Pods

This lab introduces the concept of pods and teaches how to properly configure and deploy them. We will begin by creating a simple pod with your application container running in it. We will explain what the different aspects of pod configuration mean and decide which configuration to use based on your application or use case. You will be able to define resource allocation requirements and limits for pods. We will then move on to see how we can debug the pod, check the logs, and make changes to it when needed. Some more useful tools for managing faults in pods, such as liveness and readiness probes and restart policies, are also covered in this lab.

The following exercise demonstrates how to use such a pod configuration file to create a simple pod.

Exercise 5.01: Creating a Pod with a Single Container

In this exercise, we aim to create our first simple pod that runs a single container. To complete this exercise, perform the following steps:

1. Create a file called `single-container-pod.yaml` with the following contents:

   ```
   apiVersion: v1
   kind: Pod
   metadata:
     name: first-pod
   spec:
     containers:
     - name: my-first-container
       image: nginx
   ```

2. Run the following command in Terminal to create a pod with the preceding configuration:

   ```
   kubectl create -f single-container-pod.yaml
   ```

   You should see the following response:

   ```
   pod/first-pod created
   ```

   The output indicates that the pod has been created.

3. Verify that the pod was created by getting the list of all the pods using this command:

   ```
   kubectl get pods
   ```

   You should see the following response:

   ```
   NAME         READY       STATUS       RESTARTS       AGE
   first-pod    1/1         Running      0              5m44s
   ```

4. Now that we have created our first pod, let's look into it in more detail. To do that, we can describe the pod we just created using the following command in Terminal:

   ```
   kubectl describe pod first-pod
   ```

   You should see the following output:

```
Name:               first-pod
Namespace:          default
Priority:           0
PriorityClassName:  <none>
Node:               minikube/10.0.2.15
Start Time:         Thu, 04 Jul 2019 15:12:30 +0200
Labels:             <none>
Annotations:        <none>
Status:             Running
IP:                 172.17.0.5
Containers:
  my-first-container:
    Container ID:   docker://d050324b76bcfb6ab1753cb044a12c03abd7df2274ae36dca6e0dc1689dc3c3d
    Image:          nginx
    Image ID:       docker-pullable://nginx@sha256:96fb261b66270b900ea5a2c17a26abbfabe95506e73c3a3c65869a6dbe83223a
    Port:           <none>
    Host Port:      <none>
    State:          Running
      Started:      Thu, 04 Jul 2019 15:12:37 +0200
    Ready:          True
    Restart Count:  0
    Environment:    <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from default-token-7rmnp (ro)
Conditions:
  Type              Status
  Initialized       True
  Ready             True
  ContainersReady   True
  PodScheduled      True
Volumes:
  default-token-7rmnp:
    Type:        Secret (a volume populated by a Secret)
    SecretName:  default-token-7rmnp
    Optional:    false
QoS Class:       BestEffort
Node-Selectors:  <none>
Tolerations:     node.kubernetes.io/not-ready:NoExecute for 300s
                 node.kubernetes.io/unreachable:NoExecute for 300s
Events:
  Type    Reason     Age   From               Message
  ----    ------     ----  ----               -------
  Normal  Scheduled  23m   default-scheduler  Successfully assigned default/first-pod to minikube
  Normal  Pulling    23m   kubelet, minikube  Pulling image "nginx"
  Normal  Pulled     23m   kubelet, minikube  Successfully pulled image "nginx"
  Normal  Created    23m   kubelet, minikube  Created container my-first-container
  Normal  Started    23m   kubelet, minikube  Started container my-first-container
```

The output shows various details about the pod we just created.

There are two ways to create pods in different namespaces -- by using a CLI command, or by specifying the namespace in the pod configuration. The following exercises demonstrate how you can create pods in different namespaces to reap the benefits of namespaces that were mentioned earlier.

Exercise 5.02: Creating a Pod in a Different Namespace by Specifying the Namespace in the CLI

In this exercise, we will create a pod in a namespace other than `default`. We will do that using the same pod configuration from *Exercise 5.01*, *Creating a Pod with a Single Container*, by specifying the namespace in the command argument. Follow these steps to complete the exercise:

1. Run the following command to view all the available namespaces in our Kubernetes cluster:

   ```
   kubectl get namespaces
   ```

   You should see the following list of namespaces:

```
NAME               STATUS       AGE
default            Active       16d
kube-node-lease    Active       16d
kube-public        Active       16d
kube-system        Active       16d
```

The output shows all the namespaces in our Kubernetes cluster. The `default` namespace is, as the word implies, the default namespace for all Kubernetes objects created without any namespace.

2. Run the following command to create the pod with the `single-container-pod.yaml` pod configuration but in a different namespace:

```
kubectl --namespace kube-public create -f single-container-pod.yaml
```

You should see the following response:

```
pod/first-pod created
```

Note

If you create a pod in a particular namespace, you can only view it by switching to that namespace.

3. Verify that the pod was created in the `kube-public` namespace:

```
kubectl --namespace kube-public get pods
```

You should see the following response:

```
NAME            READY        STATUS       RESTARTS      AGE
first-pod       1/1          Running      0             8s
```

The output here shows that we have successfully created the pod in the `kube-public` namespace.

The next exercise demonstrates how to create a pod in different namespace based on a YAML file.

Exercise 5.03: Creating a Pod in a Different Namespace by Specifying the Namespace in the Pod Configuration YAML file

In this exercise, we shall add a line to the YAML configuration file to specify that all pods created using this file use a specified namespace.

1. Run the following command to view all the available namespaces in our Kubernetes cluster:

```
kubectl get namespaces
```

You should see the following list of namespaces:

```
NAME               STATUS       AGE
default            Active       16d
kube-node-lease    Active       16d
kube-public        Active       16d
kube-system        Active       16d
```

2. Next, create a file named `single-container-pod-with-namespace.yaml` with the following configuration:

```
apiVersion: v1
kind: Pod
metadata:
  name: first-pod-with-namespace
  namespace: kube-public
spec:
  containers:
  - name: my-first-container
    image: nginx
```

3. Run the following command to create a pod with the `single-container-pod-with-namespace.yaml` pod configuration:

```
kubectl create -f single-container-pod-with-namespace.yaml
```

   You should see the following response:

```
pod/first-pod-with-namespace created
```

4. Verify that the pod was created in the `kube-public` namespace:

```
kubectl --namespace kube-public get pods
```

   You should see the following list of pods:

```
NAME                      READY     STATUS      RESTARTS   AGE
first-pod                  1/1      Running     0          5m2s
first-pod-with-namespace  1/1      Running     0          46s
```

   The output shows that the new pod we created occupies the `kube-public` namespace. Any other pods created using the `single-container-pod-with-namespace.yaml` pod configuration will occupy the same namespace.

