go).

OpenShift creates the defined and necessary resources, pulls the container image (in this case from Quay.io) and deploys the Pod.

Use the command `oc get` with the `-w` parameter in order to get the requested resources and afterward watch for changes.

Note

The `oc get -w` command will never end unless you terminate it with `CTRL-C`.

```
oc get pods -w --namespace <namespace>
```

Note

Instead of using the `-w` parameter you can also use the `watch` command which should be available on most Linux distributions:

```
watch oc get pods --namespace <namespace>
```

This process can last for some time depending on your internet connection and if the image is already available locally.

Note

If you want to create your own container images and use them with OpenShift, you definitely should have a look at [these best practices](#) and apply them. This image creation guide may be for OpenShift, however it also applies to Kubernetes and other container platforms.

Creating Kubernetes resources

There are two fundamentally different ways to create Kubernetes resources. You've already seen one way: Writing the resource's definition in YAML (or JSON) and then applying it on the cluster using `oc apply`.

The other variant is to use helper commands. These are more straightforward: You don't have to copy a YAML definition from somewhere else and then adapt it. However, the result is the same. The helper commands just simplify the process of creating the YAML definitions.

As an example, let's look at creating above deployment, this time using a helper command instead. If you already created the Deployment using above YAML definition, you don't have to execute this command:

```
oc create deployment example-web-go --image=quay.io/acend/example-web-go:latest --namespace <namespace>
```

It's important to know that these helper commands exist. However, in a world where GitOps concepts have an ever-increasing presence, the idea is not to constantly create these resources with helper commands. Instead, we save the resources' YAML definitions in a Git repository and leave the creation and management of those resources to a tool.

Task 3.3: Viewing the created resources

Display the created Deployment using the following command:

```
oc get deployments --namespace <namespace>
```

A [Deployment](#) defines the following facts:

- Update strategy: How application updates should be executed and how the Pods are exchanged
- Containers
 - Which image should be deployed
 - Environment configuration for Pods
 - ImagePullPolicy

- The number of Pods/Replicas that should be deployed - acend gmbh

By using the `-o` (or `--output`) parameter we get a lot more information about the deployment itself. You can choose between YAML and JSON formatting by indicating `-o yaml` or `-o json`. In this training we are going to use YAML, but please feel free to replace `yaml` with `json` if you prefer.

```
oc get deployment example-web-go -o yaml --namespace <namespace>
```

After the image has been pulled, OpenShift deploys a Pod according to the Deployment:

```
oc get pods --namespace <namespace>
```

which gives you an output similar to this:

NAME	READY	STATUS	RESTARTS	AGE
example-web-go-69b658f647-xnm94	1/1	Running	0	39s

The Deployment defines that one replica should be deployed — which is running as we can see in the output. This Pod is not yet reachable from outside the cluster.

Task 3.4: Verify the Deployment in the OpenShift web console

Try to display the logs from the example application in the OpenShift web console.

Task 3.5: Build the image yourself

Up until now, we've used pre-built images from Quay.io. OpenShift offers the ability to build images on the cluster itself using different [strategies](#) :

- Docker build strategy
- Source-to-image build strategy
- Custom build strategy
- Pipeline build strategy

We are going to use the Docker build strategy. It expects:

[...] a repository with a Dockerfile and all required artifacts in it to produce a runnable image.

All of these requirements are already fulfilled in the [source code repository on GitHub](#) , so let's build the image!

Note

Have a look at [OpenShift's documentation](#) to learn more about the other available build strategies.

First we clean up the already existing Deployment:

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```
oc delete deployment example-web-go --namespace <namespace>
```

We are now ready to create the build and deployment, all in one command:

```
oc new-app --name example-web-go --labels app=example-web-go --context-dir go/ --strategy docker https://github.com/ace  
nd/awesome-apps.git --namespace <namespace>
```

Let's watch the image's build process:

```
oc logs bc/example-web-go --follow --namespace <namespace>
```

The message `Push successful` signifies the image's successful build and push to OpenShift's internal image.

In the above command you discovered a new resource type `bc` which is the abbreviation for *BuildConfig*. A *BuildConfig* defines how a container image has to be built.

A *Build* resource represents the build process itself based upon the *BuildConfig*'s definition. A build takes place in a Pod on OpenShift, so instead of referencing the *BuildConfig* in our `oc logs` command, we could have used the build Pod's log output. However, referencing the *BuildConfig* has the advantage that it can be reused each time a build is run. A build Pod changes its name with every build.

Have a look at the new Deployment created by the `oc new-app` command:

```
oc get deployment example-web-go -o yaml --namespace <namespace>
```

It looks the same as before with the only essential exception that it uses the image we just built instead of the pre-built image from Quay.io:

```
...  
spec:  
  containers:  
    - image: image-registry.openshift-image-registry.svc:5000/<namespace>/awesome-app@sha256:4cd671273a837453464f7264  
afe845b299297ebe032f940fd005cf9c40d1e76c  
  ...
```

4. Exposing a service

In this lab, we are going to make the freshly deployed application from the last lab available online.

Task 4.1: Create a ClusterIP Service

The command `oc apply -f deployment_example-web-go.yaml` from the last lab creates a Deployment but no Service. A OpenShift Service is an abstract way to expose an application running on a set of Pods as a network service. For some parts of your application (for example, frontends) you may want to expose a Service to an external IP address which is outside your cluster.

OpenShift `ServiceTypes` allow you to specify what kind of Service you want. The default is `ClusterIP`.

Type values and their behaviors are:

- `ClusterIP` : Exposes the Service on a cluster-internal IP. Choosing this value only makes the Service reachable from within the cluster. This is the default `ServiceType`.
- `NodePort` : Exposes the Service on each Node's IP at a static port (the `NodePort`). A `ClusterIP` Service, to which the `NodePort` Service routes, is automatically created. You'll be able to contact the `NodePort` Service from outside the cluster, by requesting `<NodeIP>:<NodePort>`.
- `LoadBalancer` : Exposes the Service externally using a cloud provider's load balancer. `NodePort` and `ClusterIP` Services, to which the external load balancer routes, are automatically created.
- `ExternalName` : Maps the Service to the contents of the `externalName` field (e.g. `foo.bar.example.com`), by returning a CNAME record with its value. No proxying of any kind is set up.

You can also use Ingress to expose your Service. Ingress is not a Service type, but it acts as the entry point for your cluster. [Ingress](#) exposes HTTP and HTTPS routes from outside the cluster to services within the cluster. Traffic routing is controlled by rules defined on the Route resource. A Route may be configured to give Services externally reachable URLs, load balance traffic, terminate SSL / TLS, and offer name-based virtual hosting. An Ingress controller is responsible for fulfilling the route, usually with a load balancer, though it may also configure your edge router or additional frontends to help handle the traffic.

In order to create a Route, we first need to create a Service of type `ClusterIP`.

To create the Service add a new file `svc-web-go.yaml` with the following content:

