Kubernetes Controllers

This chapter introduces the concept of Kubernetes controllers and explains how to use them to create replicated Deployments. We will describe the use of different types of controllers, such as ReplicaSets, Deployments, DaemonSets, StatefulSets, and Jobs. You will learn how to choose a suitable controller for specific use cases. Using hands-on exercises, we will guide you through how to use these controllers with the desired configuration to deploy several replicas of Pods for your application. You will also learn how to manage them using various commands.

Let's proceed to create our first ReplicaSet.

Exercise 7.01: Creating a Simple ReplicaSet with nginx Containers

In this exercise, we will create a simple ReplicaSet and examine the Pods created by it. To successfully complete this exercise, perform the following steps:

1. Create a file called `replicaset-nginx.yaml` with the following content:

   ```
   apiVersion: apps/v1
   kind: ReplicaSet
   metadata:
     name: nginx-replicaset
     labels:
       app: nginx
   spec:
     replicas: 2
     selector:
       matchLabels:
         environment: production
     template:
       metadata:
         labels:
           environment: production
       spec:
         containers:
         - name: nginx-container
           image: nginx
   ```

   As you can see in the highlighted part of the configuration, we have three fields: `replicas`, `selector`, and `template`. We have set the number of replicas to `2`. The Pod selector has been set in such a way that this ReplicaSet will manage the Pods with the `environment: production` label. The Pod template has the simple Pod configuration that we used in previous chapters. We have ensured that the Pod label selector matches the Pod's labels in the template exactly.

2. Run the following command to create the ReplicaSet using the preceding configuration:

   ```
   kubectl create -f replicaset-nginx.yaml
   ```

   You should see the following response:

   ```
   replicaset.apps/nginx-replicaset created
   ```

3. Verify that the ReplicaSet was created by using the `kubectl get` command:

```
kubectl get rs nginx-replicaset
```

Note that `rs` is a short form of `replicaset` in all kubectl commands.

You should see the following response:

```
NAME               DESIRED    CURRENT    READY    AGE
nginx-replicaset   2          2          2        30s
```

As you can see, we have a ReplicaSet with two desired replicas, as we defined in `replicaset-nginx.yaml` in *step 1*.

4. Verify that the Pods were actually created by using the following command:

```
kubectl get pods
```

You should get the following response:

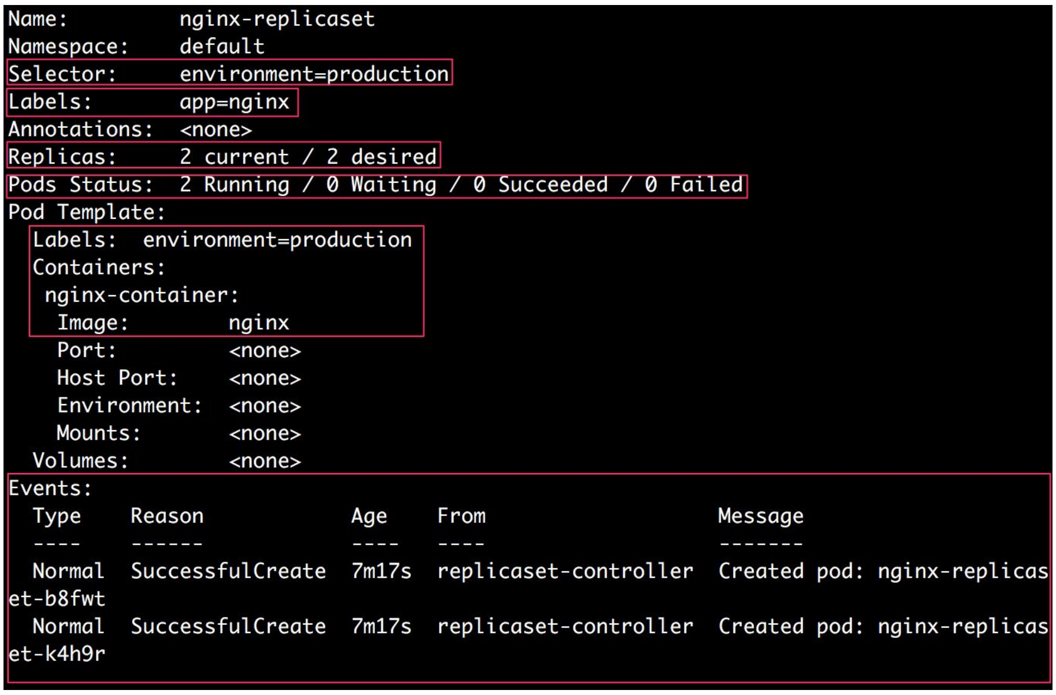
```
NAME                     READY    STATUS   RESTARTS   AGE
nginx-replicaset-b8fwt   1/1      Running  0          51s
nginx-replicaset-k4h9r   1/1      Running  0          51s
```

We can see that the names of the Pods created by the ReplicaSet take the name of the ReplicaSet as a prefix.

