- acend gmbh

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. Other ways 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

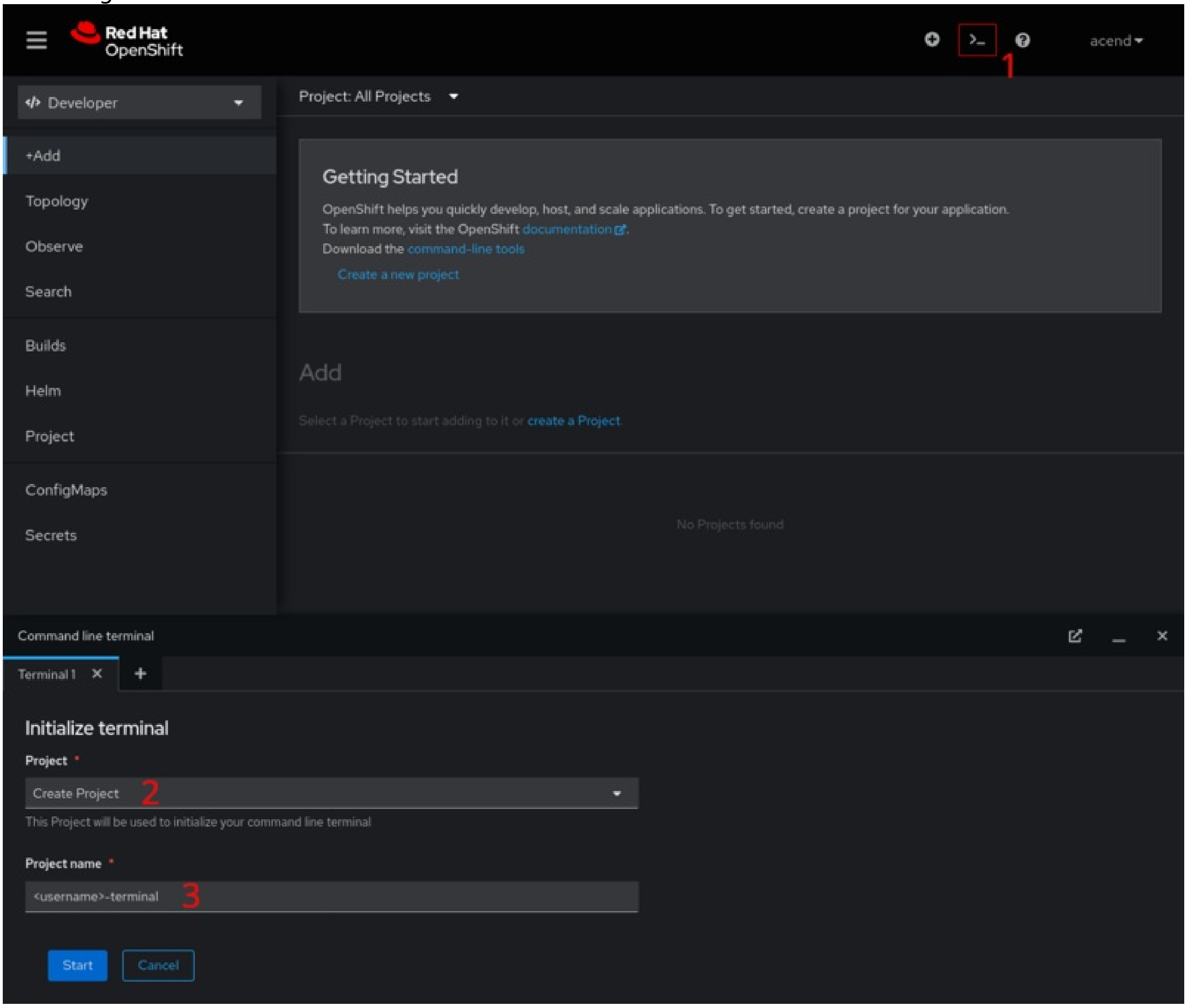
First of all, open your browser. Then, log in on OpenShift's web console using the URL and credentials provided by your trainer.

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!

- acend gmbh

Next steps

If you're interested, have a look at the *3. Other ways 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

As the labs of this training will be done in your company's environment, please follow the company-specific instructions on how to set up your local installation.

After installing `oc`, follow the instructions on *2.1. Console login* in order to log in.

2.1. Console login

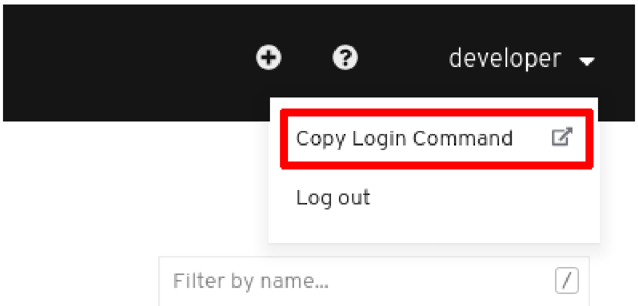
Task 2.1.1: Login on the web console

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

Task 2.1.2: 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 2.1.3: 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.

Next steps

If you're interested, have a look at the *3. Other ways 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. Other ways to work with OpenShift

Other ways to work with OpenShift

If you don't have access to a running OpenShift development environment (anymore), there are several options to get one.

- OpenShift Developer Sandbox : 30 days of no-cost access to a shared cluster on OpenShift
- OpenShift Local : A local OpenShift environmennt running on your machine
- OKD single node installation : OKD (OpenShift community edition) single node installation

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

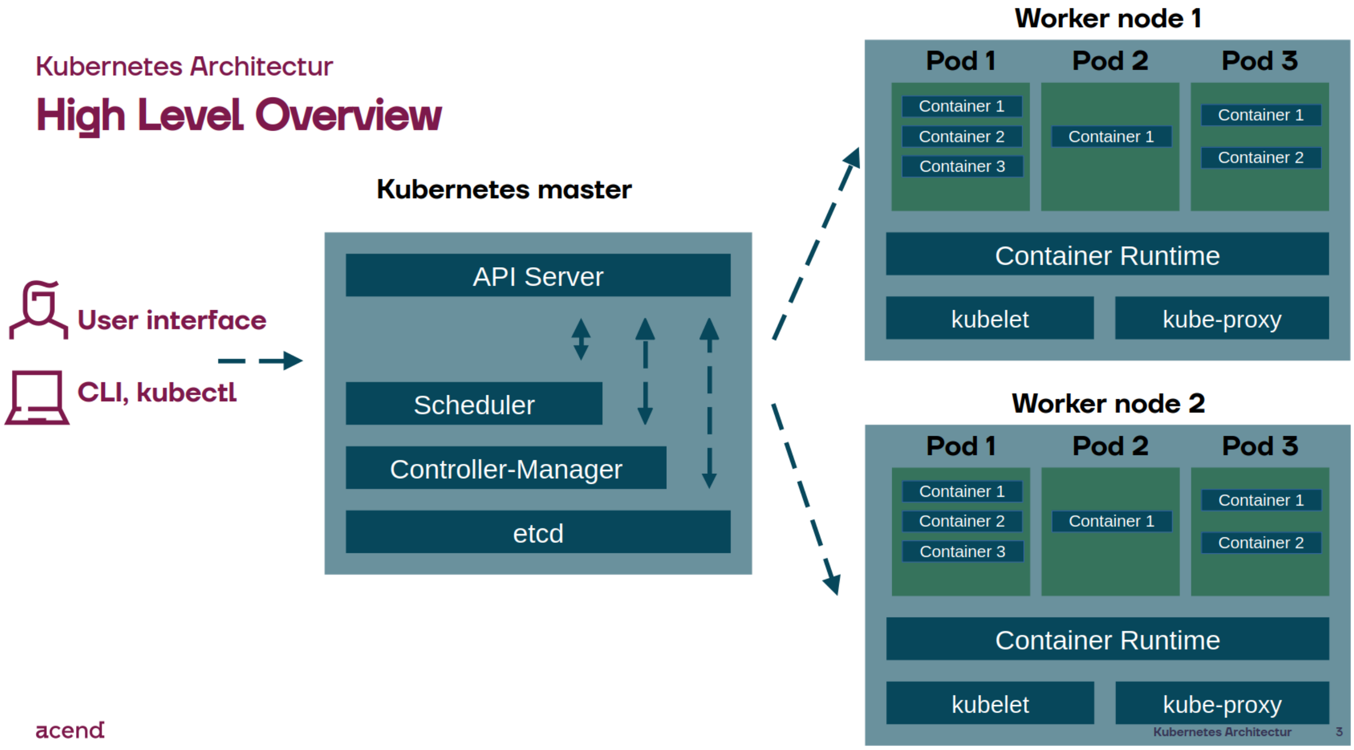
OpenShift’s underlying container engine is CRI-O . Earlier releases used Docker .