```
---
apiVersion: v1
kind: Service
metadata:
  labels:
    app: example-web-go
    name: example-web-go
spec:
  ports:
    - port: 5000
      protocol: TCP
      targetPort: 5000
  selector:
    app: example-web-go
  type: ClusterIP
```

And then apply the file with:

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```
oc apply -f svc-web-go.yaml --namespace <namespace>
```

There is also an imperative command to create a service and expose your application which can be used instead of the yaml file with the `oc apply ...` command

```
oc expose deployment example-web-go --type=ClusterIP --name=example-web-go --port=5000 --target-port=5000 --namespace <namespace>
```

You will get the error message reading `Error from server (AlreadyExists): services "example-web-go" already exists here`. This is because the `oc new-app` command you executed during lab 3 already created a service. This is the default behavior of `oc new-app` while `oc create deployment` doesn't have this functionality.

As a consequence, the `oc expose` command above doesn't add anything new but it demonstrates how to easily create a service based on a deployment.

Let's have a more detailed look at our Service:

```
oc get services --namespace <namespace>
```

Which gives you an output similar to this:

NAME	TYPE	CLUSTER-IP	EXTERNAL-IP	PORT(S)	AGE
example-web-go	ClusterIP	10.43.91.62	<none>	5000/TCP	

Note

Service IP (CLUSTER-IP) addresses stay the same for the duration of the Service's lifespan.

By executing the following command:

```
oc get service example-web-go -o yaml --namespace <namespace>
```

You get additional information:

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```
apiVersion: v1
kind: Service
metadata:
  ...
  labels:
    app: example-web-go
  managedFields:
    ...
  name: example-web-go
  namespace: <namespace>
  ...
spec:
  clusterIP: 10.43.91.62
  externalTrafficPolicy: Cluster
  ports:
    - port: 5000
      protocol: TCP
      targetPort: 5000
  selector:
    app: example-web-go
  sessionAffinity: None
  type: ClusterIP
status:
  loadBalancer: {}
```

The Service's `selector` defines which Pods are being used as Endpoints. This happens based on labels. Look at the configuration of Service and Pod in order to find out what maps to what:

```
oc get service example-web-go -o yaml --namespace <namespace>
```

```
...
  selector:
    app: example-web-go
...
```

With the following command you get details from the Pod:

Note

First, get all Pod names from your namespace with `(oc get pods --namespace <namespace>)` and then replace `<pod>` in the following command. If you have installed and configured the bash completion, you can also press the TAB key for autocompletion of the Pod's name.

```
oc get pod <pod> -o yaml --namespace <namespace>
```

Let's have a look at the label section of the Pod and verify that the Service selector matches the Pod's labels:

```
...
  labels:
    app: example-web-go
...
```

This link between Service and Pod can also be displayed in an easier fashion with the `oc describe` command:

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```
oc describe service example-web-go --namespace <namespace>
```

```
Name:                example-web-go
Namespace:           example-ns
Labels:              app=example-web-go
Annotations:         <none>
Selector:            app=example-web-go
Type:                ClusterIP
IP:                  10.39.240.212
Port:                <unset> 5000/TCP
TargetPort:          5000/TCP
Endpoints:            10.36.0.8:5000
Session Affinity:    None
External Traffic Policy: Cluster
Events:
  Type    Reason          Age   From          Message
  ----    -
  ----    -
```

The `Endpoints` show the IP addresses of all currently matched Pods.

Task 4.2: Expose the Service

With the ClusterIP Service ready, we can now create the Route resource.

```
oc expose service example-web-go --namespace <namespace>
```

The output should be:

```
route.route.openshift.io/example-web-go exposed
```

We are now able to access our app via the freshly created route at `http://example-web-go-<namespace>.<appdomain>`

Find your actual app URL by looking at your route (HOST/PORT):

```
oc get route --namespace <namespace>
```

Browse to the URL and check the output of your app.

Note

If the site doesn't load, check if you are using the `http://` , not the `https://` protocol, which might be the default in your browser.

Note

The `<appdomain>` is the default domain under which your applications will be accessible and is provided by your trainer. You can also use `oc get route example-web-go` to see the exact value of the exposed route.

Task 4.4: For fast learners

Have a closer look at the resources created in your namespace `<namespace>` with the following commands and try to understand them:

```
oc describe namespace <namespace>
```

```
oc get all --namespace <namespace>
```

```
oc describe <resource> <name> --namespace <namespace>
```

```
oc get <resource> <name> -o yaml --namespace <namespace>
```

5. Scaling

In this lab, we are going to show you how to scale applications on OpenShift. Furthermore, we show you how OpenShift makes sure that the number of requested Pods is up and running and how an application can tell the platform that it is ready to receive requests.

Note

This lab does not depend on previous labs. You can start with an empty Namespace.

Task 5.1: Scale the example application

Create a new Deployment in your Namespace. So again, let's define the Deployment using YAML in a file `deployment_example-web-app.yaml` with the following content:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  labels:
    app: example-web-app
    name: example-web-app
spec:
  replicas: 1
  selector:
    matchLabels:
      app: example-web-app
  strategy:
    rollingUpdate:
      maxSurge: 25%
      maxUnavailable: 0
    type: RollingUpdate
  template:
    metadata:
      labels:
        app: example-web-app
    spec:
      containers:
        - image: quay.io/acend/example-web-python:latest
          name: example-web-app
          resources:
            limits:
              cpu: 100m
              memory: 128Mi
            requests:
              cpu: 50m
              memory: 128Mi
```

and then apply with:

```
oc apply -f deployment_example-web-app.yaml --namespace <namespace>
```

If we want to scale our example application, we have to tell the Deployment that we want to have three running replicas instead of one. Let's have a closer look at the existing ReplicaSet:

```
oc get replicasets --namespace <namespace>
```

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Which will give you an output similar to this:

NAME	DESIRED	CURRENT	READY	AGE
example-web-app-86d9d584f8	1	1	1	110s

Or for even more details:

```
oc get replicaset <replicaset> -o yaml --namespace <namespace>
```

The ReplicaSet shows how many instances of a Pod are desired, current and ready.

Now we scale our application to three replicas:

```
oc scale deployment example-web-app --replicas=3 --namespace <namespace>
```

Check the number of desired, current and ready replicas:

```
oc get replicaset --namespace <namespace>
```

NAME	DESIRED	CURRENT	READY	AGE
example-web-app-86d9d584f8	3	3	3	4m33s

Look at how many Pods there are:

```
oc get pods --namespace <namespace>
```

Which gives you an output similar to this:

NAME	READY	STATUS	RESTARTS	AGE
example-web-app-86d9d584f8-7vjcj	1/1	Running	0	5m2s
example-web-app-86d9d584f8-hbvlv	1/1	Running	0	31s
example-web-app-86d9d584f8-qg499	1/1	Running	0	31s

Note

OpenShift supports [horizontal](#) and [vertical autoscaling](#) .

As we changed the number of replicas with the `oc scale deployment` command, the `example-web-app` Deployment now differs from your local `deployment_example-web-app.yaml` file. Change your local `deployment_example-web-app.yaml` file to match the current number of replicas and update the value `replicas` to `3` :

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```
[...]
metadata:
  labels:
    app: example-web-app
    name: example-web-app
spec:
  replicas: 3
  selector:
    matchLabels:
      app: example-web-app
[...]
```

Check for uninterruptible Deployments

Now we expose our application to the internet by creating a service and a route.

First the Service:

```
oc expose deployment example-web-app --name="example-web-app" --port=5000 --namespace <namespace>
```

Then the Route:

```
oc expose service example-web-app --namespace <namespace>
```

Let's look at our Service. We should see all three corresponding Endpoints:

```
oc describe service example-web-app --namespace <namespace>
```

```
Name:          example-web-app
Namespace:     acend-test
Labels:        app=example-web-app
Annotations:   <none>
Selector:      app=example-web-app
Type:          ClusterIP
IP Family Policy: SingleStack
IP Families:   IPv4
IP:            172.30.89.44
IPs:           172.30.89.44
Port:          <unset> 5000/TCP
TargetPort:    5000/TCP
Endpoints:     10.125.4.70:5000,10.126.4.137:5000,10.126.4.138:5000
Session Affinity: None
Events:        <none>
```

Scaling of Pods is fast as OpenShift simply creates new containers.

You can check the availability of your Service while you scale the number of replicas up and down in your browser: `http://<route hostname>` .

Note

You can find out the route's hostname by looking at the output of `oc get route` .

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Now, execute the corresponding loop command for your operating system in another console.

Linux:

```
URL=$(oc get routes example-web-app -o go-template="{{ .spec.host }}" --namespace <namespace>)
while true; do sleep 1; curl -s http://${URL}/pod/; date "+ TIME: %H:%M:%S,%3N"; done
```

Windows PowerShell:

```
while(1) {
    Start-Sleep -s 1
    Invoke-RestMethod http://<URL>/pod/
    Get-Date -Uformat "+ TIME: %H:%M:%S,%3N"
}
```

Scale from 3 replicas to 1. The output shows which Pod is still alive and is responding to requests:

```
example-web-app-86d9d584f8-7vjcj TIME: 17:33:07,289
example-web-app-86d9d584f8-7vjcj TIME: 17:33:08,357
example-web-app-86d9d584f8-hbvlv TIME: 17:33:09,423
example-web-app-86d9d584f8-7vjcj TIME: 17:33:10,494
example-web-app-86d9d584f8-qg499 TIME: 17:33:11,559
example-web-app-86d9d584f8-hbvlv TIME: 17:33:12,629
example-web-app-86d9d584f8-qg499 TIME: 17:33:13,695
example-web-app-86d9d584f8-hbvlv TIME: 17:33:14,771
example-web-app-86d9d584f8-hbvlv TIME: 17:33:15,840
example-web-app-86d9d584f8-7vjcj TIME: 17:33:16,912
example-web-app-86d9d584f8-7vjcj TIME: 17:33:17,980
example-web-app-86d9d584f8-7vjcj TIME: 17:33:19,051
example-web-app-86d9d584f8-7vjcj TIME: 17:33:20,119
example-web-app-86d9d584f8-7vjcj TIME: 17:33:21,182
example-web-app-86d9d584f8-7vjcj TIME: 17:33:22,248
example-web-app-86d9d584f8-7vjcj TIME: 17:33:23,313
example-web-app-86d9d584f8-7vjcj TIME: 17:33:24,377
example-web-app-86d9d584f8-7vjcj TIME: 17:33:25,445
example-web-app-86d9d584f8-7vjcj TIME: 17:33:26,513
```

The requests get distributed amongst the three Pods. As soon as you scale down to one Pod, there should be only one remaining Pod that responds.

Let's make another test: What happens if you start a new Deployment while our request generator is still running?

```
oc rollout restart deployment example-web-app --namespace <namespace>
```

During a short period we won't get a response:

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```
example-web-app-86d9d584f8-7vjcj TIME: 17:37:24,121
example-web-app-86d9d584f8-7vjcj TIME: 17:37:25,189
example-web-app-86d9d584f8-7vjcj TIME: 17:37:26,262
example-web-app-86d9d584f8-7vjcj TIME: 17:37:27,328
example-web-app-86d9d584f8-7vjcj TIME: 17:37:28,395
example-web-app-86d9d584f8-7vjcj TIME: 17:37:29,459
example-web-app-86d9d584f8-7vjcj TIME: 17:37:30,531
example-web-app-86d9d584f8-7vjcj TIME: 17:37:31,596
example-web-app-86d9d584f8-7vjcj TIME: 17:37:32,662
# no answer
example-web-app-f4c5dd8fc-4nx2t TIME: 17:37:33,729
example-web-app-f4c5dd8fc-4nx2t TIME: 17:37:34,794
example-web-app-f4c5dd8fc-4nx2t TIME: 17:37:35,862
example-web-app-f4c5dd8fc-4nx2t TIME: 17:37:36,929
example-web-app-f4c5dd8fc-4nx2t TIME: 17:37:37,995
example-web-app-f4c5dd8fc-4nx2t TIME: 17:37:39,060
example-web-app-f4c5dd8fc-4nx2t TIME: 17:37:40,118
example-web-app-f4c5dd8fc-4nx2t TIME: 17:37:41,187
```

In our example, we use a very lightweight Pod. If we had used a more heavyweight Pod that needed a longer time to respond to requests, we would of course see a larger gap. An example for this would be a Java application with a startup time of 30 seconds:

```
example-spring-boot-2-73aln TIME: 16:48:25,251
example-spring-boot-2-73aln TIME: 16:48:26,305
example-spring-boot-2-73aln TIME: 16:48:27,400
example-spring-boot-2-73aln TIME: 16:48:28,463
example-spring-boot-2-73aln TIME: 16:48:29,507
<html><body><h1>503 Service Unavailable</h1>
No server is available to handle this request.
</body></html>
TIME: 16:48:33,562
<html><body><h1>503 Service Unavailable</h1>
No server is available to handle this request.
</body></html>
TIME: 16:48:34,601
...
example-spring-boot-3-tjdkj TIME: 16:49:20,114
example-spring-boot-3-tjdkj TIME: 16:49:21,181
example-spring-boot-3-tjdkj TIME: 16:49:22,231
```

It is even possible that the Service gets down, and the routing layer responds with the status code 503 as can be seen in the example output above.

In the following chapter we are going to look at how a Service can be configured to be highly available.

Uninterruptible Deployments

The [rolling update strategy](#) makes it possible to deploy Pods without interruption. The rolling update strategy means that the new version of an application gets deployed and started. As soon as the application says it is ready, OpenShift forwards requests to the new instead of the old version of the Pod, and the old Pod gets terminated.

Additionally, [container health checks](#) help OpenShift to precisely determine what state the application is in.

Basically, there are two different kinds of checks that can be implemented:

- Liveness probes are used to find out if an application is still running
- Readiness probes tell us if the application is ready to receive requests (which is especially relevant for the above-mentioned rolling updates)

These probes can be implemented as HTTP checks, container execution checks (the execution of a command or script inside a container) or TCP socket checks.

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In our example, we want the application to tell OpenShift that it is ready for requests with an appropriate readiness probe.

Our example application has a health check context named health: `http://${URL}/health`

Task 5.2: Availability during deployment

Define the readiness probe on the Deployment using the following command:

```
oc set probe deploy/example-web-app --readiness --get-url=http://:5000/health --initial-delay-seconds=10 --timeout-seconds=1 --namespace <namespace>
```

The command above results in the following `readinessProbe` snippet being inserted into the Deployment:

```
...
containers:
- image: quay.io/acend/example-web-python:latest
  imagePullPolicy: Always
  name: example-web-app
  readinessProbe:
    httpGet:
      path: /health
      port: 5000
      scheme: HTTP
    initialDelaySeconds: 10
    timeoutSeconds: 1
...
```

We are now going to verify that a redeployment of the application does not lead to an interruption.

Set up the loop again to periodically check the application's response (you don't have to set the `$URL` variable again if it is still defined):

```
URL=$(oc get routes example-web-app -o go-template="{{ .spec.host }}" --namespace <namespace>)
while true; do sleep 1; curl -s http://$URL/pod/; date "+ TIME: %H:%M:%S,%3N"; done
```

Windows PowerShell:

```
while(1) {
    Start-Sleep -s 1
    Invoke-RestMethod http://[URL]/pod/
    Get-Date -Uformat "+ TIME: %H:%M:%S,%3N"
}
```

Restart your Deployment with:

```
oc rollout restart deployment example-web-app --namespace <namespace>
```

Self-healing

Via the Deployment definition we told OpenShift how many replicas we want. So what happens if we simply delete a Pod?

Look for a running Pod (status `RUNNING`) that you can bear to kill via `oc get pods` .

Show all Pods and watch for changes:

```
oc get pods -w --namespace <namespace>
```

Now delete a Pod (in another terminal) with the following command:

```
oc delete pod <pod> --namespace <namespace>
```

Observe how OpenShift instantly creates a new Pod in order to fulfill the desired number of running instances.

6. Troubleshooting

This lab helps you troubleshoot your application and shows you some tools to make troubleshooting easier.

Logging into a container

Running containers should be treated as immutable infrastructure and should therefore not be modified. However, there are some use cases in which you have to log into your running container. Debugging and analyzing is one example for this.

Task 6.1: Shell into Pod

With OpenShift you can open a remote shell into a Pod without installing SSH by using the command `oc rsh`. The command can also be used to execute any command in a Pod.

Note

If you're using Git Bash on Windows, you need to append the command with `winpty`.

Choose a Pod with `oc get pods --namespace <namespace>` and execute the following command:

```
oc rsh --namespace <namespace> <pod>
```

You now have a running shell session inside the container in which you can execute every binary available, e.g.:

```
ls -l
```

```
total 12
-rw-r--r-- 1 10020700 root      8192 Nov 27 15:12 hellos.db
-rwxrwsr-x 1 web      root     2454 Oct  5 08:55 run.py
drwxrwsr-x 1 web      root       17 Oct  5 08:55 static
drwxrwsr-x 1 web      root      63 Oct  5 08:55 templates
```

With `exit` or `CTRL+d` you can leave the container and close the connection:

```
exit
```

Task 6.2: Single commands

Single commands inside a container can also be executed with `oc rsh`:

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```
oc rsh --namespace <namespace> <pod> <command>
```

Example:

```
oc rsh --namespace acend-test example-web-app-8b465c687-t9g7b env
PATH=/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin
TERM=xterm
HOSTNAME=example-web-app-8b465c687-t9g7b
NSS_SDB_USE_CACHE=no
KUBERNETES_PORT_443_TCP=tcp://172.30.0.1:443
KUBERNETES_PORT_443_TCP_PORT=443
EXAMPLE_WEB_APP_PORT_5000_TCP_PORT=5000
...
```

The debug command

One of the disadvantages of using the `oc rsh` command is that it depends on the container to actually run. If the Pod can't even start, this is a problem but also where the `oc debug` command comes in. The `oc debug` command starts an interactive shell using the definition of a Deployment, Pod, DaemonSet, Job or even an ImageStreamTag. In OpenShift 4 it can also be used to open a shell on a Node to analyze it.

The quick way of using it is `oc debug RESOURCE/NAME` but have a good look at its help page. There are some very interesting parameters like `--as-root` that give you (depending on your permissions on the cluster) a very powerful means of debugging a Pod.

Watching log files

Log files of a Pod can be shown with the following command:

```
oc logs <pod> --namespace <namespace>
```

The parameter `-f` allows you to follow the log file (same as `tail -f`). With this, log files are streamed and new entries are shown immediately.

When a Pod is in state `CrashLoopBackOff` it means that although multiple attempts have been made, no container inside the Pod could be started successfully. Now even though no container might be running at the moment the `oc logs` command is executed, there is a way to view the logs the application might have generated. This is achieved using the `-p` or `--previous` parameter.

Note

This command will only work on pods that had container restarts. You can check the `RESTARTS` column in the `oc get pods` output if this is the case.

```
oc logs -p <pod> --namespace <namespace>
```

Task 6.3: Port forwarding

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OpenShift allows you to forward arbitrary ports to your development workstation. This allows you to access admin consoles, databases, etc., even when they are not exposed externally. Port forwarding is handled by the OpenShift control plane nodes and therefore tunneled from the client via HTTPS. This allows you to access the OpenShift platform even when there are restrictive firewalls or proxies between your workstation and OpenShift.