5. Now that we have created our first ReplicaSet, let's look at it in more detail to understand what actually happened during its creation. To do that, we can describe the ReplicaSet we just created by using the following command in the terminal:

```
kubectl describe rs nginx-replicaset
```

You should see output similar to the following:



```
Name:         nginx-replicaset
Namespace:    default
Selector:     environment=production
Labels:       app=nginx
Annotations:  <none>
Replicas:     2 current / 2 desired
Pods Status:  2 Running / 0 Waiting / 0 Succeeded / 0 Failed
Pod Template:
  Labels:  environment=production
  Containers:
   nginx-container:
    Image:        nginx
    Port:         <none>
    Host Port:    <none>
    Environment:  <none>
    Mounts:       <none>
  Volumes:        <none>
Events:
  Type    Reason            Age    From                   Message
  ----    ------            ----   ----                   -------
  Normal  SuccessfulCreate  7m17s  replicaset-controller  Created pod: nginx-replicas
et-b8fwt
  Normal  SuccessfulCreate  7m17s  replicaset-controller  Created pod: nginx-replicas
et-k4h9r
```

6. Next, we will inspect the Pods created by this ReplicaSet and verify that they have been created with the correct configuration. Run the following command to get a list of the Pods that are running:

```
kubectl get pods
```

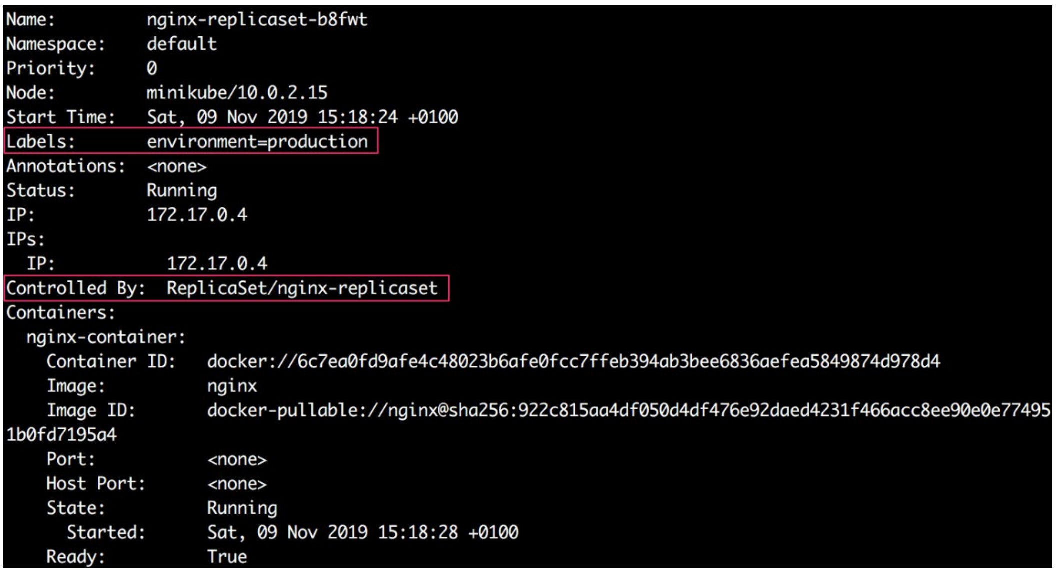
You should see a response as follows:

```
NAME                     READY   STATUS    RESTARTS   AGE
nginx-replicaset-b8fwt   1/1     Running   0          38m
nginx-replicaset-k4h9r   1/1     Running   0          38m
```

7. Run the following command to describe one of the Pods by copying its name:

```
kubectl describe pod <pod_name>
```

You should see output similar to the following:



```
Name:         nginx-replicaset-b8fwt
Namespace:    default
Priority:     0
Node:         minikube/10.0.2.15
Start Time:   Sat, 09 Nov 2019 15:18:24 +0100
Labels:       environment=production
Annotations:  <none>
Status:       Running
IP:           172.17.0.4
IPs:
  IP:           172.17.0.4
Controlled By:  ReplicaSet/nginx-replicaset
Containers:
  nginx-container:
    Container ID:   docker://6c7ea0fd9afe4c48023b6afe0fcc7ffeb394ab3bee6836aefea5849874d978d4
    Image:          nginx
    Image ID:       docker-pullable://nginx@sha256:922c815aa4df050d4df476e92daed4231f466acc8ee90e0e77495
1b0fd7195a4
    Port:           <none>
    Host Port:      <none>
    State:          Running
      Started:      Sat, 09 Nov 2019 15:18:28 +0100
    Ready:          True
```

In the highlighted sections of the preceding output, we can clearly see that the pod has the `environment=production` label and is controlled by `ReplicaSet/nginx-replicaset`.

So, we have created a simple ReplicaSet in this exercise. In the following subtopics, we will go through the highlighted sections of the preceding output to understand the ReplicaSet that's running.

Labels on the ReplicaSet

Consider the following line from the output shown in *Figure 7.1*:

```
Labels:       app=nginx
```

It shows that, as desired, the ReplicaSet was created with a label key called `app` with a value of `nginx`.

Selectors for the ReplicaSet

Now, consider the following line from the output shown in *Figure 7.1*:

```
Selector:     environment=production
```

This shows that the ReplicaSet is configured with an `environment=production` Pod selector. This means that this ReplicaSet will try to acquire Pods that have this label.