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.

- acend gmbh



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 (Alpine)
2. Install Java

- acend gmbh
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 one container which contains your application. 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

- acend gmbh
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 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 .

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:

- acend gmbh

```yaml
---
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
- `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.

```yaml
---
# 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.

```
---
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
```

- acend gmbh
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.

```yaml
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.

```yaml
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.

```yaml
---
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.

```yaml
---
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.

- acend gmbh

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

Arrays

You can specify arrays or lists on a single line.

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

Or, you can put them on multiple lines.

```yaml
---
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.

```yaml
---
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.

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

We’ve seen them span lines before.

- acend gmbh

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

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

```yaml
---
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.

Projects

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

You would usually create your first Project here using `oc new-project`. This is, however, not possible on the provided cluster. Instead, a Project named `<username>-training-test` has been pre-created for you. Use this Project for all labs in this training except for *9.5. ResourceQuotas and LimitRanges*.

> **Note**
> Please inform your trainer if you don't see such a Project.

> **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):

```
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.

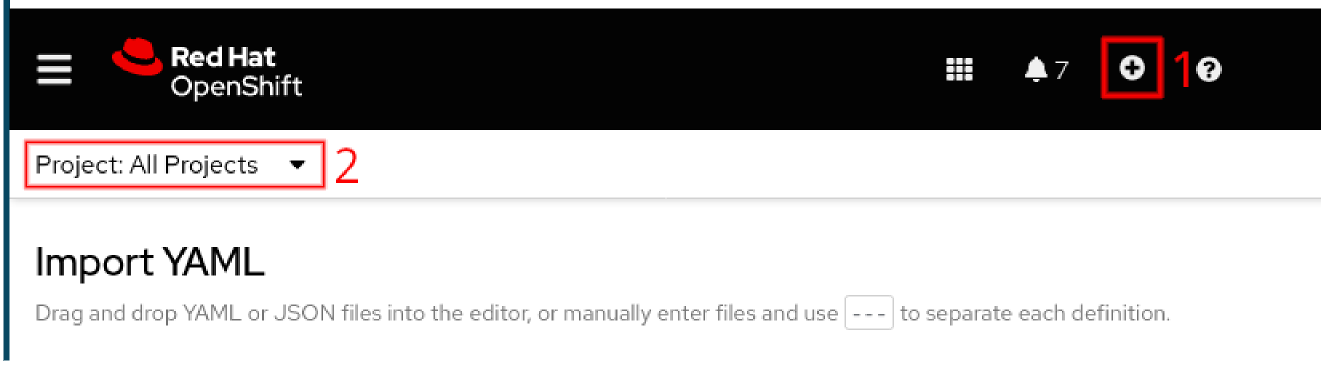
Task 3.1: Start and stop a single Pod

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.



- acend gmbh

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: awesome-app
spec:
  containers:
  - image: REGISTRY-URL/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:

```
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

- acend gmbh
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.

```yaml
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: REGISTRY-URL/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 or as source code on GitHub .

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=REGISTRY-URL/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

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.

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:

```yaml
---
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:

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

There is also am 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>
```

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:

```
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:

```
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 create route edge example-web-go --service example-web-go --namespace <namespace>
```

The output should be:

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

We are now able to access our app via the freshly created route at `https://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, lets define the Deployment using YAML in a file `deployment_example-web-app.yaml` with the following content:

```yaml
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: REGISTRY-URL/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>
```

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 replicasets --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` :

```yaml
[...]
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 create route edge example-web-app --port 5000 --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: `https://<route hostname>` .

> **Note**
> You can find out the route’s hostname by looking at the output of `oc get route` .

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

Linux:

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

Windows PowerShell:

```
while(1) {
  Start-Sleep -s 1
  Invoke-RestMethod https://<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:

```
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.

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:

- acend gmbh

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

Windows PowerShell:

```
while(1) {
  Start-Sleep -s 1
  Invoke-RestMethod https://<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:

- acend gmbh

```
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` :

```
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.

- acend gmbh

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

> **Note**
> Baloise uses Splunk to aggregate and visualize all logs, including those of Pods.

Task 6.3: Port forwarding

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 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=REGISTRY-URL/acend/example-web-python:latest --namespace acend-test --dry-run=client -o yaml
```

The result is the following YAML output:

```yaml
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: REGISTRY-URL/acend/example-web-python:latest
          name: example-web
          resources: {}
status: {}
```

`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=REGISTRY-URL/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":{"n
ame":"test-deployment","namespace":"acend-test","creationTimestamp":null,"labels":{"app":"test-deployment"}},"spec":{"r
eplicas":0,"selector":{"matchLabels":{"app":"test-deployment"}},"template":{"metadata":{"creationTimestamp":null,"label
s":{"app":"test-deployment"}},"spec":{"containers":[{"name":"example-web","image":"REGISTRY-URL/acend/example-web-pytho
n:latest","resources":{}}]}},"strategy":{}},"status":{}}
I1114 15:31:13.605817   85289 round_trippers.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>" 'h
ttps://api.ocp-staging.cloudscale.puzzle.ch:6443/apis/apps/v1/namespaces/acend-test/deployments?fieldManager=kubectl-cr
eate&fieldValidation=Ignore'
I1114 15:31:13.607320   85289 round_trippers.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_trippers.go:510] HTTP Trace: Dial to tcp:5.102.150.82:6443 succeed
I1114 15:31:13.675096   85289 round_trippers.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_trippers.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_trippers.go:577] Response Headers:
I1114 15:31:13.675151   85289 round_trippers.go:580]     Audit-Id: 509255b1-ee23-479a-be56-dfc3ab073864
I1114 15:31:13.675164   85289 round_trippers.go:580]     Cache-Control: no-cache, private
I1114 15:31:13.675181   85289 round_trippers.go:580]     Content-Type: application/json
I1114 15:31:13.675200   85289 round_trippers.go:580]     X-Kubernetes-Pf-Flowschema-Uid: e3e152ee-768c-43c5-b350-bb3cbf
806147
I1114 15:31:13.675215   85289 round_trippers.go:580]     X-Kubernetes-Pf-Prioritylevel-Uid: 47f392da-68d1-4e43-9d77-ff5
f7b7ecd2e
I1114 15:31:13.675230   85289 round_trippers.go:580]     Content-Length: 1739
I1114 15:31:13.675244   85289 round_trippers.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":"REGISTRY-URL/acend/example-web-python:latest","resources":{},"terminationMessagePath":"/dev/termination-l
og","terminationMessagePolicy":"File","imagePullPolicy":"Always"}],"restartPolicy":"Always","terminationGracePeriodSeco
nds":30,"dnsPolicy":"ClusterFirst","securityContext":{},"schedulerName":"default-scheduler"}},"strategy":{"type":"Rolli
ngUpdate","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 (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 first going to create a so-called *Secret* in which we store sensitive data. The secret will be used to access the database and also to create the initial database. The `oc create secret` command helps us create the secret like so:

```
oc create secret generic mariadb \
  --from-literal=database-name=acend_exampledb \
  --from-literal=database-password=mysqlpassword \
  --from-literal=database-root-password=mysqlrootpassword \
  --from-literal=database-user=acend_user \
  --namespace <namespace> \
  --dry-run=client -o yaml > secret_mariadb.yaml
```

Above command has not yet created any resources on our cluster as we used the `--dry-run=client` parameter and redirected the output into the file `secret_mariadb.yaml` .

The reason we haven’t actually created the Secret yet but instead put the resource definition in a file has to do with the way things work at Baloise. The file will help you later. But for now, create the Secret by applying the file’s content:

```
oc apply -f secret_mariadb.yaml
```

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>
```

- acend gmbh

```
apiVersion: v1
data:
  database-name: YWNlbmQtZXhhbXBsZS1kYg==
  database-password: bXlzcWxwYXNzd29yZA==
  database-root-password: bXlzcWxyb290cGFzc3dvcmQ=
  database-user: YWNlbmRfdXNlcg==
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 "YWNlbmQtZXhhbXBsZS1kYg==" | 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.
>
> At Baloise, secrets are managed by HashiCorp Vault and integrated into OpenShift by use of the External Secrets Operator .

We are now going to create a Deployment and a Service. As a first example, we use a database without persistent storage. Only use an ephemeral database for testing purposes as a restart of the Pod leads to data loss. We are going to look at how to persist this data in a persistent volume later on.