In the following exercise, we shall change the default kubectl namespace so that all pods without a defined namespace take our newly defined namespace instead of `default`.

Exercise 5.04: Changing the Namespace for All Subsequent kubectl Commands

In this exercise, we will change the namespace for all subsequent kubectl commands from `default` to `kube-public`.

1. Run the following command to view all the available namespaces in our Kubernetes cluster:

```
kubectl get namespaces
```

   You should see the following list of namespaces:

```
NAME              STATUS       AGE
default           Active       16d
kube-node-lease   Active       16d
kube-public       Active       16d
kube-system       Active       16d
```

2. Run the following command to change the namespace for all subsequent requests by modifying the current context:

   ```
   kubectl config set-context $(kubectl config current-context) --namespace kube-public
   ```

   You should see the following response:

   ```
   Context "minikube" modified.
   ```

3. Run the following command to list all the pods in the `kube-public` namespace without using the `namespace` argument:

   ```
   kubectl get pods
   ```

   You should see the following list of pods:

   ```
   NAME                       READY     STATUS      RESTARTS   AGE
   first-pod                   1/1      Running     0          48m
   first-pod-with-namespace   1/1      Running     0          44m
   ```

   The output shows that the preceding command lists all the pods that we have created in the `kube-public` namespace. We saw in *Exercise 5.01*, *Creating a Pod with a Single Container*, that the `kubectl get pods` command shows pods in the default namespace. But here, we get results from the `kube-public` namespace instead.

4. In this step, we will undo the changes so that it doesn't affect the upcoming exercises in this lab. We will change the default namespace to `default` again to avoid any confusion:

   ```
   kubectl config set-context $(kubectl config current-context) --namespace default
   ```

   You should see the following response:

   ```
   Context "minikube" modified.
   ```

In this exercise, we have seen how to change and reset the default namespace of the context.

Node

As you have learned in earlier labs, nodes are the various machines running in our cluster. This field reflects the node in the Kubernetes cluster where this pod was running. Knowing what node a pod is running on can help us with debugging issues with that pod. Observe the sixth line of the output shown in *Figure 5.1*:

```
Node: minikube/10.0.2.15
```

We can list all the nodes in our Kubernetes cluster by running the following command:

```
kubectl get nodes
```

You should see the following response:

```
NAME        STATUS    ROLES     AGE       VERSION
minikube    Ready     <none>    16d       v1.14.3
```

In this case, there's only one node in our cluster because we are using Minikube for these exercises:

```
apiVersion: v1
kind: Pod
metadata:
  name: firstpod
spec:
  nodeName: my-favorite-node # run this pod on a specific node
  containers:
  - name: my-first-pod
    image: nginx
```

If we have more than one node in our cluster, we can configure our pod to run on a particular node by adding the following `nodeName` field to the configuration, as seen in the sixth line in the previous spec.

Note

In a production environment, `nodeName` is typically not used for assigning a certain pod to run on the desired node. In the next lab, we will learn about `nodeSelector`, which is a better way to control which node the pod gets assigned to.

Status

This field tells us the status of the pod so that we can take appropriate action, such as starting or stopping a pod as required. While this demonstration shows one of the ways to get the status of the pod, in actual practice, you would want to automate actions based on the pod status. Consider the tenth line of the output shown in *Figure 5.1*:

```
Status: Running
```

This states that the current status of the pod is `Running`. This field reflects which phase of its life cycle a pod is in. We will talk about various phases of a pod's life cycle in the next section of this lab.

Containers

Earlier in this lab, we saw that we can bundle various containers inside a pod. This field lists all the containers that we have created in this pod. Consider the output field from line 12 onwards in *Figure 5.1*:

```
Containers:
  my-first-container:
    Container ID:   docker://d050324b76bcfb6ab1753cb044a12c03abd7df2274ae36dca6e0dc1689dc3c3d
    Image:          nginx
    Image ID:       docker-pullable://nginx@sha256:96fb261b66270b900ea5a2c17a26abbfabe95506e73c3a3c65869a6dbe83223a
    Port:           <none>
    Host Port:      <none>
    State:          Running
      Started:      Thu, 04 Jul 2019 15:12:37 +0200
    Ready:          True
    Restart Count:  0
    Environment:    <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from default-token-7rmnp (ro)
```

We have only one in this case. We can see that the name and the image of the container are the same as we specified in the YAML configuration. The following is a list of the other fields that we can set:

- `Image` : Name of the Docker image
- `Args` : The arguments to the entry point for the container
- `Command` : The command to run on the container once it starts
- `Ports` : A list of ports to expose from the container
- `Env` : A list of environment variables to be set in the container
- `resources` : The resource requirements of the container

In the following exercise, we shall create a container using a simple command.

Exercise 5.05: Using CLI Commands to Create a Pod Running a Container

In this exercise, we will create a pod that will run a container by running a command.

1. First, let's create a file named `pod-with-container-command.yaml` with the following pod configuration:

   ```
   apiVersion: v1
   kind: Pod
   metadata:
     name: command-pod
   spec:
     containers:
     - name: container-with-command
       image: ubuntu
       command:
       - /bin/bash
       - -ec
       - while :; do echo '.'; sleep 5; done
   ```

2. Run the following command to create the pod using the configuration defined in the `pod-with-container-command.yaml` file:

   ```
   kubectl create -f pod-with-container-command.yaml
   ```

   You should see the following response:

   ```
   pod/command-pod created
   ```

The YAML file we created in the previous step instructs the pod to start a container with an Ubuntu image and run the following command:

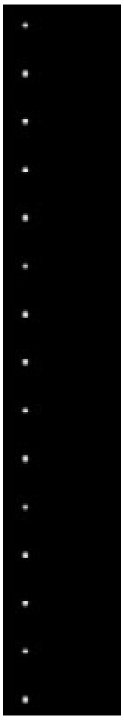
```
/bin/bash -ec "while :; do echo '.'; sleep 5; done"
```

This command should print a dot (`.`) character on a new line every 5 seconds.