Replicas

Consider the following line from the output shown in *Figure 7.1*:

```
Replicas:     2 current / 2 desired
```

We can see that the ReplicaSet has the desired count of `2` for the Pods, and it also shows that there are currently two replicas present.

Pods Status

While the `Replicas` field only shows the number of Pods currently present, `Pods Status` shows the actual status of those Pods:

```
Pods Status:  2 Running / 0 Waiting / 0 Succeeded / 0 Failed
```

We can see that there are currently two Pods running under this ReplicaSet.

Pods Template

Now, let's consider the `Pod Template` section of the output shown in *Figure 7.1*. We can see that the Pod template is the same as was described in the configuration.

Events

In the last section of the output shown in *Figure 7.1*, we can see that there are two events, which denotes that two pods were created to get to the desired count of two Pods for the ReplicaSet.

In the last exercise, we created a ReplicaSet to maintain a number of running replicas. Now, let's consider a scenario where some nodes or Pods fail for some reason. We will see how the ReplicaSet will behave in this situation.

Exercise 7.02: Deleting Pods Managed by a ReplicaSet

In this exercise, we will delete one of the Pods managed by a ReplicaSet to see how it responds. This way, we will be simulating a single or multiple Pods failing during the runtime of a ReplicaSet:

Note

In this exercise, we will assume that you have successfully completed the previous exercise as we will be reusing the ReplicaSet created in that exercise.

1. Verify that the Pods created by the ReplicaSet are still running:

   ```
   kubectl get pods
   ```

   You should see something similar to the following response:

   ```
   NAME                      READY    STATUS   RESTARTS   AGE
   nginx-replicaset-9tgb9    1/1      Running  0          103s
   nginx-replicaset-zdjb5    1/1      Running  0          103s
   ```

2. Delete the first Pod to replicate Pod failure during runtime by using the following command:

   ```
   kubectl delete pod <pod_name>
   ```

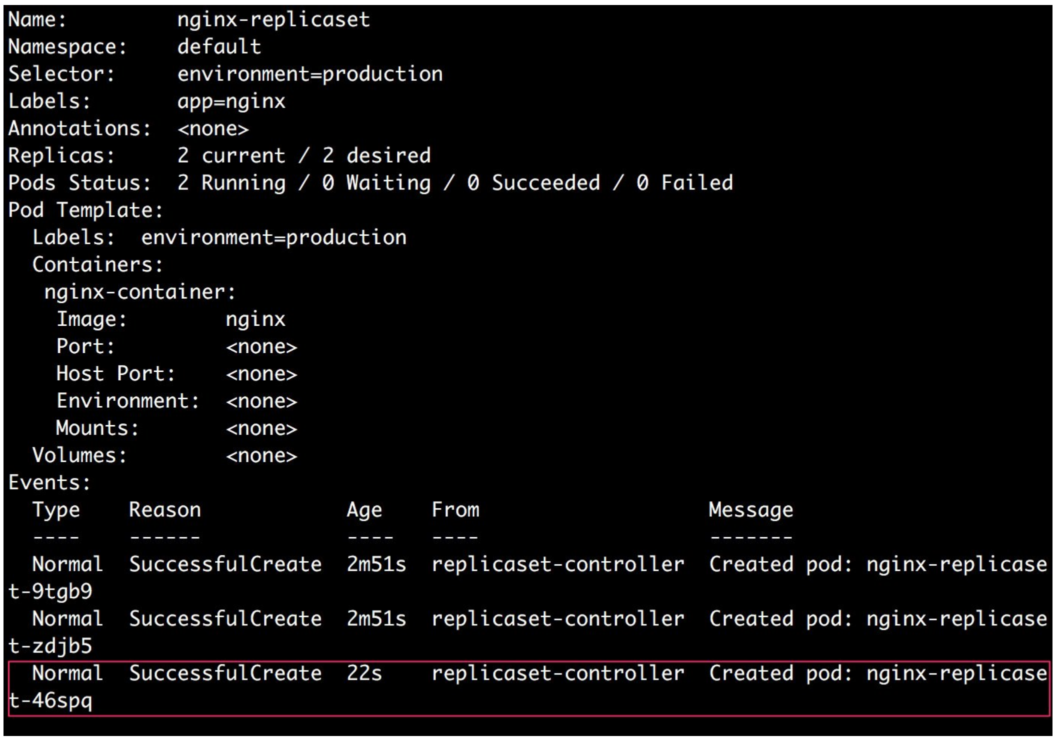
   You should see a response similar to the following:

   ```
   pod "nginx-replicaset-9tgb9" deleted
   ```

3. Describe the ReplicaSet and check the events:

   ```
   kubectl describe rs nginx-replicaset
   ```

   You should see output similar to the following:



```
Name:         nginx-replicaset
Namespace:    default
Selector:     environment=production
Labels:       app=nginx
Annotations:  <none>
Replicas:     2 current / 2 desired
Pods Status:  2 Running / 0 Waiting / 0 Succeeded / 0 Failed
Pod Template:
  Labels:  environment=production
  Containers:
   nginx-container:
    Image:        nginx
    Port:         <none>
    Host Port:    <none>
    Environment:  <none>
    Mounts:       <none>
  Volumes:        <none>
Events:
  Type    Reason            Age    From                   Message
  ----    ------            ----   ----                   -------
  Normal  SuccessfulCreate  2m51s  replicaset-controller  Created pod: nginx-replicase
t-9tgb9
  Normal  SuccessfulCreate  2m51s  replicaset-controller  Created pod: nginx-replicase
t-zdjb5
  Normal  SuccessfulCreate  22s    replicaset-controller  Created pod: nginx-replicase
t-46spq
```

```
As highlighted in the preceding output, we can see that after a Pod
is deleted, the ReplicaSet creates a new Pod using the Pod
configuration in the `Template` section of the ReplicaSet
configuration. Even if we delete all the Pods managed by the
ReplicaSet, they will be recreated. So, to delete all the Pods
permanently and to avoid the recreation of the Pods, we need to
delete the ReplicaSet itself.
```

4. Run the following command to delete the ReplicaSet:

   ```
   kubectl delete rs nginx-replicaset
   ```

   You should see the following response:

   ```
   replicaset.apps "nginx-replicaset" deleted
   ```

   As shown in the preceding output, the `nginx-replicaset` ReplicaSet was deleted.

5. Run the following command to verify that the Pods managed by the ReplicaSet were also deleted:

   ```
   kubectl get pods
   ```

   You should get the following response:

   ```
   No resources found in default namespace
   ```

   As you can see from this output, we can verify that the Pods were deleted.

Consider a scenario where you have already deployed a single Pod for testing. Now, it is ready to go live. You apply the required label changes from development to production, and now you want to control this using a ReplicaSet. We will see how to do this in the following exercise.

Exercise 7.03: Creating a ReplicaSet Given That a Matching Pod Already Exists

In this exercise, we will create a Pod that matches the Pod template in the ReplicaSet and then create the ReplicaSet. Our aim is to prove that the newly created ReplicaSet will acquire the existing Pod and start managing it as if it created that Pod itself.

In order to successfully complete this exercise, perform the following steps:

1. Create a file called `pod-matching-replicaset.yaml` with the following content:

   ```
   apiVersion: v1
   kind: Pod
   metadata:
     name: pod-matching-replicaset
     labels:
       environment: production
   spec:
     containers:
     - name: first-container
       image: nginx
   ```

2. Run the following command to create the Pod using the preceding configuration:

   ```
   kubectl create -f pod-matching-replicaset.yaml
   ```

   You should see the following response:

   ```
   pod/pod-matching-replicaset created
   ```

3. Create a file called `replicaset-nginx.yaml` with the following content:

   ```
   apiVersion: apps/v1
   kind: ReplicaSet
   metadata:
     name: nginx-replicaset
     labels:
       app: nginx
   spec:
     replicas: 2
     selector:
       matchLabels:
         environment: production
     template:
       metadata:
         labels:
           environment: production
       spec:
         containers:
   ```

```
      - name: nginx-container
        image: nginx
```

4. Run the following command to create the ReplicaSet using the preceding configuration:

   ```
   kubectl create -f replicaset-nginx.yaml
   ```

   You should see a response similar to the following:

   ```
   replicaset.apps/nginx-replicaset created
   ```

   This output indicates that the Pod has been created.

5. Run the following command to check the status of the ReplicaSet:

   ```
   kubectl get rs nginx-replicaset
   ```

   You should get the following response:

   ```
   NAME               DESIRED   CURRENT   READY   AGE
   nginx-replicaset   2         2         2       2
   ```

   We can see that there are currently two Pods managed by the ReplicaSet, as desired.

6. Next, let's check what Pods are running by using the following command:

   ```
   kubectl get pods
   ```

   You should see output similar to the following:

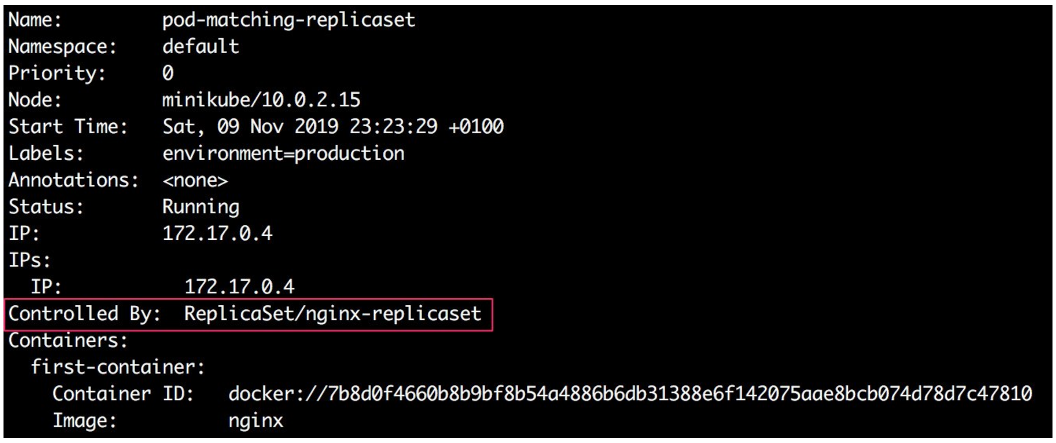
   ```
   NAME                      READY      STATUS    RESTARTS    AGE
   nginx-replicaset-4dr7s    1/1        Running   0           28s
   pod-matching-replicaset   1/1        Running   0           81s
   ```

   In this output, we can see that the manually created Pod named `pod-matching-replicaset` is still running and that there was only one new Pod created by the `nginx-replicaset` ReplicaSet.