Get the name of the Pod:

```
oc get pod --namespace <namespace>
```

Then execute the port forwarding command using the Pod's name:

Note

Best run this command in a separate shell, or in the background by adding a "&" at the end of the command.

```
oc port-forward <pod> 5000:5000 --namespace <namespace>
```

Don't forget to change the Pod name to your own installation. If configured, you can use auto-completion.

The output of the command should look like this:

```
Forwarding from 127.0.0.1:5000 -> 5000
Forwarding from [::1]:5000 -> 5000
```

Note

Use the additional parameter `--address <IP address>` (where `<IP address>` refers to a NIC's IP address from your local workstation) if you want to access the forwarded port from outside your own local workstation.

The application is now available with the following link: <http://localhost:5000/> . Or try a `curl` command:

```
curl localhost:5000
```

With the same concept you can access databases from your local workstation or connect your local development environment via remote debugging to your application in the Pod.

[This documentation page](#) offers some more details about port forwarding.

Note

The `oc port-forward` process runs as long as it is not terminated by the user. So when done, stop it with `CTRL-C`.

Events

OpenShift maintains an event log with high-level information on what's going on in the cluster. It's possible

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that everything looks okay at first but somehow something seems stuck. Make sure to have a look at the events because they can give you more information if something is not working as expected.

Use the following command to list the events in chronological order:

```
oc get events --sort-by=.metadata.creationTimestamp --namespace <namespace>
```

Dry-run

To help verify changes, you can use the optional `oc flag --dry-run=client -o yaml` to see the rendered YAML definition of your Kubernetes objects, without sending it to the API.

The following `oc` subcommands support this flag (non-final list):

- `apply`
- `create`
- `expose`
- `patch`
- `replace`
- `run`
- `set`

For example, we can use the `--dry-run=client` flag to create a template for our Deployment:

```
oc create deployment example-web-app --image=quay.io/acend/example-web-python:latest --namespace acend-test --dry-run=client -o yaml
```

The result is the following YAML output:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  creationTimestamp: null
  labels:
    app: example-web-app
  name: example-web-app
  namespace: acend-test
spec:
  replicas: 1
  selector:
    matchLabels:
      app: example-web-app
  strategy: {}
  template:
    metadata:
      creationTimestamp: null
      labels:
        app: example-web-app
    spec:
      containers:
        - image: quay.io/acend/example-web-python:latest
          name: example-web
          resources: {}
status: {}
```

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oc API requests

If you want to see the HTTP requests `oc` sends to the Kubernetes API in detail, you can use the optional flag `--v=10`.

For example, to see the API request for creating a deployment:

```
oc create deployment test-deployment --image=quay.io/acend/example-web-python:latest --namespace <namespace> --replicas=0 --v=10
```

The resulting output looks like this:

```
I1114 15:31:13.605759    85289 request.go:1073] Request Body: {"kind":"Deployment","apiVersion":"apps/v1","metadata":{"name":"test-deployment","namespace":"acend-test","creationTimestamp":null,"labels":{"app":"test-deployment"}}, "spec":{"replicas":0,"selector":{"matchLabels":{"app":"test-deployment"}},"template":{"metadata":{"creationTimestamp":null,"label s":{"app":"test-deployment"},"spec":{"containers":[{"name":"example-web","image":"quay.io/acend/example-web-python:late st","resources":{}}]},"strategy":{"},"status":{"}}
```

```
I1114 15:31:13.605817    85289 round_tripper.go:466] curl -v -XPOST -H "Accept: application/json, */*" -H "Content-Typ e: application/json" -H "User-Agent: oc/4.11.0 (linux/amd64) kubernetes/262ac9c" -H "Authorization: Bearer <masked>" 'ht tps://api.ocp-staging.cloudscale.puzzle.ch:6443/apis/apps/v1/namespaces/acend-test/deployments?fieldManager=kubectl-c reate&fieldValidation=Ignore'
```

```
I1114 15:31:13.607320    85289 round_tripper.go:495] HTTP Trace: DNS Lookup for api.ocp-staging.cloudscale.puzzle.ch re solved to [[5.102.150.82 ]]
```

```
I1114 15:31:13.611279    85289 round_tripper.go:510] HTTP Trace: Dial to tcp:5.102.150.82:6443 succeed
```

```
I1114 15:31:13.675096    85289 round_tripper.go:553] POST https://api.ocp-staging.cloudscale.puzzle.ch:6443/apis/apps/v 1/namespaces/acend-test/deployments?fieldManager=kubectl-create&fieldValidation=Ignore 201 Created in 69 milliseconds
```

```
I1114 15:31:13.675120    85289 round_tripper.go:570] HTTP Statistics: DNSLookup 1 ms Dial 3 ms TLSHandshake 35 ms Serve rProcessing 27 ms Duration 69 ms
```

```
I1114 15:31:13.675137    85289 round_tripper.go:577] Response Headers:
```

```
I1114 15:31:13.675151    85289 round_tripper.go:580] Audit-Id: 509255b1-ee23-479a-be56-dfc3ab073864
```

```
I1114 15:31:13.675164    85289 round_tripper.go:580] Cache-Control: no-cache, private
```

```
I1114 15:31:13.675181    85289 round_tripper.go:580] Content-Type: application/json
```

```
I1114 15:31:13.675200    85289 round_tripper.go:580] X-Kubernetes-Pf-Flowschema-Uid: e3e152ee-768c-43c5-b350-bb3cbf806147
```

```
I1114 15:31:13.675215    85289 round_tripper.go:580] X-Kubernetes-Pf-Prioritylevel-Uid: 47f392da-68d1-4e43-9d77-ff5f7b7ecd2e
```

```
I1114 15:31:13.675230    85289 round_tripper.go:580] Content-Length: 1739
```

```
I1114 15:31:13.675244    85289 round_tripper.go:580] Date: Mon, 14 Nov 2022 14:31:13 GMT
```