3. Let's check the logs of this pod to verify that it's doing what it's expected to do. To check the logs of a pod, we can use the `kubectl logs` command:

   ```
   kubectl logs command-pod -f
   ```

   You should see the following response:



In the log, which keeps updating periodically, we see a dot (`.`) character printed on a new line every 5 seconds. Thus, we have successfully created the desired container.

Note

The `-f` flag is to follow the logs on the container. That is, the log keeps updating in real-time. If we skip that flag, we will see the logs without following them.

In the next exercise, we shall run a container that opens up a port, which is something that you would have to do regularly to make the container accessible to the rest of your cluster or the internet.

Exercise 5.06: Creating a Pod Running a Container That Exposes a Port

In this exercise, we will create a pod that runs a container that will expose a port that we can access from outside the pod.

1. First, let's create a file named `pod-with-exposed-port.yaml` with the following pod configuration:

```
apiVersion: v1
kind: Pod
metadata:
  name: port-exposed-pod
spec:
  containers:
    - name: container-with-exposed-port
      image: nginx
      ports:
        - containerPort: 80
```

2. Run the following command to create the pod using the `pod-with-exposed-port.yaml` file:

   ```
   kubectl create -f pod-with-exposed-port.yaml
   ```

   You should see the following response:

   ```
   pod/port-exposed-pod created
   ```

   This pod should create a container and expose its port `80`. We have configured the pod to run a container with an `nginx` image, which is a popular web server.

3. Next, we will forward port `80` from the pod to localhost:

   ```
   sudo kubectl port-forward pod/port-exposed-pod 80
   ```

   You should see the following response:

   ```
   Forwarding from 127.0.0.1:80 -> 80
   Forwarding from [::1] -> 80
   ```

   This will expose port `80` from the pod to localhost port `80`.

   Note

   We will need to keep this command running in one terminal.

4. Now, we can simply enter either `http://localhost` or `http://127.0.0.1` in the address bar of the browser.

5. Alternatively, we can run the following command and see the HTML source code of the default index page in the response:

   ```
   curl 127.0.0.1
   ```

   You should see the following output:

```
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
<style>
    body {
        width: 35em;
        margin: 0 auto;
        font-family: Tahoma, Verdana, Arial, sans-serif;
    }
</style>
</head>
<body>
<h1>Welcome to nginx!</h1>
<p>If you see this page, the nginx web server is successfully installed and
working. Further configuration is required.</p>

<p>For online documentation and support please refer to
<a href="http://nginx.org/">nginx.org</a>.<br/>
Commercial support is available at
<a href="http://nginx.com/">nginx.com</a>.</p>

<p><em>Thank you for using nginx.</em></p>
</body>
</html>
```

6. Next, let's verify that the pod is actually receiving the request by checking the logs using the `kubectl logs` command:

   ```
   kubectl logs port-exposed-pod
   ```

   You should see the following response:

   ```
   127.0.0.1 - - [04/Jul/2019:15:37:48 +0000] "GET / HTTP/1.1" 200 612 "-" "Mozilla/5.0 (Macintosh; Inte
   l Mac OS X 10_14_4) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/75.0.3770.100 Safari/537.36" "-"
   ```

The log shows that our container that is running an `nginx` image is receiving our HTTP request to localhost and responding as expected.

We can also define the minimum and maximum resource allocation for our containers. This is useful for managing the resources used by our deployments. This can be achieved using the following two fields in the YAML configuration file:

- `limits`: Describes the maximum amount of resources allowed for this container.
- `requests`: Describes the minimum amount of resources required for this container.

We can use these fields to define the minimum and maximum memory and CPU resources for our containers. The CPU resource is measured in CPU units. 1 CPU unit means that the container has access to 1 logical CPU core.

In the next exercise, we shall create a container with defined resource requirements.

Exercise 5.07: Creating a Pod Running a Container with Resource Requirements

In this exercise, we will create a pod with a container that has resource requirements. First of all, let's see how we can configure the container's resource requirements:

1. Create a file named `pod-with-resource-requirements.yaml` with a pod configuration that specifies both `limits` and `requests` for memory and CPU resources, as shown here:

   ```
   apiVersion: v1
   kind: Pod
   metadata:
     name: resource-requirements-pod
   spec:
     containers:
       - name: container-with-resource-requirements
         image: nginx
         resources:
           limits:
             memory: "128M"
             cpu: "1"
           requests:
             memory: "64M"
             cpu: "0.5"
   ```

   In this YAML file, we define the minimum memory requirement for the container to be 64 MB and the maximum memory that the container can occupy to be 128 MB. If the container tries to allocate more than 128 MB of memory, it will be killed with a status of `OOMKilled`.

   The minimum CPU requirement for CPU is 0.5 (which can also be understood as 500 milli-CPUs and can be written as `500m` instead of `0.5`) and the container will only be allowed to use a maximum of 1 CPU unit.