7. Next, we will use the `kubectl describe` command to check whether the Pod named `pod-matching-replicaset` is being managed by the ReplicaSet:

   ```
   kubectl describe pod pod-matching-replicaset
   ```

   You should see output similar to the following:



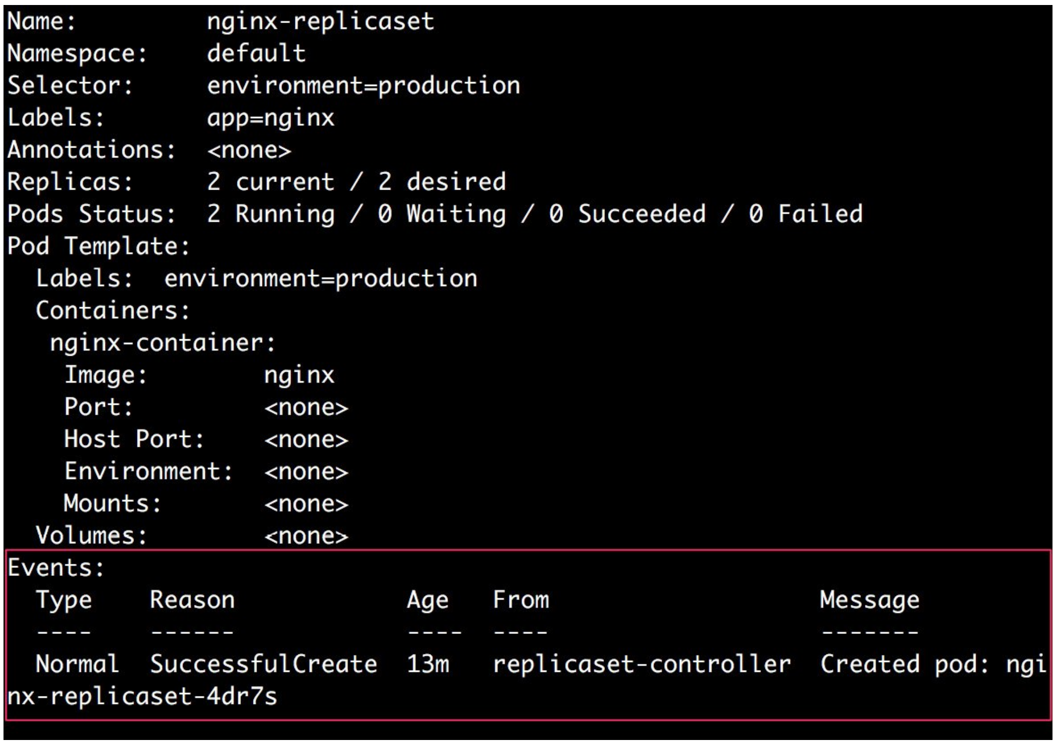
```
Name:         pod-matching-replicaset
Namespace:    default
Priority:     0
Node:         minikube/10.0.2.15
Start Time:   Sat, 09 Nov 2019 23:23:29 +0100
Labels:       environment=production
Annotations:  <none>
Status:       Running
IP:           172.17.0.4
IPs:
  IP:           172.17.0.4
Controlled By:  ReplicaSet/nginx-replicaset
Containers:
  first-container:
    Container ID:   docker://7b8d0f4660b8b9bf8b54a4886b6db31388e6f142075aae8bcb074d78d7c47810
    Image:          nginx
```

```
In the highlighted section of the truncated output, we can see that
even though this Pod was created manually before the ReplicaSet
event existed, this Pod is now managed by the ReplicaSet itself.
```

8. Next, we will describe the ReplicaSet to see how many Pod creations were triggered by it:

```
kubectl describe rs nginx-replicaset
```

You should see output similar to the following:



```
Name:         nginx-replicaset
Namespace:    default
Selector:     environment=production
Labels:       app=nginx
Annotations:  <none>
Replicas:     2 current / 2 desired
Pods Status:  2 Running / 0 Waiting / 0 Succeeded / 0 Failed
Pod Template:
  Labels:  environment=production
  Containers:
   nginx-container:
    Image:        nginx
    Port:         <none>
    Host Port:    <none>
    Environment:  <none>
    Mounts:       <none>
  Volumes:        <none>
Events:
  Type    Reason            Age   From                   Message
  ----    ------            ----  ----                   -------
  Normal  SuccessfulCreate  13m   replicaset-controller  Created pod: ngi
nx-replicaset-4dr7s
```

9. Run the following command to delete the ReplicaSet for cleanup:

```
kubectl delete rs nginx-replicaset
```

You should see the following response:

```
replicaset.apps "nginx-replicaset" deleted
```

So, we can see that a ReplicaSet is capable of acquiring existing Pods as long as they match the label selector criteria. In cases where there are more matching Pods than the desired count, the ReplicaSet will terminate some of the Pods in order to maintain the total count of running Pods.