```
I1114 15:31:13.676116    85289 request.go:1073] Response Body: {"kind":"Deployment","apiVersion":"apps/v1","metadata":{" name":"test-deployment","namespace":"acend-test","uid":"a6985d28-3caa-451f-a648-4c7cde3b51ac","resourceVersion":"206938 5577","generation":1,"creationTimestamp":"2022-11-14T14:31:13Z","labels":{"app":"test-deployment"},"managedFields":[{"m anager":"kubectl-create","operation":"Update","apiVersion":"apps/v1","time":"2022-11-14T14:31:13Z","fieldsType":"Fields V1","fieldsV1":{"f:metadata":{"f:labels":{".":""},"f:app":"","f:spec":{"f:progressDeadlineSeconds":"","f:replicas":""," f:revisionHistoryLimit":"","f:selector":"","f:strategy":{"f:rollingUpdate":{".":""},"f:maxSurge":"","f:maxUnavailable": {}},"f:type":"","f:template":{"f:metadata":{"f:labels":{".":""},"f:app":"","f:spec":{"f:containers":[{"k:\\\"name\\\":\\\"e xample-web\\\"}":{".":""},"f:image":"","f:imagePullPolicy":"","f:name":"","f:resources":"","f:terminationMessagePath":"","f :terminationMessagePolicy":"","f:dnsPolicy":"","f:restartPolicy":"","f:schedulerName":"","f:securityContext":"","f:t erminationGracePeriodSeconds":{}}]},"spec":{"replicas":0,"selector":{"matchLabels":{"app":"test-deployment"},"temp late":{"metadata":{"creationTimestamp":null,"labels":{"app":"test-deployment"},"spec":{"containers":[{"name":"example- web","image":"quay.io/acend/example-web-python:latest","resources":{},"terminationMessagePath":"/dev/termination-log"," terminationMessagePolicy":"File","imagePullPolicy":"Always"},"restartPolicy":"Always","terminationGracePeriodSeconds": 30,"dnsPolicy":"ClusterFirst","securityContext":"","schedulerName":"default-scheduler"},"strategy":{"type":"RollingUpd ate","rollingUpdate":{"maxUnavailable":"25%","maxSurge":"25%"},"revisionHistoryLimit":10,"progressDeadlineSeconds":600 },"status":{}} deployment.apps/test-deployment created
```

As you can see, the output conveniently contains the corresponding `curl` commands which we could use in our own code, tools, pipelines etc.

Note

If you created the deployment to see the output, you can delete it again as it's not used anywhere else

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(which is also the reason why the replicas are set to 0):

```
oc delete deploy/test-deployment --namespace <namespace>
```

Progress

At this point, you are able to visualize your progress on the labs by browsing through the following page <http://localhost:5000/progress>

If you are not able to open your awesome-app with localhost, because you are using a webshell, you can also use the ingress address: `https://example-web-app-<namespace>.<appdomain>/progress` to access the dashboard.

You may need to set some extra permissions to let the dashboard monitor your progress. Have fun!

```
oc create rolebinding progress --clusterrole=view --serviceaccount=<namespace>:default --namespace=<namespace>
```

7. Attaching a database

Numerous applications are stateful in some way and want to save data persistently, be it in a database, as files on a filesystem or in an object store. In this lab, we are going to create a MariaDB database and configure our application to store its data in it.

Warning

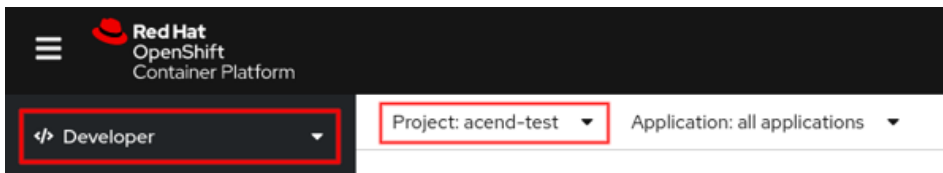
Please make sure you completed labs *2. First steps*, *3. Deploying a container image* and *4. Exposing a service* before you continue with this lab.

Task 7.1: Instantiate a MariaDB database

We are going to use an OpenShift template to create the database. This can be done by either using the Web Console or the CLI. Both are going to be explained in this lab, so pick the one you are more comfortable with.

Instantiate a template using the Web Console

Make sure you are in OpenShift's **Developer** view (upper left dropdown) and have selected the correct Project:



Now click **+Add**, choose **Database, MariaDB (Ephemeral)** and then **Instantiate Template**. A form opens. Check that the first field corresponds to the correct Project and set the **MariaDB Database Name** field to `acend_example` and leave the remaining fields as they are. Finally, click **Create** at the end of the form.

Instantiate a template using the CLI

Warning

Do not execute these steps if you already have created a MariaDB database using the Web Console.

We are going to instantiate the MariaDB Template from the `openshift` Project. Before we can do that, we need to know what parameters the Template expects. Let's find out:

```
oc process --parameters openshift//mariadb-ephemeral
```

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NAME	DESCRIPTION	GENERATOR	VALUE
MEMORY_LIMIT	Maximum amount of memory the container can use.		512Mi
NAMESPACE	The OpenShift Namespace where the ImageStream resides.		openshift
DATABASE_SERVICE_NAME	The name of the OpenShift Service exposed for the database.		ariadb
MYSQL_USER	Username for MariaDB user that will be used for accessing the database.	expression	ser[A-Z0-9]{3}
MYSQL_PASSWORD	Password for the MariaDB connection user.	expression	a-zA-Z0-9]{16}
MYSQL_ROOT_PASSWORD	Password for the MariaDB root user.	expression	a-zA-Z0-9]{16}
MYSQL_DATABASE	Name of the MariaDB database accessed.		ampledb
MARIADB_VERSION	Version of MariaDB image to be used (10.2 or latest).		0.2

As you might already see, each of the parameters has a default value (“VALUE” column). Also, the parameters `MYSQL_USER`, `MYSQL_PASSWORD` and `MYSQL_ROOT_PASSWORD` are going to be generated (“GENERATOR” is set to `expression` and “VALUE” contains a regular expression). This means we don’t necessarily have to overwrite any of them so let’s simply use those defaults:

```
oc process openshift//mariadb-ephemeral -pMYSQL_DATABASE=acend_exampladb | oc apply --namespace=<namespace> -f -
```

The output should be:

```
secret/mariadb created
service/mariadb created
deploymentconfig.apps.openshift.io/mariadb created
```

Task 7.2: Inspection

What just happened is that you instantiated an OpenShift Template that creates multiple resources using the (default) values as parameters. Let’s have a look at the resources that have just been created by looking at the Template’s definition:

```
oc get templates -n openshift mariadb-ephemeral -o yaml
```

The Template’s content reveals a Secret, a Service and a DeploymentConfig.

The Secret contains the database name, user, password, and the root password. However, these values will neither be shown with `oc get` nor with `oc describe` :

```
oc get secret mariadb --output yaml --namespace <namespace>
```

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```
apiVersion: v1
data:
  database-name: YWNlbnQtZXhhbXBsZS1kYg==
  database-password: bX1zcWxwYXNzd29yZA==
  database-root-password: bX1zcWxyb290cGFzc3dvcmQ=
  database-user: YWNlbnRfdXNlcg==
kind: Secret
metadata:
  ...
type: Opaque
```

The reason is that all the values in the `.data` section are base64 encoded. Even though we cannot see the true values, they can easily be decoded:

```
echo "YWNlbnQtZXhhbXBsZS1kYg==" | base64 -d
```

Note

There's also the `oc extract` command which can be used to extract the content of Secrets and ConfigMaps into a local directory. Use `oc extract --help` to see how it works.