2. Next, we will create the pod that uses this YAML configuration with the `kubectl create` command:

   ```
   kubectl create -f pod-with-resource-requirements.yaml
   ```

   You should see the following response:

   ```
   pod/resource-requirements-pod created
   ```

3. Next, let's make sure the pod is created with the correct resource requirements. Check the pod definitions using the `describe` command:

   ```
   kubectl describe pod resource-requirements-pod
   ```

   You should see the following output:

```
Name:               resource-requirements-pod
Namespace:          default
Priority:           0
PriorityClassName:  <none>
Node:               minikube/10.0.2.15
Start Time:         Thu, 04 Jul 2019 18:45:58 +0200
Labels:             <none>
Annotations:        <none>
Status:             Running
IP:                 172.17.0.8
Containers:
  container-with-resource-requirements:
    Container ID:   docker://92c3f8344059e29fe6b8db519b18bf09a86508e05a4ce6664ce45e976fe9175e
    Image:          nginx
    Image ID:       docker-pullable://nginx@sha256:96fb261b66270b900ea5a2c17a26abbfabe95506e73c3a3c65869a6dbe83223a
    Port:           <none>
    Host Port:      <none>
    State:          Running
      Started:      Thu, 04 Jul 2019 18:46:01 +0200
    Ready:          True
    Restart Count:  0
    Limits:
      cpu:     1
      memory:  128M
    Requests:
      cpu:        500m
      memory:     64M
    Environment:  <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from default-token-7rmnp (ro)
Conditions:
  Type              Status
  Initialized       True
  Ready             True
  ContainersReady   True
  PodScheduled      True
Volumes:
  default-token-7rmnp:
    Type:        Secret (a volume populated by a Secret)
    SecretName:  default-token-7rmnp
    Optional:    false
QoS Class:       Burstable
Node-Selectors:  <none>
Tolerations:     node.kubernetes.io/not-ready:NoExecute for 300s
                 node.kubernetes.io/unreachable:NoExecute for 300s
Events:
  Type    Reason     Age    From               Message
  ----    ------     ----   ----               -------
  Normal  Scheduled  5m34s  default-scheduler  Successfully assigned default/resource-requirements-pod to minikube
  Normal  Pulling    5m33s  kubelet, minikube  Pulling image "nginx"
  Normal  Pulled     5m31s  kubelet, minikube  Successfully pulled image "nginx"
  Normal  Created    5m31s  kubelet, minikube  Created container container-with-resource-requirements
  Normal  Started    5m31s  kubelet, minikube  Started container container-with-resource-requirements
```

The highlighted fields in the output show that the pod has been assigned the `limits` and `requests` sections that we stated in the YAML file.

What happens if we define unrealistic resource requirements for our pod? Let's explore that in the following exercise.

Exercise 5.08: Creating a Pod with Resource Requests That Can't Be Met by Any of the Nodes

In this exercise, we will create a pod with large resource requests that are too big for the nodes in the cluster and see what happens.

1. Create a file named `pod-with-huge-resource-requirements.yaml` with the following pod configuration:

```
apiVersion: v1
kind: Pod
metadata:
  name: huge-resource-requirements-pod
spec:
```

```
  containers:
    - name: container-with-huge-resource-requirements
      image: nginx
      resources:
        limits:
          memory: "128G"
          cpu: "1000"
        requests:
          memory: "64G"
          cpu: "500"
```

In this YAML file, we define the minimum requirement to be 64 GB of memory and 500 CPU cores. It is unlikely that the machine that you are running this exercise on would meet those requirements.

2. Next, we will create the pod that uses this YAML configuration with the `kubectl create` command:

```
kubectl create -f pod-with-huge-resource-requirements.yaml
```

You should see the following response:

```
pod/huge-resource-requirements-pod created
```

3. Now, let's see what's going on with our pod. Get its status using the `kubectl get` command:

```
kubectl get pod huge-resource-requirements-pod
```

You should see the following response:

```
NAME                             READY   STATUS    RESTARTS   AGE
huge-resource-requirements-pod   0/1     Pending   0          55s
```

```
We see that the pod has been in the `Pending` state for
almost a minute. That\'s unusual!
```

4. Let's dig deeper and describe the pod using the following command:

```
kubectl describe pod huge-resource-requirements-pod
```

You should see the following output:

```
Name:               huge-resource-requirements-pod
Namespace:          default
Priority:           0
PriorityClassName:  <none>
Node:               <none>
Labels:             <none>
Annotations:        <none>
Status:             Pending
IP:
Containers:
  container-with-huge-resource-requirements:
    Image:      nginx
    Port:       <none>
    Host Port:  <none>
    Limits:
      cpu:     1k
      memory:  128G
    Requests:
      cpu:        500
      memory:     64G
    Environment:  <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from default-token-7rmnp (ro)
Conditions:
  Type           Status
  PodScheduled   False
Volumes:
  default-token-7rmnp:
    Type:        Secret (a volume populated by a Secret)
    SecretName:  default-token-7rmnp
    Optional:    false
QoS Class:       Burstable
Node-Selectors:  <none>
Tolerations:     node.kubernetes.io/not-ready:NoExecute for 300s
                 node.kubernetes.io/unreachable:NoExecute for 300s
Events:
  Type     Reason            Age                  From               Message
  ----     ------            ----                 ----               -------
  Warning  FailedScheduling  67s (x4 over 2m18s)  default-scheduler  0/1 nodes are available:
1 Insufficient cpu, 1 Insufficient memory.
```

Let's focus on the last line of the output. We can clearly see that there's a warning stating that the Kubernetes controller couldn't find any nodes that satisfy the CPU and memory requirements of the pod. Hence, the pod scheduling has failed.

To summarize, pod scheduling works on the basis of resource requirements. A pod will only be scheduled on a node that satisfies all its resource requirements. If we do not specify a resource (memory or CPU) limit, there's no upper bound on the number of resources a pod can use.

This poses the risk of one bad pod consuming too much CPU or allocating too much memory that impacts the other pods running in the same namespace/cluster. Hence, it's a good idea to add resource requests and limits to the pod configuration in a production environment.

As mentioned earlier in the lab, a pod can run more than one container. In the following exercise, we will create a pod with more than one container.