In our case we want to create a Deployment and Service for our MariaDB database. Save this snippet as `mariadb.yaml` :

```
apiVersion: v1
kind: Service
metadata:
  name: mariadb
  labels:
    template: mariadb-ephemeral-template
spec:
  ports:
  - name: mariadb
    port: 3306
    protocol: TCP
    targetPort: 3306
  selector:
    app: mariadb
  type: ClusterIP
---
apiVersion: apps/v1
kind: Deployment
metadata:
  name: mariadb
  labels:
    app: mariadb
spec:
  selector:
```

```yaml
    matchLabels:
      app: mariadb
  strategy:
    type: Recreate
  template:
    metadata:
      labels:
        app: mariadb
    spec:
      containers:
        - image: REGISTRY-URL/acend/mariadb-105:1
          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
          livenessProbe:
            tcpSocket:
              port: 3306
          ports:
            - containerPort: 3306
              name: mariadb
          resources:
            limits:
              cpu: 500m
              memory: 512Mi
            requests:
              cpu: 50m
              memory: 128Mi
          volumeMounts:
            - mountPath: /var/lib/mysql/data
              name: mariadb-data
      volumes:
        - emptyDir: {}
          name: mariadb-data
```

Apply it with:

```
oc apply -f mariadb.yaml --namespace <namespace>
```

As soon as the container image has been pulled, you will see a new Pod using `oc get pods` .

The environment variables defined in the deployment configure the MariaDB Pod and how our frontend will be able to access it.

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:

```
...
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_exampledb
```

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.

```
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:

```yaml
        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:

```
...
containers:
- image: REGISTRY-URL/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.

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:

- acend gmbh

```
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/du
mp.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:

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

- acend gmbh

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

Import a dump:

```
mysql -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

- acend gmbh
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 deploy/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 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 loose any data.

9. Additional concepts

OpenShift does not only know Pods, Deployments, Services, etc. There are various other kinds of resources. In the next few labs, we are going to have a look at some of them.

9.1. StatefulSets

Stateless applications or applications with a stateful backend can be described as Deployments. However, sometimes your application has to be stateful. Examples would be an application that needs a static, non-changing hostname every time it starts or a clustered application with a strict start/stop order of its services (e.g. RabbitMQ). These features are offered by StatefulSets.

> **Note**
> This lab does not depend on other labs.

Consistent hostnames

While in normal Deployments a hash-based name of the Pods (also represented as the hostname inside the Pod) is generated, StatefulSets create Pods with preconfigured names. An example of a RabbitMQ cluster with three instances (Pods) could look like this:

```
rabbitmq-0
rabbitmq-1
rabbitmq-2
```

Scaling

Scaling is handled differently in StatefulSets. When scaling up from 3 to 5 replicas in a Deployment, two additional Pods are started at the same time (based on the configuration). Using a StatefulSet, scaling is done serially:

Let’s use our RabbitMQ example again:

1. The StatefulSet is scaled up using: `oc scale deployment rabbitmq --replicas=5 --namespace <namespace>`
2. `rabbitmq-3` is started
3. As soon as Pod `rabbitmq-3` is in `Ready` state the same procedure starts for `rabbitmq-4`

When scaling down, the order is inverted. The highest-numbered Pod will be stopped first. As soon as it has finished terminating the now highest-numbered Pod is stopped. This procedure is repeated as long as the desired number of replicas has not been reached.

Update procedure

During an update of an application with a StatefulSet the highest-numbered Pod will be the first to be updated and only after a successful start the next Pod follows.

1. Highest-numbered Pod is stopped
2. New Pod (with new image tag) is started
3. If the new Pod successfully starts, the procedure is repeated for the second highest-numbered Pod
4. And so on

If the start of a new Pod fails, the update will be interrupted so that the architecture of your application won’t break.

Dedicated persistent volumes

A very convenient feature is that unlike a Deployment a StatefulSet makes it possible to attach a different, dedicated persistent volume to each of its Pods. This is done using a so-called *VolumeClaimTemplate*. This spares you from defining identical Deployments with 1 replica each but different volumes.

Conclusion

The controllable and predictable behavior can be a perfect match for applications such as RabbitMQ or etcd, as you need unique names for such application clusters.

Task 9.1.1: Create a StatefulSet

Create a file named `sts_nginx-cluster.yaml` with the following definition of a StatefulSet:

```
apiVersion: apps/v1
kind: StatefulSet
metadata:
  name: nginx-cluster
spec:
  serviceName: "nginx"
  replicas: 1
  selector:
    matchLabels:
      app: nginx
  template:
    metadata:
      labels:
        app: nginx
    spec:
      containers:
        - name: nginx
          image: REGISTRY-URL/acend/nginx-unprivileged:1.18-alpine
          ports:
            - containerPort: 8080
              name: nginx
          resources:
            limits:
              cpu: 40m
              memory: 64Mi
            requests:
              cpu: 10m
              memory: 32Mi
```

Create the StatefulSet:

```
oc apply -f sts_nginx-cluster.yaml --namespace <namespace>
```

To watch the pods' progress, open a second console and execute the watch command:

```
oc get pods --selector app=nginx -w --namespace <namespace>
```

> **Note**
> Friendly reminder that the `oc get -w` command will never end unless you terminate it with `CTRL-c`.

Task 9.1.2: Scale the StatefulSet

Scale the StatefulSet up:

```
oc scale statefulset nginx-cluster --replicas=3 --namespace <namespace>
```

You can again watch the pods' progress like you did in the first task.

Task 9.1.3: Update the StatefulSet

In order to update the image tag in use in a StatefulSet, you can use the `oc set image` command. Set the StatefulSet's image tag to `latest` :

```
oc set image statefulset nginx-cluster nginx=REGISTRY-URL/acend/nginx-unprivileged:latest --namespace <namespace>
```

Task 9.1.4: Rollback

Imagine you just realized that switching to the `latest` image tag was an awful idea (because it is generally not advisable). Rollback the change:

```
oc rollout undo statefulset nginx-cluster --namespace <namespace>
```

Task 9.1.5: Cleanup

As with every other OpenShift resource you can delete the StatefulSet with:

> **Warning**
> To avoid issues on your personal progress dashboard, we would advise not to delete the StatefulSet from this lab

```
oc delete statefulset nginx-cluster --namespace <namespace>
```

Further information can be found in the Kubernetes' StatefulSet documentation or this published article .

9.2. DaemonSets

A DaemonSet is almost identical to a normal Deployment. The difference is that it makes sure that exactly one Pod is running on every (or some specified) Node. When a new Node is added, the DaemonSet automatically deploys a Pod on the new Node if its selector matches. When the DaemonSet is deleted, all related Pods are deleted.

One obvious use case for a DaemonSet is some kind of agent or daemon to e.g. grab logs from each Node of the cluster (e.g., Fluentd, Logstash or a Splunk forwarder).

More information about DaemonSet can be found in the documentation .

9.3. CronJobs and Jobs

Jobs are different from normal Deployments: Jobs execute a time-constrained operation and report the result as soon as they are finished; think of a batch job. To achieve this, a Job creates a Pod and runs a defined command. A Job isn't limited to creating a single Pod, it can also create multiple Pods. When a Job is deleted, the Pods started (and stopped) by the Job are also deleted.

For example, a Job is used to ensure that a Pod is run until its completion. If a Pod fails, for example because of a Node error, the Job starts a new one. A Job can also be used to start multiple Pods in parallel.

More detailed information can be retrieved from the OpenShift documentation .

> **Note**
> This lab depends on *7. Attaching a database* or *8. Persistent storage*.

Task 9.3.1: Create a Job for a database dump

Similar to the task to import a database dump , we now want to create a dump of the running database, but without the need of interactively logging into the Pod.

Let’s first look at the Job resource that we want to create.

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: database-dump
spec:
  template:
    spec:
      containers:
      - name: mariadb
        image: REGISTRY-URL/acend/mariadb-105:1
        command:
        - 'bash'
        - '-eo'
        - 'pipefail'
        - '-c'
        - >
          trap "echo Backup failed; exit 0" ERR;
          FILENAME=backup-${MYSQL_DATABASE}-`date +%Y-%m-%d_%H%M%S`.sql.gz;
          mysqldump --user=${MYSQL_USER} --password=${MYSQL_PASSWORD} --host=${MYSQL_HOST} --port=${MYSQL_PORT} --skip-lock-tables --quick --add-drop-database --routines ${MYSQL_DATABASE} | gzip > /tmp/$FILENAME;
          echo "";
          echo "Backup successful"; du -h /tmp/$FILENAME;
        env:
        - name: MYSQL_DATABASE
          valueFrom:
            secretKeyRef:
              key: database-name
              name: mariadb
        - name: MYSQL_USER
          valueFrom:
            secretKeyRef:
              key: database-user
              name: mariadb
        - name: MYSQL_HOST
          value: mariadb
        - name: MYSQL_PORT
          value: "3306"
        - name: MYSQL_PASSWORD
          valueFrom:
            secretKeyRef:
              key: database-password
              name: mariadb
        resources:
          limits:
            cpu: 100m
            memory: 128Mi
          requests:
            cpu: 20m
            memory: 64Mi
      restartPolicy: Never
```

The parameter `.spec.template.spec.containers[0].image` shows that we use the same image as the running database. In contrast to the database Pod, we don't start a database afterwards, but run a `mysqldump` command, specified with `.spec.template.spec.containers[0].command`. To perform the dump, we use the environment variables of the database deployment to set the hostname, user and password parameters of the `mysqldump` command. The `MYSQL_PASSWORD` variable refers to the value of the secret, which is already used for the database Pod. This way we ensure that the dump is performed with the same credentials.