Another common operation is horizontally scaling a ReplicaSet that you previously created. Let's say that you create a ReplicaSet with a certain number of replicas and later you need to have more or fewer replicas to manage increased or decreased demand. Let's see how you can scale the number of replicas in the next exercise.

Exercise 7.04: Scaling a ReplicaSet after It Is Created

In this exercise, we will create a ReplicaSet with two replicas and then modify it to increase the number of replicas. Then, we will reduce the number of replicas.

In order to successfully complete this exercise, perform the following steps:

1. Create a file called `replicaset-nginx.yaml` with the following content:

```
apiVersion: apps/v1
kind: ReplicaSet
metadata:
  name: nginx-replicaset
  labels:
    app: nginx
spec:
  replicas: 2
  selector:
    matchLabels:
      environment: production
  template:
    metadata:
      labels:
        environment: production
    spec:
      containers:
      - name: nginx-container
        image: nginx
```

2. Run the following command to create the ReplicaSet using the `kubectl apply` command, as described in the preceding code:

```
kubectl apply -f replicaset-nginx.yaml
```

You should get the following response:

```
replicaset.apps/nginx-replicaset created
```

3. Run the following command to check all the existing Pods:

```
kubectl get pods
```

You should get a response similar to the following:

```
NAME                      READY    STATUS    RESTARTS    AGE
nginx-replicaset-99tj7    1/1      Running   0           23s
nginx-replicaset-s4stt    1/1      Running   0           23s
```

We can see that there are two Pods created by the replica set.

4. Run the following command to scale up the number of replicas for the ReplicaSet to `4` :

```
kubectl scale --replicas=4 rs nginx-replicaset
```

You should see the following response:

```
replicaset.apps/nginx-replicaset scaled
```

5. Run the following command to check all the Pods that are running:

```
kubectl get pods
```

You should see output similar to the following:

```
NAME                      READY    STATUS    RESTARTS    AGE
nginx-replicaset-99tj7    1/1      Running   0           75s
nginx-replicaset-klh6k    1/1      Running   0           21s
nginx-replicaset-lrqsk    1/1      Running   0           21s
nginx-replicaset-s4stt    1/1      Running   0           75s
```

We can see that now there are a total of four Pods. The ReplicaSet created two new Pods after we applied the new configuration.

6. Next, let's run the following command to scale down the number of replicas to `1` :

```
kubectl scale --replicas=1 rs nginx-replicaset
```

You should see the following response:

```
replicaset.apps/nginx-replicaset scaled
```

7. Run the following command to check all the Pods that are running:

```
kubectl get pods
```

You should see a response similar to the following:

```
nginx-replicaset-s4stt    1/1      Running   0           11m
```

We can see that this time, the ReplicaSet deleted all the Pods exceeding the count from the desired count of `1` and kept only one replica running.

8. Run the following command to delete the ReplicaSet for cleanup:

```
kubectl delete rs nginx-replicaset
```

You should see the following response:

```
replicaset.apps "nginx-replicaset" deleted
```

In this exercise, we have managed to scale the number of replicas up and down. This could be particularly useful if the traffic to your application grows or decreases for any reason.

Exercise 7.05: Creating a Simple Deployment with Nginx Containers

In this exercise, we will create our first Deployment Pod using the configuration described in the previous section.

To successfully complete this exercise, perform the following steps:

1. Create a file called `nginx-deployment.yaml` with the following content:

   ```
   apiVersion: apps/v1
   kind: Deployment
   metadata:
     name: nginx-deployment
     labels:
       app: nginx
   spec:
     replicas: 3
     selector:
       matchLabels:
         app: nginx
         environment: production
     template:
       metadata:
         labels:
           app: nginx
           environment: production
       spec:
         containers:
         - name: nginx-container
           image: nginx
   ```

   In this configuration, we can see that the Deployment will have three replicas of Pods running with the `app: nginx` and `environment: production` labels.

2. Run the following command to create the Deployment defined in the previous step:

   ```
   kubectl apply -f nginx-deployment.yaml
   ```

   You should see the following response:

   ```
   deployment.apps/nginx-deployment created
   ```

3. Run the following command to check the status of the Deployment:

   ```
   kubectl get deployment nginx-deployment
   ```

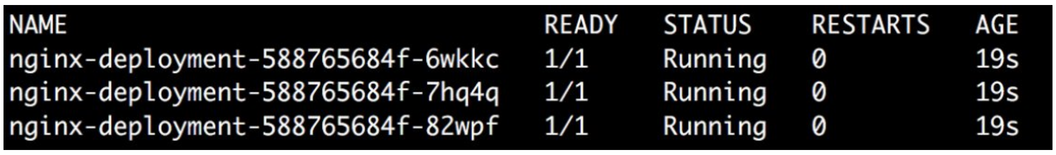
   You should see a response similar to the following:

```
NAME               READY    UP-TO-DATE    AVAILABLE   AGE
nginx-deployment   3/3      3             3           26m
```

4. Run the following command to check all the Pods that are running:

   ```
   kubectl get pods
   ```

   You should see a response similar to the following:

   ```
   NAME                                READY   STATUS    RESTARTS   AGE
   nginx-deployment-588765684f-6wkkc   1/1     Running   0          19s
   nginx-deployment-588765684f-7hq4q   1/1     Running   0          19s
   nginx-deployment-588765684f-82wpf   1/1     Running   0          19s
   ```