Exercise 5.09: Creating a Pod with Multiple Containers Running inside It

In this exercise, we will create a pod with multiple containers. For that, we can use the configuration that we used in the previous section, with the only difference being that the `containers` field will now contain more than one container spec. Follow these steps to complete the exercise:

1. Create a file named `multiple-container-pod.yaml` with the following pod configuration:

```
apiVersion: v1
kind: Pod
metadata:
  name: multi-container-pod
spec:
  containers:
    - name: first-container
      image: nginx
    - name: second-container
      image: ubuntu
      command:
        - /bin/bash
        - -ec
        - while :; do echo '.'; sleep 5; done
```

2. Next, we will create a pod that uses the preceding YAML configuration with the `kubectl create` command:

```
kubectl create -f multiple-container-pod.yaml
```

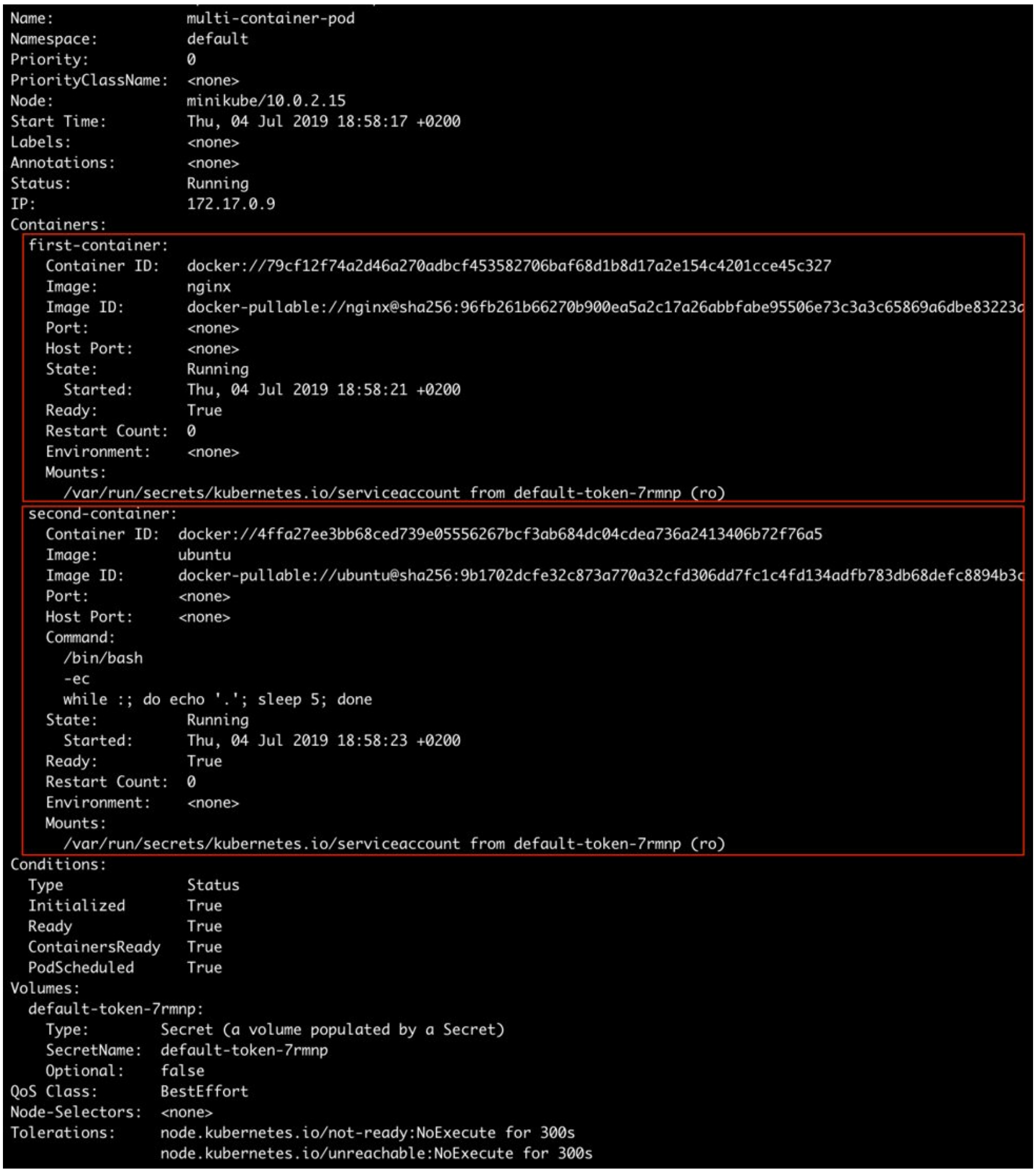
   You should see the following response:

```
pod/multi-container-pod created
```

3. Next, we will describe the pod and see what containers it is running:

```
kubectl describe pod multi-container-pod
```

   You should see the following output:



```
Name:               multi-container-pod
Namespace:          default
Priority:           0
PriorityClassName:  <none>
Node:               minikube/10.0.2.15
Start Time:         Thu, 04 Jul 2019 18:58:17 +0200
Labels:             <none>
Annotations:        <none>
Status:             Running
IP:                 172.17.0.9
Containers:
  first-container:
    Container ID:   docker://79cf12f74a2d46a270adbcf453582706baf68d1b8d17a2e154c4201cce45c327
    Image:          nginx
    Image ID:       docker-pullable://nginx@sha256:96fb261b66270b900ea5a2c17a26abbfabe95506e73c3a3c65869a6dbe83223c
    Port:           <none>
    Host Port:      <none>
    State:          Running
      Started:      Thu, 04 Jul 2019 18:58:21 +0200
    Ready:          True
    Restart Count:  0
    Environment:    <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from default-token-7rmnp (ro)
  second-container:
    Container ID:  docker://4ffa27ee3bb68ced739e05556267bcf3ab684dc04cdea736a2413406b72f76a5
    Image:         ubuntu
    Image ID:      docker-pullable://ubuntu@sha256:9b1702dcfe32c873a770a32cfd306dd7fc1c4fd134adfb783db68defc8894b3c
    Port:          <none>
    Host Port:     <none>
    Command:
      /bin/bash
      -ec
      while :; do echo '.'; sleep 5; done
    State:          Running
      Started:      Thu, 04 Jul 2019 18:58:23 +0200
    Ready:          True
    Restart Count:  0
    Environment:    <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from default-token-7rmnp (ro)
Conditions:
  Type              Status
  Initialized       True
  Ready             True
  ContainersReady   True
  PodScheduled      True
Volumes:
  default-token-7rmnp:
    Type:        Secret (a volume populated by a Secret)
    SecretName:  default-token-7rmnp
    Optional:    false
QoS Class:       BestEffort
Node-Selectors:  <none>
Tolerations:     node.kubernetes.io/not-ready:NoExecute for 300s
                 node.kubernetes.io/unreachable:NoExecute for 300s
```

As can be seen from the preceding output, we have two containers running in a single pod. Now, we need to make sure we can access the logs from either container.