Let's create our Job: Create a file named `job_database-dump.yaml` with the content above and execute the following command:

```
oc apply -f ./job_database-dump.yaml --namespace <namespace>
```

Check if the Job was successful:

```
oc describe jobs/database-dump --namespace <namespace>
```

The executed Pod can be shown as follows:

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

To show all Pods belonging to a Job in a human-readable format, the following command can be used:

```
oc get pods --selector=job-name=database-dump --output=go-template="{{range .items}}{{.metadata.name}}{{end}}" --namesp
ace <namespace>
```

CronJobs

A CronJob is nothing else than a resource which creates a Job at a defined time, which in turn starts (as we saw in the previous section) a Pod to run a command. Typical use cases are cleanup Jobs, which tidy up old data for a running Pod, or a Job to regularly create and save a database dump as we just did during this lab.

The CronJob's definition will remind you of the Deployment's structure, or really any other control resource. There's most importantly the `schedule` specification in [cron schedule format](), some more things you could define and then the Job's definition itself that is going to be created by the CronJob:

```yaml
apiVersion: batch/v1
kind: CronJob
metadata:
  name: database-dump
spec:
  schedule: "5 4 * * *"
  concurrencyPolicy: "Replace"
  startingDeadlineSeconds: 200
  successfulJobsHistoryLimit: 3
  failedJobsHistoryLimit: 1
  jobTemplate:
    spec:
      template:
        spec:
          containers:
          - name: mariadb
            ...
```

Further information can be found in the OpenShift CronJob documentation .

9.4. ConfigMaps

Similar to environment variables, *ConfigMaps* allow you to separate the configuration for an application from the image. Pods can access those variables at runtime which allows maximum portability for applications running in containers. In this lab, you will learn how to create and use ConfigMaps.

ConfigMap creation

A ConfigMap can be created using the `oc create configmap` command as follows:

```
oc create configmap <name> <data-source> --namespace <namespace>
```

Where the `<data-source>` can be a file, directory, or command line input.

Task 9.4.1: Java properties as ConfigMap

A classic example for ConfigMaps are properties files of Java applications which can't be configured with environment variables.

First, create a file called `java.properties` with the following content:

```
key=value
key2=value2
```

Now you can create a ConfigMap based on that file:

```
oc create configmap javaconfiguration --from-file=./java.properties --namespace <namespace>
```

Verify that the ConfigMap was created successfully:

```
oc get configmaps --namespace <namespace>
```

```
NAME                  DATA   AGE
javaconfiguration     1      7s
```

Have a look at its content:

```
oc get configmap javaconfiguration -o yaml --namespace <namespace>
```

Which should yield output similar to this one:

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: javaconfiguration
data:
  java.properties: |
    key=value
    key2=value2
```

Task 9.4.2: Attach the ConfigMap to a container

Next, we want to make a ConfigMap accessible for a container. There are basically the following possibilities to achieve this :

- ConfigMap properties as environment variables in a Deployment
- Command line arguments via environment variables
- Mounted as volumes in the container

In this example, we want the file to be mounted as a volume inside the container.

As in *8. Persistent storage*, we can use the `oc set volume` command to achieve this:

> **Note**
> If you are using Windows and your shell uses the POSIX-to-Windows path conversion, remember to prepend your command with `MSYS_NO_PATHCONV=1` if the resulting mount path was mistakenly converted.

```
oc set volume deploy/example-web-app --add --configmap-name=javaconfiguration --mount-path=/etc/config --name=config-vo
lume --type configmap --namespace <namespace>
```

> **Note**
> This task doesn't have any effect on the example application inside the container. It is for demonstration purposes only.

- acend gmbh
This results in the addition of the following parts to the Deployment (check with `oc get deploy example-web-app -o yaml`):

```
...
  volumeMounts:
  - mountPath: /etc/config
    name: config-volume
...
volumes:
- configMap:
    defaultMode: 420
    name: javaconfiguration
  name: config-volume
...
```

This means that the container should now be able to access the ConfigMap’s content in `/etc/config/java.properties` . Let’s check:

```
oc exec <pod> --namespace <namespace> -- cat /etc/config/java.properties
```

> **Note**
> On Windows, you can use Git Bash with `winpty oc exec -it <pod> --namespace <namespace> -- cat //etc/config/java.properties`.

```
key=value
key2=value2
```

Like this, the property file can be read and used by the application inside the container. The image stays portable to other environments.

Task 9.4.3: ConfigMap environment variables

Use a ConfigMap by [populating environment variables into the container](#) instead of a file.

9.5. ResourceQuotas and LimitRanges

In this lab, we are going to look at ResourceQuotas and LimitRanges. As OpenShift users, we are most certainly going to encounter the limiting effects that ResourceQuotas and LimitRanges impose.

> **Warning**
> For this lab to work it is vital that you use the namespace `<username>-quota-test` !

ResourceQuotas

ResourceQuotas among other things limit the amount of resources Pods can use in a Namespace. They can also be used to limit the total number of a certain resource type in a Project. In more detail, there are these

- acend gmbh
kinds of quotas:

- *Compute ResourceQuotas* can be used to limit the amount of memory and CPU
- *Storage ResourceQuotas* can be used to limit the total amount of storage and the number of PersistentVolumeClaims, generally or specific to a StorageClass
- *Object count quotas* can be used to limit the number of a certain resource type such as Services, Pods or Secrets

Defining ResourceQuotas makes sense when the cluster administrators want to have better control over consumed resources. A typical use case are public offerings where users pay for a certain guaranteed amount of resources which must not be exceeded.

In order to check for defined quotas in your Namespace, simply see if there are any of type ResourceQuota:

```
oc get resourcequota --namespace <namespace>-quota
```

To show in detail what kinds of limits the quota imposes:

```
oc describe resourcequota <quota-name> --namespace <namespace>-quota
```

For more details, have look into OpenShift's documentation about resource quotas .

Requests and limits

As we've already seen, compute ResourceQuotas limit the amount of memory and CPU we can use in a Project. Only defining a ResourceQuota, however is not going to have an effect on Pods that don't define the amount of resources they want to use. This is where the concept of limits and requests comes into play.

Limits and requests on a Pod, or rather on a container in a Pod, define how much memory and CPU this container wants to consume at least (request) and at most (limit). Requests mean that the container will be guaranteed to get at least this amount of resources, limits represent the upper boundary which cannot be crossed. Defining these values helps OpenShift in determining on which Node to schedule the Pod because it knows how many resources should be available for it.

> **Note**
> Containers using more CPU time than what their limit allows will be throttled. Containers using more memory than what they are allowed to use will be killed.

Defining limits and requests on a Pod that has one container looks like this:

```
apiVersion: v1
kind: Pod
metadata:
  name: lr-demo
  namespace: lr-example
spec:
  containers:
  - name: lr-demo-ctr
    image: REGISTRY-URL/acend/nginx-unprivileged:latest
    resources:
      limits:
        memory: "200Mi"
        cpu: "700m"
      requests:
        memory: "200Mi"
        cpu: "700m"
```

You can see the familiar binary unit “Mi” is used for the memory value. Other binary (“Gi”, “Ki”, …) or decimal units (“M”, “G”, “K”, …) can be used as well.

The CPU value is denoted as “m”. “m” stands for *millicpu* or sometimes also referred to as *millicores* where `"1000m"` is equal to one core/vCPU/hyperthread.

Quality of service

Setting limits and requests on containers has yet another effect: It might change the Pod’s *Quality of Service* class. There are three such *QoS* classes:

- *Guaranteed*
- *Burstable*
- *BestEffort*

The Guaranteed QoS class is applied to Pods that define both limits and requests for both memory and CPU resources on all their containers. The most important part is that each request has the same value as the limit. Pods that belong to this QoS class will never be killed by the scheduler because of resources running out on a Node.

> **Note**
> If a container only defines its limits, OpenShift automatically assigns a request that matches the limit.

The Burstable QoS class means that limits and requests on a container are set, but they are different. It is enough to define limits and requests on one container of a Pod even though there might be more, and it also only has to define limits and requests on memory or CPU, not necessarily both.

The BestEffort QoS class applies to Pods that do not define any limits and requests at all on any containers. As its class name suggests, these are the kinds of Pods that will be killed by the scheduler first if a Node runs out of memory or CPU. As you might have already guessed by now, if there are no BestEffort QoS Pods, the scheduler will begin to kill Pods belonging to the class of *Burstable*. A Node hosting only Pods of class Guaranteed will (theoretically) never run out of resources.

LimitRanges

As you now know what limits and requests are, we can come back to the statement made above:

> As we’ve already seen, compute ResourceQuotas limit the amount of memory and CPU we can use in a Namespace. Only defining a ResourceQuota, however is not going to have an effect on Pods that don’t define the amount of resources they want to use. This is where the concept of limits and requests comes

- acend gmbh
  into play.

So, if a cluster administrator wanted to make sure that every Pod in the cluster counted against the compute ResourceQuota, the administrator would have to have a way of defining some kind of default limits and requests that were applied if none were defined in the containers. This is exactly what *LimitRanges* are for.

Quoting the [Kubernetes documentation](), LimitRanges can be used to:

- Enforce minimum and maximum compute resource usage per Pod or container in a Namespace
- Enforce minimum and maximum storage requests per PersistentVolumeClaim in a Namespace
- Enforce a ratio between request and limit for a resource in a Namespace
- Set default request/limit for compute resources in a Namespace and automatically inject them to containers at runtime

If for example a container did not define any requests or limits and there was a LimitRange defining the default values, these default values would be used when deploying said container. However, as soon as limits or requests were defined, the default values would no longer be applied.

The possibility of enforcing minimum and maximum resources and defining ResourceQuotas per Namespace allows for many combinations of resource control.

Task 9.5.1: Namespace

> **Warning**
> Remember to use the namespace `<username>-quota-test`, otherwise this lab will not work!

Analyse the LimitRange in your Namespace (there has to be one, if not you are using the wrong Namespace):

```
oc describe limitrange --namespace <namespace>-quota
```

The command above should output this (name and Namespace will vary):

```
Name:       ce01a1b6-a162-479d-847c-4821255cc6db
Namespace:  eltony-quota-lab
Type        Resource  Min  Max  Default Request  Default Limit  Max Limit/Request Ratio
----        --------  ---  ---  ---------------  -------------  -----------------------
Container   memory    -    -    16Mi             32Mi           -
Container   cpu       -    -    10m              100m           -
```

Check for the ResourceQuota in your Namespace (there has to be one, if not you are using the wrong Namespace):

```
oc describe quota --namespace <namespace>-quota
```

The command above will produce an output similar to the following (name and namespace may vary)

```
Name:            lab-quota
Namespace:       eltony-quota-lab
Resource         Used  Hard
--------         ----  ----
requests.cpu     0     100m
requests.memory  0     100Mi
```

Task 9.5.2: Default memory limit

Create a Pod using the stress image:

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: stress2much
spec:
  containers:
    - command:
        - stress
        - --vm
        - "1"
        - --vm-bytes
        - 85M
        - --vm-hang
        - "1"
      image: REGISTRY-URL/acend/stress:latest
      imagePullPolicy: Always
      name: stress
```

Apply this resource with:

```
oc apply -f pod_stress2much.yaml --namespace <namespace>-quota
```

Note

You have to actively terminate the following command pressing `CTRL+c` on your keyboard.

Watch the Pod's creation with:

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

You should see something like the following:

```
NAME          READY   STATUS              RESTARTS   AGE
stress2much   0/1     ContainerCreating   0          1s
stress2much   0/1     ContainerCreating   0          2s
stress2much   0/1     OOMKilled           0          5s
stress2much   1/1     Running             1          7s
stress2much   0/1     OOMKilled           1          9s
stress2much   0/1     CrashLoopBackOff    1          20s
```

The `stress2much` Pod was OOM (out of memory) killed. We can see this in the `STATUS` field. Another way to find out why a Pod was killed is by checking its status. Output the Pod's YAML definition:

```
oc get pod stress2much --output yaml --namespace <namespace>-quota
```

Near the end of the output you can find the relevant status part:

```
  containerStatuses:
  - containerID: docker://da2473f1c8ccdffbb824d03689e9fe738ed689853e9c2643c37f206d10f93a73
    image: REGISTRY-URL/acend/stress:latest
    lastState:
      terminated:
        ...
        reason: OOMKilled
        ...
```

So let's look at the numbers to verify the container really had too little memory. We started the `stress` command using the parameter `--vm-bytes 85M` which means the process wants to allocate 85 megabytes of memory. Again looking at the Pod's YAML definition with:

```
oc get pod stress2much --output yaml --namespace <namespace>-quota
```

reveals the following values:

```
...
    resources:
      limits:
        cpu: 100m
        memory: 32Mi
      requests:
        cpu: 10m
        memory: 16Mi
...
```

These are the values from the LimitRange, and the defined limit of 32 MiB of memory prevents the `stress` process of ever allocating the desired 85 MB.

Let's fix this by recreating the Pod and explicitly setting the memory request to 85 MB.

First, delete the `stress2much` pod with:

```
oc delete pod stress2much --namespace <namespace>-quota
```

Then create a new Pod where the requests and limits are set:

- acend gmbh

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: stress
spec:
  containers:
    - command:
        - stress
        - --vm
        - "1"
        - --vm-bytes
        - 85M
        - --vm-hang
        - "1"
      image: REGISTRY-URL/acend/stress:latest
      imagePullPolicy: Always
      name: stress
      resources:
        limits:
          cpu: 100m
          memory: 100Mi
        requests:
          cpu: 10m
          memory: 85Mi
```

And apply this again with:

```
oc apply -f pod_stress.yaml --namespace <namespace>-quota
```

> **Note**
> Remember, if you only set the limit, the request will be set to the same value.

You should now see that the Pod is successfully running:

```
NAME     READY   STATUS    RESTARTS   AGE
stress   1/1     Running   0          25s
```

Task 9.5.3: Hitting the quota

Create another Pod, again using the `stress` image. This time our application is less demanding and only needs 10 MB of memory (`--vm-bytes 10M`):

Create a new Pod resource with:

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: overbooked
spec:
  containers:
    - command:
        - stress
        - --vm
        - "1"
        - --vm-bytes
        - 10M
        - --vm-hang
        - "1"
      image: REGISTRY-URL/acend/stress:latest
      imagePullPolicy: Always
      name: overbooked
```

```
oc apply -f pod_overbooked.yaml --namespace <namespace>-quota
```

We are immediately confronted with an error message:

```
Error from server (Forbidden): pods "overbooked" is forbidden: exceeded quota: lab-quota, requested: memory=16Mi, used:
 memory=85Mi, limited: memory=100Mi
```

The default request value of 16 MiB of memory that was automatically set on the Pod lets us hit the quota which in turn prevents us from creating the Pod.

Let’s have a closer look at the quota with:

```
oc get quota --output yaml --namespace <namespace>-quota
```

which should output the following YAML definition:

```
...
  status:
    hard:
      cpu: 100m
      memory: 100Mi
    used:
      cpu: 20m
      memory: 80Mi
...
```

The most interesting part is the quota’s status which reveals that we cannot use more than 100 MiB of memory and that 80 MiB are already used.