Note

By default, Secrets are not encrypted!

However, both [OpenShift](#) and [Kubernetes \(1.13 and later\)](#) offer the capability to encrypt data in etcd.

Another option would be the use of a secrets management solution like [Vault by HashiCorp](#).

The interesting thing about Secrets is that they can be reused, e.g., in different Deployments. We could extract all the plaintext values from the Secret and put them as environment variables into the Deployments, but it's way easier to instead simply refer to its values inside the Deployment (as in this lab) like this:

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```
...
spec:
  template:
    spec:
      containers:
      - name: mariadb
        env:
        - name: MYSQL_USER
          valueFrom:
            secretKeyRef:
              key: database-user
              name: mariadb
        - name: MYSQL_PASSWORD
          valueFrom:
            secretKeyRef:
              key: database-password
              name: mariadb
        - name: MYSQL_ROOT_PASSWORD
          valueFrom:
            secretKeyRef:
              key: database-root-password
              name: mariadb
        - name: MYSQL_DATABASE
          valueFrom:
            secretKeyRef:
              key: database-name
              name: mariadb
...

```

Above lines are an excerpt of the MariaDB Deployment. Most parts have been cut out to focus on the relevant lines: The references to the `mariadb` Secret. As you can see, instead of directly defining environment variables you can refer to a specific key inside a Secret. We are going to make further use of this concept for our Python application.

Task 7.3: Attach the database to the application

By default, our `example-web-app` application uses an SQLite memory database.

However, this can be changed by defining the following environment variable to use the newly created MariaDB database:

```
#MYSQL_URI=mysql://<user>:<password>@<host>/<database>
MYSQL_URI=mysql://acend_user:mysqlpassword@mariadb/acend_exempledb

```

The connection string our `example-web-app` application uses to connect to our new MariaDB, is a concatenated string from the values of the `mariadb` Secret.

For the actual MariaDB host, you can either use the MariaDB Service's ClusterIP or DNS name as the address. All Services and Pods can be resolved by DNS using their name.

The following commands set the environment variables for the deployment configuration of the `example-web-app` application:

Warning

Depending on the shell you use, the following `set env` command works but inserts too many apostrophes! Check the deployment's environment variable afterwards or directly edit it as described further down below.

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```
oc set env --from=secret/mariadb --prefix=MYSQL_ deploy/example-web-app --namespace <namespace>
```

and

```
oc set env deploy/example-web-app MYSQL_URI='mysql://$(MYSQL_DATABASE_USER):$(MYSQL_DATABASE_PASSWORD)@mariadb/$(MYSQL_DATABASE_NAME)' --namespace <namespace>
```

The first command inserts the values from the Secret, the second finally uses these values to put them in the environment variable `MYSQL_URI` which the application considers.

You can also do the changes by directly editing your local `deployment_example-web-app.yaml` file. Find the section which defines the containers. You should find it under:

```
...
spec:
...
  template:
...
    spec:
      containers:
      - image: ...
...
```

The dash before `image:` defines the beginning of a new container definition. The following specifications should be inserted into this container definition:

```
env:
- name: MYSQL_DATABASE_NAME
  valueFrom:
    secretKeyRef:
      key: database-name
      name: mariadb
- name: MYSQL_DATABASE_PASSWORD
  valueFrom:
    secretKeyRef:
      key: database-password
      name: mariadb
- name: MYSQL_DATABASE_ROOT_PASSWORD
  valueFrom:
    secretKeyRef:
      key: database-root-password
      name: mariadb
- name: MYSQL_DATABASE_USER
  valueFrom:
    secretKeyRef:
      key: database-user
      name: mariadb
- name: MYSQL_URI
  value: mysql://$(MYSQL_DATABASE_USER):$(MYSQL_DATABASE_PASSWORD)@mariadb/$(MYSQL_DATABASE_NAME)
```

Your file should now look like this:

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```
...
containers:
- image: quay.io/acend/example-web-python:latest
  imagePullPolicy: Always
  name: example-web-app
...
env:
- name: MYSQL_DATABASE_NAME
  valueFrom:
    secretKeyRef:
      key: database-name
      name: mariadb
- name: MYSQL_DATABASE_PASSWORD
  valueFrom:
    secretKeyRef:
      key: database-password
      name: mariadb
- name: MYSQL_DATABASE_ROOT_PASSWORD
  valueFrom:
    secretKeyRef:
      key: database-root-password
      name: mariadb
- name: MYSQL_DATABASE_USER
  valueFrom:
    secretKeyRef:
      key: database-user
      name: mariadb
- name: MYSQL_URI
  value: mysql://$(MYSQL_DATABASE_USER):$(MYSQL_DATABASE_PASSWORD)@mariadb/$(MYSQL_DATABASE_NAME)
```

Then use:

```
oc apply -f deployment_example-web-app.yaml --namespace <namespace>
```

to apply the changes.

The environment can also be checked with the `set env` command and the `--list` parameter:

```
oc set env deploy/example-web-app --list --namespace <namespace>
```

This will show the environment as follows:

```
# deployments/example-web-app, container example-web-app
# MYSQL_DATABASE_PASSWORD from secret mariadb, key database-password
# MYSQL_DATABASE_ROOT_PASSWORD from secret mariadb, key database-root-password
# MYSQL_DATABASE_USER from secret mariadb, key database-user
# MYSQL_DATABASE_NAME from secret mariadb, key database-name
MYSQL_URI=mysql://$(MYSQL_DATABASE_USER):$(MYSQL_DATABASE_PASSWORD)@mariadb/$(MYSQL_DATABASE_NAME)
```

Warning

Do not proceed with the lab before all example-web-app pods are restarted successfully.

The change of the deployment definition (environment change) triggers a new rollout and all example-web-app pods will be restarted. The application will not be connected to the database until all pods are restarted successfully.

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In order to find out if the change worked we can either look at the container's logs (`oc logs <pod>`) or we could register some "Hellos" in the application, delete the Pod, wait for the new Pod to be started and check if they are still there.

Note

This does not work if we delete the database Pod as its data is not yet persisted.

Task 7.4: Manual database connection

As described in *6. Troubleshooting* we can log into a Pod with `oc rsh <pod>` .

Show all Pods:

```
oc get pods --namespace <namespace>
```

Which gives you an output similar to this:

NAME	READY	STATUS	RESTARTS	AGE
example-web-app-574544fd68-qfkcm	1/1	Running	0	2m20s
mariadb-f845ccdb7-hf2x5	1/1	Running	0	31m
mariadb-1-deploy	0/1	Completed	0	11m

Log into the MariaDB Pod:

Note

As mentioned in *6. Troubleshooting*, remember to append the command with `winpty` if you're using Git Bash on Windows.