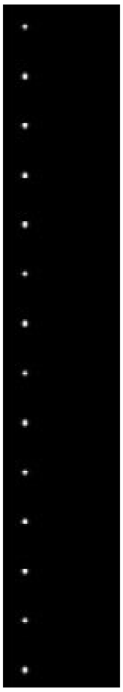
We can specify the container name to get the logs for a particular container running in a pod, as shown here:

```
kubectl logs <pod-name> <container-name>
```

For example, to see the logs for a second container that is printing out dots on a new line every 5 seconds, use this command:

```
kubectl logs multi-container-pod second-container -f
```

You should see the following response:



The output we see here is similar to *Exercise 5.05*, *Using CLI Commands to Create a Pod Running a Container*, as we have essentially used a similar container as we defined there.

Thus, we have created a pod with multiple containers and accessed the logs of the desired container.

Exercise 5.10: Creating a Pod Running a Container with a Liveness Probe and No Restart Policy

In this exercise, we will create a pod with a liveness probe and no restart policy. Not specifying a restart policy for a pod means that the default policy of `Always` will be used.

1. Create `liveness-probe.yaml` with the following pod configuration:

```
apiVersion: v1
kind: Pod
metadata:
  name: liveness-probe
spec:
  containers:
    - name: ubuntu-container
      image: ubuntu
      command:
        - /bin/bash
        - -ec
        - touch /tmp/live; sleep 30; rm /tmp/live; sleep 600
      livenessProbe:
        exec:
          command:
            - cat
            - /tmp/live
```

```
        initialDelaySeconds: 5
        periodSeconds: 5
```

This pod configuration means that there will be a container created from an Ubuntu image and the following command will be run once it starts:

```
/bin/bash -ec "touch /tmp/live; sleep 30; rm /tmp/live; sleep 600"
```

The preceding command creates an empty file at path `/tmp/live`, sleeps for 30 seconds, deletes the `/tmp/live` file, and then sleeps for 10 minutes before terminating with success.

Next, we have a liveness probe that executes the following command every 5 seconds with an initial delay of 5 seconds:

```
cat /tmp/live
```

2. Run the following command to create the pod using `liveness-probe.yaml`:

```
kubectl create -f liveness-probe.yaml
```

3. When the container starts, the liveness probe will succeed because the command will execute successfully. Now, let's wait for at least 30 seconds and run the `describe` command:

```
kubectl describe pod liveness-probe
```

You should see the following output:

```
Name:               liveness-probe
Namespace:          default
Priority:           0
PriorityClassName:  <none>
Node:               minikube/10.0.2.15
Start Time:         Thu, 04 Jul 2019 19:18:02 +0200
Labels:             <none>
Annotations:        <none>
Status:             Running
IP:                 172.17.0.8
Containers:
  ubuntu-container:
    Container ID:  docker://48c9d901474a25835f00fb5a9e2e2ed38823f12ba24691b7b3383b0d392f016a
    Image:         ubuntu
    Image ID:      docker-pullable://ubuntu@sha256:9b1702dcfe32c873a770a32cfd306dd7fc1c4fd134adfb783db68defc8894b3c
    Port:          <none>
    Host Port:     <none>
    Command:
      /bin/bash
      -ec
      touch /tmp/ready; sleep 30; rm /tmp/ready; sleep 600
    State:          Running
      Started:      Thu, 04 Jul 2019 19:18:05 +0200
    Ready:          True
    Restart Count:  0
    Liveness:       exec [cat /tmp/ready] delay=5s timeout=1s period=5s #success=1 #failure=3
    Environment:    <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from default-token-7rmnp (ro)
Conditions:
  Type              Status
  Initialized       True
  Ready             True
  ContainersReady   True
  PodScheduled      True
Volumes:
  default-token-7rmnp:
    Type:        Secret (a volume populated by a Secret)
    SecretName:  default-token-7rmnp
    Optional:    false
QoS Class:       BestEffort
Node-Selectors:  <none>
Tolerations:     node.kubernetes.io/not-ready:NoExecute for 300s
                 node.kubernetes.io/unreachable:NoExecute for 300s
Events:
  Type     Reason     Age   From                Message
  ----     ------     ----  ----                -------
  Normal   Scheduled  35s   default-scheduler   Successfully assigned default/liveness-probe to minikube
  Normal   Pulling    34s   kubelet, minikube   Pulling image "ubuntu"
  Normal   Pulled     32s   kubelet, minikube   Successfully pulled image "ubuntu"
  Normal   Created    32s   kubelet, minikube   Created container ubuntu-container
  Normal   Started    32s   kubelet, minikube   Started container ubuntu-container
  Warning  Unhealthy  0s    kubelet, minikube   Liveness probe failed: cat: /tmp/ready: No such file or directory
```

```
In the last line, which is highlighted, we can see that the liveness
probe has failed for the first time.
```

4. Let's wait for a few more seconds until the probe has failed three times and run the same command again:

```
kubectl describe pod liveness-probe
```