Fortunately, our application can live with less memory than what the LimitRange sets. Let’s set the request to the remaining 10 MiB:

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: overbooked
spec:
  containers:
    - command:
        - stress
        - --vm
        - "1"
        - --vm-bytes
        - 10M
        - --vm-hang
        - "1"
      image: REGISTRY-URL/acend/stress:latest
      imagePullPolicy: Always
      name: overbooked
      resources:
        limits:
          cpu: 100m
          memory: 50Mi
        requests:
          cpu: 10m
          memory: 10Mi
```

And apply with:

```
oc apply -f pod_overbooked.yaml --namespace <namespace>-quota
```

Even though the limits of both Pods combined overstretch the quota, the requests do not and so the Pods are allowed to run.

9.6. Init containers

A Pod can have multiple containers running apps within it, but it can also have one or more *init containers*, which are run before the app container is started.

Init containers are exactly like regular containers, except:

- Init containers always run to completion.
- Each init container must complete successfully before the next one starts.

Check out the [Init Containers documentation]() for more details.

Task 9.6.1: Add an init container

In *7. Attaching a database* you created the `example-web-app` application. In this task, you are going to add an init container which checks if the MariaDB database is ready to be used before actually starting your example application.

Edit your existing `example-web-app` Deployment by changing your local `deployment_example-web-app.yaml`. Add the init container into the existing Deployment (same indentation level as containers):

```
...
    spec:
      initContainers:
        - name: wait-for-db
          image: REGISTRY-URL/acend/busybox:1.28
          command:
            [
              "sh",
              "-c",
              "until nslookup mariadb.$(cat /var/run/secrets/kubernetes.io/serviceaccount/namespace).svc.cluster.local;
 do echo waiting for mydb; sleep 2; done",
            ]
...
```

And then apply again with:

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

Note

This obviously only checks if there is a DNS Record for your MariaDB Service and not if the database is ready. But you get the idea, right?

Let’s see what has changed by analyzing your newly created `example-web-app` Pod with the following command (use `oc get pod` or auto-completion to get the Pod name):

```
oc describe pod <pod> --namespace <namespace>
```

You see the new init container with the name `wait-for-db` :

```
...
Init Containers:
  wait-for-db:
    Container ID:  docker://77e6e309c88cfe62d03ed97e8fae20704bbf547a1e717a8f699ba79d9879cca2
    Image:         busybox
    Image ID:      docker-pullable://busybox@sha256:141c253bc4c3fd0a201d32dc1f493bcf3fff003b6df416dea4f41046e0f37d47
    Port:          <none>
    Host Port:     <none>
    Command:
      sh
      -c
      until nslookup mariadb.$(cat /var/run/secrets/kubernetes.io/serviceaccount/namespace).svc.cluster.local; do echo
waiting for mydb; sleep 2; done
    State:          Terminated
      Reason:       Completed
      Exit Code:    0
      Started:      Tue, 10 Nov 2020 21:00:24 +0100
      Finished:     Tue, 10 Nov 2020 21:02:52 +0100
    Ready:          True
    Restart Count:  0
    Environment:    <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from default-token-xz2b7 (ro)
...
```

The init container has the `State: Terminated` and an `Exit Code: 0` which means it was successful. That’s what we wanted, the init container was successfully executed before our main application.

You can also check the logs of the init container with:

```
oc logs -c wait-for-db <pod> --namespace <namespace>
```

Which should give you something similar to:

```
Server:    10.43.0.10
Address 1: 10.43.0.10 kube-dns.kube-system.svc.cluster.local

Name:      mariadb.acend-test.svc.cluster.local
Address 1: 10.43.243.105 mariadb.acend-test.svc.cluster.local
```

Deployment hooks on OpenShift

A similar concept are the so-called pre and post deployment hooks. Those hooks basically give the possibility to execute Pods before and after a deployment is in progress.

Check out the official documentation for further information.

9.7. Sidecar containers

Let’s first have another look at the Pod’s description on the Kubernetes documentation page :

> A Pod (as in a pod of whales or pea pod) is a group of one or more containers (such as Docker containers), with shared storage/network, and a specification for how to run the containers. A Pod’s contents are always co-located and co-scheduled, and run in a shared context. A Pod models an application-specific “logical host” - it contains one or more application containers which are relatively tightly coupled — in a pre-container world, being executed on the same physical or virtual machine would mean being executed on the same logical host. The shared context of a Pod is a set of Linux namespaces, cgroups, and potentially other facets of isolation - the same things that isolate a Docker container. Within a Pod’s context, the individual applications may have further sub-isolations applied.

A sidecar container is a utility container in the Pod. Its purpose is to support the main container. It is important to note that the standalone sidecar container does not serve any purpose, it must be paired with one or more main containers. Generally, sidecar containers are reusable and can be paired with numerous types of main containers.

In a sidecar pattern, the functionality of the main container is extended or enhanced by a sidecar container without strong coupling between the two. Although it is always possible to build sidecar container functionality into the main container, there are several benefits with this pattern:

- Different resource profiles, i.e. independent resource accounting and allocation
- Clear separation of concerns at packaging level, i.e. no strong coupling between containers
- Reusability, i.e., sidecar containers can be paired with numerous “main” containers
- Failure containment boundary, making it possible for the overall system to degrade gracefully
- Independent testing, packaging, upgrade, deployment and if necessary rollback

Task 9.7.1: Add a Prometheus MySQL exporter as a sidecar

In *8. Persistent storage* you created a MariaDB deployment. In this task you are going to add the Prometheus MySQL exporter to it.

Change the existing `mariadb` Deployment using by first editing your local `mariadb.yaml` file. Add a new (sidecar) container into your Deployment:

And add a new (sidecar) container to it:

```
    containers:
      - ...
      - image: REGISTRY-URL/acend/mysqld-exporter:latest-2023.06.17-00.13.04
        name: mysqld-exporter
        env:
        - name: MYSQL_DATABASE_ROOT_PASSWORD
          valueFrom:
            secretKeyRef:
              key: database-root-password
              name: mariadb
        - name: DATA_SOURCE_NAME
          value: root:$(MYSQL_DATABASE_ROOT_PASSWORD)@(localhost:3306)/
    ...
```

and then apply the change with:

```
oc apply -f mariadb.yaml --namespace <namespace>
```

Your Pod now has two running containers. Verify this with:

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

The output should look similar to this:

```
NAME                         READY   STATUS    RESTARTS   AGE
mariadb-65559644c9-cdjjk     2/2     Running   0          5m35s
```

Note the `READY` column which shows you 2 ready containers.

You can get the logs from the mysqld-exporter with:

```
oc logs <pod> -c mysqld-exporter --namespace <namespace>
```

Which gives you an output similar to this:

```
time="2020-05-10T11:31:02Z" level=info msg="Starting mysqld_exporter (version=0.12.1, branch=HEAD, revision=48667bf7c3b
438b5e93b259f3d17b70a7c9aff96)" source="mysqld_exporter.go:257"
time="2020-05-10T11:31:02Z" level=info msg="Build context (go=go1.12.7, user=root@0b3e56a7bc0a, date=20190729-12:35:58)
" source="mysqld_exporter.go:258"
time="2020-05-10T11:31:02Z" level=info msg="Enabled scrapers:" source="mysqld_exporter.go:269"
time="2020-05-10T11:31:02Z" level=info msg=" --collect.global_variables" source="mysqld_exporter.go:273"
time="2020-05-10T11:31:02Z" level=info msg=" --collect.slave_status" source="mysqld_exporter.go:273"
time="2020-05-10T11:31:02Z" level=info msg=" --collect.global_status" source="mysqld_exporter.go:273"
time="2020-05-10T11:31:02Z" level=info msg=" --collect.info_schema.query_response_time" source="mysqld_exporter.go:273"
time="2020-05-10T11:31:02Z" level=info msg=" --collect.info_schema.innodb_cmp" source="mysqld_exporter.go:273"
time="2020-05-10T11:31:02Z" level=info msg=" --collect.info_schema.innodb_cmpmem" source="mysqld_exporter.go:273"
time="2020-05-10T11:31:02Z" level=info msg="Listening on :9104" source="mysqld_exporter.go:283"
```

By using the `port-forward` subcommand, you can even have a look at the Prometheus metrics:

```
oc port-forward <pod> 9104 --namespace <namespace>
```

And then use `curl` to check the mysqld_exporter metrics with:

```
curl http://localhost:9104/metrics
```

10. Deployment strategies

> **Note**
> This lab is optional.

In this lab, we are going to have a look at the different Deployment strategies.

This document should give you a good start. For more details, have a look at the examples or use this demo in which the different strategies are implemented as Helm charts.

Task 10.1: Apply deployment strategies

Apply some deployment strategies to the example from the Scaling .

11. Helm

Helm is a Cloud Native Foundation project to define, install and manage applications in Kubernetes.

tl;dr

Helm is a Package Manager for Kubernetes

- package multiple K8s resources into a single logical deployment unit
- … but it’s not just a Package Manager

- acend gmbh
Helm is a Deployment Management for Kubernetes

- do a repeatable deployment
- manage dependencies: reuse and share
- manage multiple configurations
- update, rollback and test application deployments

11.1. Helm overview

Ok, let's start with Helm. First, you have to understand the following 3 Helm concepts: **Chart**, **Repository** and **Release**.

A **Chart** is a Helm package. It contains all of the resource definitions necessary to run an application, tool, or service inside of a Kubernetes cluster. Think of it like the Kubernetes equivalent of a Homebrew formula, an Apt dpkg, or a Yum RPM file.

A **Repository** is the place where charts can be collected and shared. It's like Perl's CPAN archive or the Fedora Package Database, but for Kubernetes packages.

A **Release** is an instance of a chart running in a Kubernetes cluster. One chart can often be installed many times in the same cluster. Each time it is installed, a new release is created. Consider a MySQL chart. If you want two databases running in your cluster, you can install that chart twice. Each one will have its own release, which will in turn have its own release name.

With these concepts in mind, we can now explain Helm like this:

> Helm installs charts into Kubernetes, creating a new release for each installation. To find new charts, you can search Helm chart repositories.

11.2. CLI installation

This guide shows you how to install the `helm` CLI tool. `helm` can be installed either from source or from pre-built binary releases. We are going to use the pre-built releases. `helm` binaries can be found on [Helm's release page](#) for the usual variety of operating systems.

> **Warning**
> If you do this training in our acend web based environment, no installation is required.

Task 11.2.1: Install CLI

Install the CLI for your **Operating System**

1. [Download the latest release](#)
2. Unpack it (e.g. `tar -zxvf <filename>`)
3. Copy to the correct location
   - Linux: Find the `helm` binary in the unpacked directory and move it to its desired destination (e.g. `mv linux-amd64/helm ~/.local/bin/`)
     - The desired destination should be listed in your $PATH environment variable (`echo $PATH`)
   - macOS: Find the `helm` binary in the unpacked directory and move it to its desired destination (e.g. `mv darwin-amd64/helm ~/bin/`)
     - The desired destination should be listed in your $PATH environment variable (`echo $PATH`)
   - Windows: Find the `helm` binary in the unpacked directory and move it to its desired destination
     - The desired destination should be listed in your $PATH environment variable (`echo $PATH`)

Task 11.2.2: Verify

To verify, run the following command and check if `Version` is what you expected:

```
helm version
```

The output is similar to this:

```
version.BuildInfo{Version:"v3.10.1", GitCommit:"9f88ccb6aee40b9a0535fcc7efea6055e1ef72c9", GitTreeState:"clean", GoVersion:"go1.18.7"}
```

From here on you should be able to run the client.

11.3. Generic Chart setup

In the following labs we are going to create our first Helm Charts with the help of Baloise's Generic Chart and deploy them.

Baloise's Generic Helm Chart is meant as a template and easy starting point to deploy common Kubernetes resource manifests. By declaring the Generic Chart as a dependency of your own Chart, you can make use of all the features the Generic Chart offers.

Task 11.3.1: Setup the dependency

So first, let's create your own Chart. Open your favorite terminal and make sure you're in the workspace for this lab, e.g. `cd ~/<workspace-kubernetes-training>` :

```
helm create mychart
```

You will now find a `mychart` directory with the newly created chart. It already is a valid and fully functional Chart which deploys an nginx instance. However, instead of using these generated templates and values, we want to use the Generic Chart. Change into your Chart's directory and remove the generated templates:

```
cd mychart/
rm -r templates/
```

Before we declare the Generic Chart as a dependency, have a look at the generated `Chart.yaml` using your favorite text editor:

```
vim Chart.yaml
```

As you can see, the `Chart.yaml` defines the metadata for your chart, so feel free to change anything.

- acend gmbh
Also note that the `version` and `appVersion` values are different. This is because the `version` field refers to the Helm Chart's version while the `appVersion` refers to the application's version that's deployed using this Chart.

In order to declare the Generic Chart as a dependency, add the following lines to your `Chart.yaml` :

```yaml
dependencies:
  - name:  generic-chart
    version: 3.13.0
    repository: https://CHART-REPOSITORY-URL/shared/release/
    alias: first-example-app
```

Save and close the file. You can check if you added the dependency correctly be executing:

```
helm dependency list
```

Above command should show you the dependency:

```
helm dependency list
NAME          VERSION REPOSITORY                                              STATUS
generic-chart  3.13.0   https://CHART-REPOSITORY-URL/shared/release/    missing
```

Note the `STATUS` field and its `missing` value. This is because the dependency has not yet been downloaded. Let's change this, execute:

```
helm dependency update
```

Note that `helm dependency list` now shows `ok` under `STATUS` and the `charts/` directory contains a gzipped tarball.

11.4. A first example using the Generic Chart

You're now all set to begin with a first example!

Task 11.4.1: Create a `values.yaml` file

Still inside your `mychart` Helm Chart directory, open the already existing `values.yaml` file. Inside you'll find a host of defined parameters. Delete them all.

Instead, fill in the following content:

- acend gmbh

```yaml
first-example-app:
  replicaCount: 1
  image:
    repository: REGISTRY-URL/example/nginx-sample
    tag: latest
    pullPolicy: IfNotPresent
  ingress:
    controller: Route
    clusterName: CLUSTER-NAME
  network:
    http:
      servicePort: 8080
      ingress:
        clusterName: CLUSTER-NAME
  readinessProbe:
    httpGet:
      path: /
      port: 8080
    initialDelaySeconds: 5
    timeoutSeconds: 1
  resources:
    requests:
      cpu: 10m
      memory: 16Mi
    limits:
      cpu: 200m
      memory: 32Mi
```

Task 11.4.2: A first test

Before applying anything to the cluster, you should test if the current values have the desired effect. In order to do so, execute the following command:

> **Note**
> Don't forget to replace `<username>`.

```
helm template my-first-release-<username> .
```

Executing above command will output the rendered templates from the Generic Chart with the values you defined inside `values.yaml` . Check what would be created and if the values are correct.

Task 11.4.3: Install the chart

If you are satisfied with the output, install the release on the cluster:

> **Note**
> Don't forget to replace `<username>` and `<namespace>`.

```
helm install my-first-release-<username> . --namespace <namespace>
```

You should get the following output:

- acend gmbh

```
NAME: my-first-release-<username>
LAST DEPLOYED: Tue Nov 22 16:40:01 2022
NAMESPACE: <namespace>
STATUS: deployed
REVISION: 1
TEST SUITE: None
```

Congratulations! You successfully deployed your first app using Helm!

You should now see a freshly created pod and a route inside your namespace. Check the route's URL and open it in your browser. A mountainous view and welcome message should greet you.

11.5. Generic Chart usage

You have now seen how to set up and use the Generic Chart. Now it's your turn!

Task 11.5.1: Setup

Repeat the steps from *11.3. Generic Chart setup* in order to create a new Chart.

> **Note**
> Note the `alias:` line inside `Chart.yaml`. You can change this value to whatever you'd like, but you need to use the same name as first line inside your `values.yaml` !
>
> This is also how you can use the Generic Chart multiple times if you have more than one app/component.

Task 11.5.2: example-web-app

Implement the example-web-app application from lab *5. Scaling* using the Generic Chart.

> **Note**
> Have a look at the Chart's documentation in its git repository or in the Baloise documentation site for all the available values.

Task 11.5.3: Your own applications

Do you have applications of your own? Deploy them using the Generic Chart!

12. Kustomize

> **Note**
> This lab is optional.

Kustomize is a tool to manage YAML configurations for Kubernetes objects in a declarative and reusable manner. In this lab, we will use Kustomize to deploy the same app for two different environments.

Installation

Kustomize can be used in two different ways:

- As a standalone `kustomize` binary, downloadable from [kubernetes.io]
- With the parameter `--kustomize` or `-k` in certain `oc` subcommands such as `apply` or `create`

> **Note**
> You might get a different behaviour depending on which variant you use. The reason for this is that the version built into `oc` is usually older than the standalone binary.

Usage

The main purpose of Kustomize is to build configurations from a predefined file structure (which will be introduced in the next section):

```
kustomize build <dir>
```

The same can be achieved with `oc` :

```
oc kustomize <dir>
```

The next step is to apply this configuration to the OpenShift cluster:

```
kustomize build <dir> | oc apply -f -
```

Or in one `oc` command with the parameter `-k` instead of `-f` :

```
oc apply -k <dir>
```

Task 12.1: Prepare a Kustomize config

We are going to deploy a simple application:

- The Deployment starts an application based on nginx
- A Service exposes the Deployment
- The application will be deployed for two different example environments, integration and production

Kustomize allows inheriting Kubernetes configurations. We are going to use this to create a base configuration and then override it for the different environments. Note that Kustomize does not use templating. Instead, smart patch and extension mechanisms are used on plain YAML manifests to keep things as simple as possible.

Get the example config

Find the needed resource files inside the folder `content/en/docs/kustomize/kustomize` of the techlab github repository. Clone the repository or get the content as zip

Change to the folder `content/en/docs/kustomize/kustomize` to execute the kustomize commands.

> **Note**
>
> Commands for git checkout and folder switch:
>
> ```
> git clone https://github.com/acend/kubernetes-basics-training.git
> cd kubernetes-basics-training/content/en/docs/kustomize/kustomize/
> ```

File structure

The structure of a Kustomize configuration typically looks like this:

```
.
├── base
│   ├── deployment.yaml
│   ├── kustomization.yaml
│   └── service.yaml
└── overlays
    ├── production
    │   ├── deployment-patch.yaml
    │   ├── kustomization.yaml
    │   └── service-patch.yaml
    └── staging
        ├── deployment-patch.yaml
        ├── kustomization.yaml
        └── service-patch.yaml
```

Base

Let’s have a look at the `base` directory first which contains the base configuration. There’s a `deployment.yaml` with the following content:

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: kustomize-app
spec:
  selector:
    matchLabels:
      app: kustomize-app
  template:
    metadata:
      labels:
        app: kustomize-app
    spec:
      containers:
        - name: kustomize-app
          image: quay.io/acend/example-web-go
          env:
            - name: APPLICATION_NAME
              value: app-base
          command:
            - sh
            - -c
            - |-
              set -e
              /bin/echo "My name is $APPLICATION_NAME"
              /usr/local/bin/go
          ports:
            - name: http
              containerPort: 80
              protocol: TCP
```

There’s also a Service for our Deployment in the corresponding `base/service.yaml` :

```yaml
apiVersion: v1
kind: Service
metadata:
  name: kustomize-app
spec:
  ports:
    - port: 80
      targetPort: 80
  selector:
    app: kustomize-app
```

And there’s an additional `base/kustomization.yaml` which is used to configure Kustomize:

```yaml
resources:
  - service.yaml
  - deployment.yaml
```

It references the previous manifests `service.yaml` and `deployment.yaml` and makes them part of our base configuration.

Overlays

Now let’s have a look at the other directory which is called `overlays` . It contains two subdirectories `staging` and `production` which both contain a `kustomization.yaml` with almost the same content.

`overlays/staging/kustomization.yaml` :

```yaml
nameSuffix: -staging
bases:
  - ../../base
patchesStrategicMerge:
  - deployment-patch.yaml
  - service-patch.yaml
```

`overlays/production/kustomization.yaml` :

```yaml
nameSuffix: -production
bases:
  - ../../base
patchesStrategicMerge:
  - deployment-patch.yaml
  - service-patch.yaml
```

Only the first key `nameSuffix` differs.

In both cases, the `kustomization.yaml` references our base configuration. However, the two directories contain two different `deployment-patch.yaml` files which patch the `deployment.yaml` from our base configuration.

`overlays/staging/deployment-patch.yaml` :

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: kustomize-app
spec:
  selector:
    matchLabels:
      app: kustomize-app-staging
  template:
    metadata:
      labels:
        app: kustomize-app-staging
    spec:
      containers:
        - name: kustomize-app
          env:
            - name: APPLICATION_NAME
              value: kustomize-app-staging
```

`overlays/production/deployment-patch.yaml` :

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: kustomize-app
spec:
  selector:
    matchLabels:
      app: kustomize-app-production
  template:
    metadata:
      labels:
        app: kustomize-app-production
    spec:
      containers:
        - name: kustomize-app
          env:
            - name: APPLICATION_NAME
              value: kustomize-app-production
```

The main difference here is that the environment variable `APPLICATION_NAME` is set differently. The `app` label also differs because we are going to deploy both Deployments into the same Namespace.

The same applies to our Service. It also comes in two customizations so that it matches the corresponding Deployment in the same Namespace.

`overlays/staging/service-patch.yaml` :

```yaml
apiVersion: v1
kind: Service
metadata:
  name: kustomize-app
spec:
  selector:
    app: kustomize-app-staging
```

`overlays/production/service-patch.yaml` :

```yaml
apiVersion: v1
kind: Service
metadata:
  name: kustomize-app
spec:
  selector:
    app: kustomize-app-production
```

Note
All files mentioned above are also directly accessible from GitHub .

Prepare the files as described above in a local directory of your choice.

Task 12.2: Deploy with Kustomize

We are now ready to deploy both apps for the two different environments. For simplicity, we will use the same Namespace.

```
oc apply -k overlays/staging --namespace <namespace>
```

```
service/kustomize-app-staging created
deployment.apps/kustomize-app-staging created
```

```
oc apply -k overlays/production --namespace <namespace>
```

```
service/kustomize-app-production created
deployment.apps/kustomize-app-production created
```

As you can see, we now have two deployments and services deployed. Both of them use the same base configuration. However, they have a specific configuration on their own as well.

Let’s verify this. Our app writes a corresponding log entry that we can use for analysis:

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

```
NAME                                     READY   STATUS    RESTARTS   AGE
kustomize-app-production-74c7bdb7d-8cccd 1/1     Running   0          2m1s
kustomize-app-staging-7967885d5b-qp6l8   1/1     Running   0          5m33s
```

```
oc logs kustomize-app-staging-7967885d5b-qp6l8
```

```
My name is kustomize-app-staging
```

```
oc logs kustomize-app-production-74c7bdb7d-8cccd
```

```
My name is kustomize-app-production
```

Further information

Kustomize has more features of which we just covered a couple. Please refer to the docs for more information.

- Kustomize documentation: https://kubernetes-sigs.github.io/kustomize/
- API reference: https://kubernetes-sigs.github.io/kustomize/api-reference/
- Another `kustomization.yaml` reference: https://kubectl.docs.kubernetes.io/pages/reference/kustomize.html

- acend gmbh
    - Examples: https://github.com/kubernetes-sigs/kustomize/tree/master/examples

13. Kubernetes and OpenShift differences

> **Note**
> This lab is optional.

Even though OpenShift is based on Kubernetes, there are some important differences. As a concluding lab, we are going to have a look at these differences.

Life cycle and versions

Red Hat releases a new OpenShift 4 release every six months, as is the case with Kubernetes. The important difference however is that the latest OpenShift release is always based on the second latest Kubernetes release.

Keep this in mind especially when using Kubernetes' documentation e.g. about some resource type.

You can find out more about OpenShift's life cycle policy on this page .

Resource types

OpenShift extends the Kubernetes API to support certain additional resource types.

Namespaces and Projects

In *2. First steps* you created your first Project on OpenShift. You won't find the concept of a "Project" in Kubernetes except in other Kubernetes distributions, specifically in Rancher.

> **Note**
> Rancher's and OpenShift's concepts of a project have nothing in common.

A Project in OpenShift is based on the Namespace resource type. When creating a Project in OpenShift, a Namespace with the exact same name is created in the background.

The probably only reason for the Project resource type to exist is that OpenShift provides additional administrative controls for Projects. OpenShift users can, e.g., be prevented from creating their own Namespaces/Projects .

Ingresses and Routes

Ingresses and Routes enable you to make an application reachable to the outside of OpenShift. They contain the configuration needed and signal the platform that a certain service needs to be accessible to the outside world.

Red Hat introduced the concept of Routes in OpenShift 3.0 and still uses it up until now. Support for the Ingress resource type was introduced in OpenShift 3.10 which means that you can use both Routes and Ingresses as you see fit. Of course both have their advantages and disadvantages.

One of the obvious advantages of the Ingress resource type is its compatibility with other Kubernetes distributions. However, different kinds of Ingress controllers support different features making this statement semisolid. One of the obvious advantages of using Routes is that they're easy to create using the `oc expose` command.

> **Note**
> In OpenShift, creating an Ingress resource leads to the creation of a corresponding Route in the same Namespace.

Task 13.1: Create an Ingress resource

In *5. Scaling* you exposed the example-web-app application via Route using the `oc expose` command.

Expose the application using an Ingress resource. It's best to not delete the existing Route, so you can compare them. Bear in mind that you need to use another hostname in that case.

> **Note**
> Make use of the Kubernetes documentation about Ingress resources.

Solution

Your Ingress resource should look similar to this:

```yaml
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: example-web-app
spec:
  rules:
  - host: <hostname>
    http:
      paths:
      - path: /
        pathType: Prefix
        backend:
          service:
            name: example-web-app
            port:
              number: 5000
```

ImageStreams

One of the reasons Kubernetes Deployments cannot support the missing automation features is because in OpenShift, they are based on other resource types like the *ImageStream*. Kubernetes has not yet adopted a similar resource type.

ImageStreams are references to an actual image in an image registry. They can be configured to periodically check if the referenced image has been updated in order to trigger builds or deployments. More details can be found in [OpenShift's documentation](#) .

BuildConfigs and Builds

You already encountered these resource types in *3. Deploying a container image*. BuildConfigs and Builds make it possible to build a container image on OpenShift instead of relying on an external tool.