```
oc rsh --namespace <namespace> <mariadb-pod-name>
```

You are now able to connect to the database and display the data. Login with:

```
mysql -u$MYSQL_USER -p$MYSQL_PASSWORD -h$MARIADB_SERVICE_HOST $MYSQL_DATABASE
```

```
Welcome to the MariaDB monitor.  Commands end with ; or \g.
Your MariaDB connection id is 52810
Server version: 10.2.22-MariaDB MariaDB Server
```

```
Copyright (c) 2000, 2018, Oracle, MariaDB Corporation Ab and others.
```

```
Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.
```

```
MariaDB [acend_exampledb]>
```

Show all tables with:

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```
show tables;
```

Show any entered “Hellos” with:

```
select * from hello;
```

Task 7.5: Import a database dump

Our task is now to import this [dump.sql](#) into the MariaDB database running as a Pod. Use the `mysql` command line utility to do this. Make sure the database is empty beforehand. You could also delete and recreate the database.

Note

You can also copy local files into a Pod using `oc cp`. Be aware that the `tar` binary has to be present inside the container and on your operating system in order for this to work! Install `tar` on UNIX systems with e.g. your package manager, on Windows there's e.g. [cwRsync](#). If you cannot install `tar` on your host, there's also the possibility of logging into the Pod and using `curl -O <url>`.

Solution

This is how you copy the database dump into the MariaDB Pod.

Download the [dump.sql](#) or get it with `curl`:

```
curl -O https://raw.githubusercontent.com/acend/kubernetes-basics-training/main/content/en/docs/attaching-a-database/dump.sql
```

Copy the dump into the MariaDB Pod:

```
oc cp ./dump.sql <podname>:/tmp/ --namespace <namespace>
```

This is how you log into the MariaDB Pod:

```
oc rsh --namespace <namespace> <podname>
```

This command shows how to drop the whole database:

```
mariadb -u$MYSQL_USER -p$MYSQL_PASSWORD -h$MARIADB_SERVICE_HOST $MYSQL_DATABASE
```

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```
drop database `acend_exampledb`;  
create database `acend_exampledb`;  
exit
```

Import a dump:

```
mariadb -u$MYSQL_USER -p$MYSQL_PASSWORD -h$MARIADB_SERVICE_HOST $MYSQL_DATABASE < /tmp/dump.sql
```

Check your app to see the imported “Hellos”.

Note

You can find your app URL by looking at your route:

```
oc get route --namespace <namespace>
```

Note

A database dump can be created as follows:

```
oc rsh --namespace <namespace> <podname>
```

```
mysqldump --user=$MYSQL_USER --password=$MYSQL_PASSWORD -h$MARIADB_SERVICE_HOST $MYSQL_DATABASE > /tmp/dump.sql
```

```
oc cp <podname>:/tmp/dump.sql /tmp/dump.sql
```

8. Persistent storage

By default, data in containers is not persistent as was the case e.g. in *7. Attaching a database*. This means that the data written in a container is lost as soon as it does not exist anymore. We want to prevent this from happening. One possible solution to this problem is to use persistent storage.

Request storage

Attaching persistent storage to a Pod happens in two steps. The first step includes the creation of a so-called *PersistentVolumeClaim* (PVC) in our namespace. This claim defines amongst other things what size we would like to get.

The *PersistentVolumeClaim* only represents a request but not the storage itself. It is automatically going to be bound to a *PersistentVolume* by OpenShift, one that has at least the requested size. If only volumes exist that have a bigger size than was requested, one of these volumes is going to be used. The claim will automatically be updated with the new size. If there are only smaller volumes available, the claim cannot be fulfilled as long as no volume with the exact same or larger size is created.

Attaching a volume to a Pod

In a second step, the PVC from before is going to be attached to the Pod. In *5. Scaling* we used `oc set` to add a readiness probe to the Deployment. We are now going to do the same and insert the *PersistentVolume*.

Task 8.1: Add a PersistentVolume

The `oc set volume` command makes it possible to create a PVC and attach it to a Deployment in one fell swoop:

Note

If you are using Windows, your shell might assume that it has to use the POSIX-to-Windows path conversion for the mount path `/var/lib/mysql`. PowerShell is known to not do this while, e.g., Git Bash does.

Prepend your command with `MSYS_NO_PATHCONV=1` if the resulting mount path was mistakenly converted.

```
oc set volume dc/mariadb --add --name=mariadb-data --claim-name=mariadb-data --type persistentVolumeClaim --mount-path=/var/lib/mysql --claim-size=1G --overwrite --namespace <namespace>
```

With the instruction above we create a PVC named `mariadb-data` of 1Gi in size, attach it to the DeploymentConfig `mariadb` and mount it at `/var/lib/mysql`. This is where the MariaDB process writes its data by default so after we make this change, the database will not even notice that it is writing in a *PersistentVolume*.

Note

Because we just changed the DeploymentConfig with the `oc set` command, a new Pod was automatically redeployed. This unfortunately also means that we just lost the data we inserted before.

We need to redeploy the application pod, our application automatically creates the database schema at

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startup time. Wait for the database pod to be started fully before restarting the application pod.

If you want to force a redeployment of a Pod, you can use this:

```
oc rollout restart deployment example-web-app --namespace <namespace>
```

Using the command `oc get persistentvolumeclaim` or `oc get pvc`, we can display the freshly created PersistentVolumeClaim:

```
oc get pvc --namespace <namespace>
```

Which gives you an output similar to this:

NAME	STATUS	VOLUME	CAPACITY	ACCESS MODES	STORAGECLASS	AGE
mariadb-data	Bound	pvc-2cb78deb-d157-11e8-a406-42010a840034	1Gi	RWO	standard	11s

The two columns `STATUS` and `VOLUME` show us that our claim has been bound to the PersistentVolume `pvc-2cb78deb-d157-11e8-a406-42010a840034`.

Error case

If the container is not able to start it is the right moment to debug it! Check the logs from the container and search for the error.

```
oc logs mariadb-f845ccdb7-hf2x5 --namespace <namespace>
```

Note

If the container won't start because the data directory already has files in it, use the `oc debug` command mentioned in [7. Attaching a database](#) to check its content and remove it if necessary.

Task 8.2: Persistence check

Restore data

Repeat [the task to import a database dump](#).

Test

Scale your MariaDB Pod to 0 replicas and back to 1. Observe that the new Pod didn't lose any data.