You should see the following output:

```
Name:               liveness-probe
Namespace:          default
Priority:           0
PriorityClassName:  <none>
Node:               minikube/10.0.2.15
Start Time:         Thu, 04 Jul 2019 19:18:02 +0200
Labels:             <none>
Annotations:        <none>
Status:             Running
IP:                 172.17.0.8
Containers:
  ubuntu-container:
    Container ID:  docker://48c9d901474a25835f00fb5a9e2e2ed38823f12ba24691b7b3383b0d392f016a
    Image:         ubuntu
    Image ID:      docker-pullable://ubuntu@sha256:9b1702dcfe32c873a770a32cfd306dd7fc1c4fd134adfb783db68defc8894b3c
    Port:          <none>
    Host Port:     <none>
    Command:
      /bin/bash
      -ec
      touch /tmp/ready; sleep 30; rm /tmp/ready; sleep 600
    State:          Running
      Started:      Thu, 04 Jul 2019 19:18:05 +0200
    Ready:          True
    Restart Count:  0
    Liveness:       exec [cat /tmp/ready] delay=5s timeout=1s period=5s #success=1 #failure=3
    Environment:    <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from default-token-7rmnp (ro)
Conditions:
  Type              Status
  Initialized       True
  Ready             True
  ContainersReady   True
  PodScheduled      True
Volumes:
  default-token-7rmnp:
    Type:        Secret (a volume populated by a Secret)
    SecretName:  default-token-7rmnp
    Optional:    false
QoS Class:       BestEffort
Node-Selectors:  <none>
Tolerations:     node.kubernetes.io/not-ready:NoExecute for 300s
                 node.kubernetes.io/unreachable:NoExecute for 300s
Events:
  Type     Reason     Age                From               Message
  ----     ------     ----               ----               -------
  Normal   Scheduled  50s                default-scheduler  Successfully assigned default/liveness-probe to minikube
  Normal   Pulling    49s                kubelet, minikube  Pulling image "ubuntu"
  Normal   Pulled     47s                kubelet, minikube  Successfully pulled image "ubuntu"
  Normal   Created    47s                kubelet, minikube  Created container ubuntu-container
  Normal   Started    47s                kubelet, minikube  Started container ubuntu-container
  Warning  Unhealthy  5s (x3 over 15s)   kubelet, minikube  Liveness probe failed: cat: /tmp/ready: No such file or directory
  Normal   Killing    5s                 kubelet, minikube  Container ubuntu-container failed liveness probe, will be restarted
```

```
The last two highlighted lines in the output tell us that the
liveness probe has failed three times. And now, the pod will be
killed and restarted.
```

5. Next, we will verify that the pod has been restarted at least once using the following command:

   ```
   kubectl get pod liveness-probe
   ```

   You should see the following response:

   ```
   NAME             READY     STATUS     RESTARTS    AGE
   liveness-probe   1/1       Running    1           89s
   ```

This output shows that the pod has been restarted upon failing the liveness probe.

Let's now take a look at what happens if we set the restart policy to `Never`.

Exercise 5.11: Creating a Pod Running a Container with a Liveness Probe and a Restart Policy

In this exercise, we will use the same pod configuration from the last exercise, the only difference being that the `restartPolicy` field will be set to `Never`. Follow these steps to complete the activity:

1. Create `liveness-probe-with-restart-policy.yaml` with the following pod configuration:

   ```
   apiVersion: v1
   kind: Pod
   metadata:
     name: liveness-probe-never-restart
   spec:
     restartPolicy: Never
     containers:
       - name: ubuntu-container
         image: ubuntu
         command:
           - /bin/bash
           - -ec
           - touch /tmp/ready; sleep 30; rm /tmp/ready; sleep 600
         livenessProbe:
           exec:
             command:
               - cat
               - /tmp/ready
           initialDelaySeconds: 5
           periodSeconds: 5
   ```

2. Run the following command to create the pod using `liveness-probe.yaml`:

   ```
   kubectl create -f liveness-probe-with-restart-policy.yaml
   ```

   You should see the following response:

   ```
   pod/liveness-probe-never-restart created
   ```

3. Let's wait for around one minute and run the `describe` command:

   ```
   kubectl describe pod liveness-probe-never-restart
   ```

   You should see the following output:

```
Name:               liveness-probe-never-restart
Namespace:          default
Priority:           0
PriorityClassName:  <none>
Node:               minikube/10.0.2.15
Start Time:         Thu, 04 Jul 2019 19:26:59 +0200
Labels:             <none>
Annotations:        <none>
Status:             Running
IP:                 172.17.0.8
Containers:
  ubuntu-container:
    Container ID:  docker://8613aa11bc7fa87e03256c7a929ab8c6f35c165b96372b0d7d25619ab2d7e14b
    Image:         ubuntu
    Image ID:      docker-pullable://ubuntu@sha256:9b1702dcfe32c873a770a32cfd306dd7fc1c4fd134adfb783db68defc8894b3c
    Port:          <none>
    Host Port:     <none>
    Command:
      /bin/bash
      -ec
      touch /tmp/ready; sleep 30; rm /tmp/ready; sleep 600
    State:          Running
      Started:      Thu, 04 Jul 2019 19:27:02 +0200
    Ready:          True
    Restart Count:  0
    Liveness:       exec [cat /tmp/ready] delay=5s timeout=1s period=5s #success=1 #failure=3
    Environment:    <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from default-token-7rmnp (ro)
Conditions:
  Type              Status
  Initialized       True
  Ready             True
  ContainersReady   True
  PodScheduled      True
Volumes:
  default-token-7rmnp:
    Type:        Secret (a volume populated by a Secret)
    SecretName:  default-token-7rmnp
    Optional:    false
QoS Class:       BestEffort
Node-Selectors:  <none>
Tolerations:     node.kubernetes.io/not-ready:NoExecute for 300s
                 node.kubernetes.io/unreachable:NoExecute for 300s
Events:
  Type     Reason     Age                 From               Message
  ----     ------     ----                ----               -------
  Normal   Scheduled  47s                 default-scheduler  Successfully assigned default/liveness-probe-never-restart to minikube
  Normal   Pulling    46s                 kubelet, minikube  Pulling image "ubuntu"
  Normal   Pulled     44s                 kubelet, minikube  Successfully pulled image "ubuntu"
  Normal   Created    44s                 kubelet, minikube  Created container ubuntu-container
  Normal   Started    44s                 kubelet, minikube  Started container ubuntu-container
  Warning  Unhealthy  2s (x3 over 12s)    kubelet, minikube  Liveness probe failed: cat: /tmp/ready: No such file or directory
  Normal   Killing    2s                  kubelet, minikube  Stopping container ubuntu-container
```

As we can see, in the last two highlighted lines, the controller will only kill the container and will never attempt to restart it, respecting the restart policy specified in the pod specification.

In the following exercise, we shall take a look at the implementation of a readiness probe.

Exercise 5.12: Creating a Pod Running a Container with a Readiness Probe

In this exercise, we will create a pod with a container that has a readiness probe.

1. Create a file named `readiness-probe.yaml` with the following pod configuration:

```
apiVersion: v1
kind: Pod
metadata:
  name: readiness-probe
spec:
  containers:
    - name: ubuntu-container
      image: ubuntu
      command:
        - /bin/bash
```

```
    - -ec
    - sleep 30; touch /tmp/ready; sleep 600
  readinessProbe:
    exec:
      command:
        - cat
        - /tmp/ready
    initialDelaySeconds: 10
    periodSeconds: 5
```

The preceding pod configuration specifies that there will be a container created from an Ubuntu image and the following command will be run once it starts:

```
/bin/bash -ec "sleep 30; touch /tmp/ready; sleep 600"
```

The preceding command sleeps for 30 seconds, creates an empty file at `/tmp/ready`, and then sleeps for 10 minutes before terminating with success.

Next, we have a readiness probe that executes the following command every 5 seconds with an initial delay of 10 seconds:

```
cat /tmp/ready
```

2. Run the following command to create the pod using `readiness-probe.yaml`:

```
kubectl create -f readiness-probe.yaml
```

You should see the following response:

```
pod/readiness-probe created
```

When the container starts, the default value of the readiness probe will be `Failure`. It will wait for 10 seconds before executing the probe for the first time.

3. Let's check the state of the pod:

```
kubectl get pod readiness-probe
```

You should see the following response:

```
NAME              READY     STATUS     RESTARTS     AGE
readiness-probe   0/1       Running    0            8s
```

We can see that the pod is not ready yet.

4. Now, let's try to find more information about this pod using the `describe` command. If we wait for more than 10 seconds after the container starts, we will see that the readiness probe starts failing:

```
kubectl describe pod readiness-probe
```

You should see the following output:

```
Name:               readiness-probe
Namespace:          default
Priority:           0
PriorityClassName:  <none>
Node:               minikube/10.0.2.15
Start Time:         Fri, 05 Jul 2019 00:40:14 +0200
Labels:             <none>
Annotations:        <none>
Status:             Running
IP:                 172.17.0.8
Containers:
  ubuntu-container:
    Container ID:  docker://58d6c9d12f16e81269ce4679ca9e54f750a4b997d6407976162085c82293cfef
    Image:         ubuntu
    Image ID:      docker-pullable://ubuntu@sha256:9b1702dcfe32c873a770a32cfd306dd7fc1c4fd134adfb783db68defc8894b3c
    Port:          <none>
    Host Port:     <none>
    Command:
      /bin/bash
      -ec
      sleep 30; touch /tmp/ready; sleep 600
    State:          Running
      Started:      Fri, 05 Jul 2019 00:40:17 +0200
    Ready:          False
    Restart Count:  0
    Readiness:      exec [cat /tmp/ready] delay=10s timeout=1s period=5s #success=1 #failure=3
    Environment:    <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from default-token-7rmnp (ro)
Conditions:
  Type              Status
  Initialized       True
  Ready             False
  ContainersReady   False
  PodScheduled      True
Volumes:
  default-token-7rmnp:
    Type:        Secret (a volume populated by a Secret)
    SecretName:  default-token-7rmnp
    Optional:    false
QoS Class:       BestEffort
Node-Selectors:  <none>
Tolerations:     node.kubernetes.io/not-ready:NoExecute for 300s
                 node.kubernetes.io/unreachable:NoExecute for 300s
Events:
  Type     Reason     Age   From               Message
  ----     ------     ----  ----               -------
  Normal   Scheduled  19s   default-scheduler  Successfully assigned default/readiness-probe to minikube
  Normal   Pulling    18s   kubelet, minikube  Pulling image "ubuntu"
  Normal   Pulled     16s   kubelet, minikube  Successfully pulled image "ubuntu"
  Normal   Created    16s   kubelet, minikube  Created container ubuntu-container
  Normal   Started    16s   kubelet, minikube  Started container ubuntu-container
  Warning  Unhealthy  2s    kubelet, minikube  Readiness probe failed: cat: /tmp/ready: No such file or directory
```

```
That output tells us that the readiness probe has failed once
already. If we wait for a while and run that command again, we will
see that the readiness probe keeps failing until 30 seconds have
elapsed since the starting time of the container. After that, the
readiness probe will start succeeding since a file will be created
at `/tmp/ready`.
```

5. Let's check the state of the pod again:

   ```
   kubectl get pod readiness-probe
   ```

   You should see the following response:

   ```
   NAME              READY    STATUS     RESTARTS     AGE
   readiness-probe   1/1      Running    0            66s
   ```

We can see that the probe has succeeded, and the pod is now in the `Ready` state.

Activity 5.01: Deploying an Application in a Pod

Imagine you are working with a team of developers who have built an awesome application that they want you to deploy in a pod. The application has a process that starts up and takes approximately 20 seconds to load all the required assets. Once the application starts up, it's ready to start receiving requests. If, for some reason, the application crashes, you would want the pod to restart itself as well. They have given you the task of creating the pod using a configuration that will satisfy these needs for the application developers in the best way possible.

We have provided a pre-made application image to emulate the behavior of the application mentioned above. You can get it by using this line in your pod spec:

```
image: fenago/the-kubernetes-workshop:custom-application-for-pods-chapter
```

Note

Ideally, you would want to create this pod in a different namespace to keep it separate from the rest of the stuff that you created during the exercises. So, feel free to create a namespace and create the pod in that namespace.

Here are the high-level steps to complete this activity:

1. Create a new namespace for your pod.
2. Create a pod configuration that's suitable for the application requirements. Ensure that you use an appropriate namespace, restart policy, readiness and liveness probes, and container image given by application developers.
3. Create a pod using the configuration you've just created.
4. Make sure the pod is running as per the requirements.

   Note

   The solution to this activity can be found at the following address: `Activity_Solutions\Solution_Final.pdf`.

Summary

In this lab, we have explored various components of pod configuration and learned when to use what. We should now be able to create a pod and choose the right values of various fields in the pod configuration according to the needs of your application. This ability puts us in a position where we can use our strong understanding of this essential, basic building block and extend it to develop a full-fledged application that's deployed reliably.

In the next lab, we will discuss how we can add labels and arbitrary metadata to pods and use them to identify or search for pods. That will help us to organize our pods as well as choose a subset of them when required.