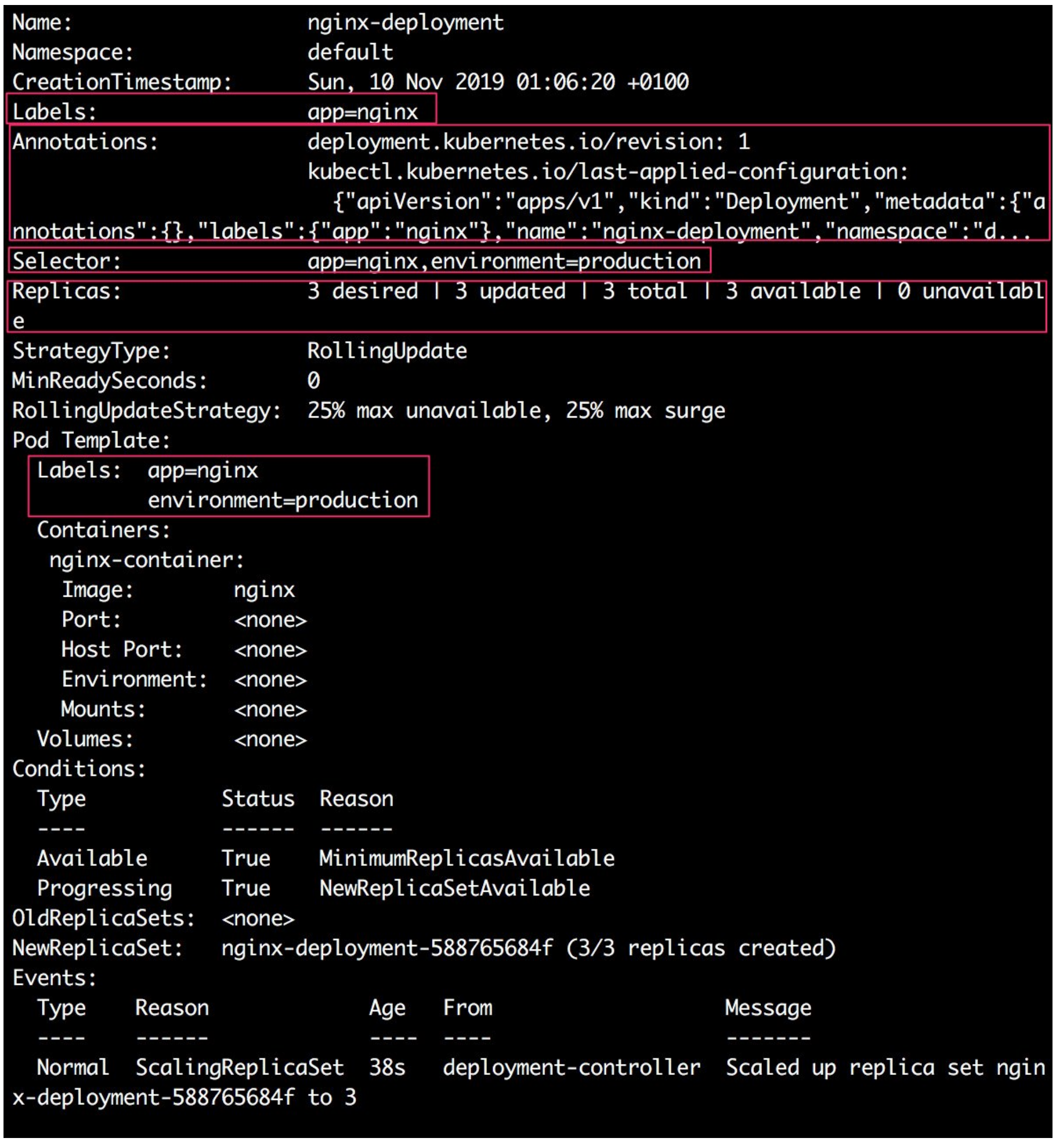
```
We can see that the Deployment has created three Pods, as desired.

Let\'s try to understand the names given to the Pods automatically.
`nginx-deployment` creates a ReplicaSet named
`nginx-deployment-588765684f`. The ReplicaSet then creates
three replicas of Pods, each of which has a name that is prefixed
with the name of the ReplicaSet followed by a unique identifier.
```

5. Now that we have created our first Deployment, let's look at it in more detail to understand what actually happened during its creation. To do that, we can describe the Deployment we just created using the following command in the terminal:

   ```
   kubectl describe rs nginx-deployment
   ```

   You should see output similar to this:



```
Name:                   nginx-deployment
Namespace:              default
CreationTimestamp:      Sun, 10 Nov 2019 01:06:20 +0100
Labels:                 app=nginx
Annotations:            deployment.kubernetes.io/revision: 1
                        kubectl.kubernetes.io/last-applied-configuration:
                          {"apiVersion":"apps/v1","kind":"Deployment","metadata":{"a
nnotations":{},"labels":{"app":"nginx"},"name":"nginx-deployment","namespace":"d...
Selector:               app=nginx,environment=production
Replicas:               3 desired | 3 updated | 3 total | 3 available | 0 unavailabl
e
StrategyType:           RollingUpdate
MinReadySeconds:        0
RollingUpdateStrategy:  25% max unavailable, 25% max surge
Pod Template:
  Labels:  app=nginx
           environment=production
  Containers:
   nginx-container:
    Image:        nginx
    Port:         <none>
    Host Port:    <none>
    Environment:  <none>
    Mounts:       <none>
  Volumes:        <none>
Conditions:
  Type           Status  Reason
  ----           ------  ------
  Available      True    MinimumReplicasAvailable
  Progressing    True    NewReplicaSetAvailable
OldReplicaSets:  <none>
NewReplicaSet:   nginx-deployment-588765684f (3/3 replicas created)
Events:
  Type    Reason             Age   From                   Message
  ----    ------             ----  ----                   -------
  Normal  ScalingReplicaSet  38s   deployment-controller  Scaled up replica set ngin
x-deployment-588765684f to 3
```

This output shows various details about the Deployment we just created. In the following subtopics, we will go through the highlighted sections of the preceding output to understand the Deployment that's running.

Labels and Annotations on the Deployment

Similar to ReplicaSets, we can see the following line highlighted in the output shown in *Figure 7.8*:

```
Labels:    app=nginx
```

This indicates that the Deployment was created with an `app=nginx` label. Now, let's consider the next field in the output:

```
Annotations:    deployment.kubernetes.io/revision: 1
                kubectl.kubernetes.io/last-applied-configuration:
{"apiVersion":"apps/v1","kind":"Deployment","metadata":{"annotations":{},"labels":
{"app":"nginx"},"name":"nginx-deployment","namespace":"d...
```

There are two annotations added to the Deployment automatically.

The Revision annotation

The Kubernetes controller adds an annotation with the `deployment.kubernetes.io/revision` key, which contains information about how many revisions have been there for a particular Deployment.

The last-applied-configuration annotation

Another annotation added by the controller has the `kubectl.kubernetes.io/last-applied-configuration` key, which contains the last configuration (in JSON format) that was applied to the Deployment. This annotation is particularly helpful in rolling back a Deployment to a previous revision if a new revision doesn't work well.

Selectors for the Deployment

Now, consider the following line from the output shown in *Figure 7.8*:

```
Selector:    app=nginx,environment=production
```

This shows which Pod selectors the Deployment is configured with. So, this Deployment will try to acquire the Pods that have both of these labels.

Replicas

Consider the following line from the output shown in *Figure 7.8*:

```
Replicas:    3 desired | 3 updated | 3 total | 3 available | 0 unavailable
```

We can see that the Deployment has the desired count of `3` for the Pods, and it also shows that there are currently `3` replicas present.

Rolling Back a Deployment

In a real-life scenario, you may make a mistake when making a change in the Deployment configuration. You can easily undo a change and roll back to a previous stable revision of the Deployment.

We can use the `kubectl rollout` command to check the revision history and rollback. But to make this work, we also need to use the `--record` flag when we use any `apply` or `set` commands to modify the Deployment. This flag records the rollout history. Then, you can view the rollout history using the following command:

```
kubectl rollout history deployment <deployment_name>
```

Then, we can undo any updates by using the following command:

```
kubectl rollout undo deployment <deployment_name>
```

Let's take a closer look at how this works in the following exercise:

Exercise 7.06: Rolling Back a Deployment

In this exercise, we will update the Deployment twice. We will make an intentional mistake in the second update and try to roll back to a previous revision:

1. Create a file called `app-deployment.yaml` with the following content:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: app-deployment
  labels:
    environment: production
spec:
  replicas: 3
  selector:
    matchLabels:
      app: nginx
      environment: production
  template:
    metadata:
      labels:
        app: nginx
        environment: production
    spec:
      containers:
      - name: nginx-container
        image: nginx
```

2. Run the following command to create the Deployment:

   ```
   kubectl apply -f app-deployment.yaml
   ```

   You should see the following response:

   ```
   deployment.apps/app-deployment created
   ```

3. Run the following command to check the rollout history of the newly created Deployment:

   ```
   kubectl rollout history deployment app-deployment
   ```

   You should see the following response:

   ```
   deployment.apps/app-deployment
   REVISION     CHANGE-CAUSE
   1            <none>
   ```

   This output shows that the Deployment has no rollout history as of now.

4. For the first update, let's change the name of the container to `nginx` instead of `nginx-container`. Update the content of the `app-deployment.yaml` file with the following:

   ```
   apiVersion: apps/v1
   kind: Deployment
   metadata:
     name: app-deployment
     labels:
       environment: production
   spec:
     replicas: 3
   ```

```
  selector:
    matchLabels:
      app: nginx
      environment: production
  template:
    metadata:
      labels:
        app: nginx
        environment: production
    spec:
      containers:
      - name: nginx
        image: nginx
```

As you can see, the only thing that has changed in this template is the container name.

5. Apply the changed configuration using the `kubectl apply` command with the `--record` flag. The `--record` flag ensures that the update to the Deployment is recorded in the rollout history of the Deployment:

   ```
   kubectl apply -f app-deployment.yaml --record
   ```

   You should see the following response:

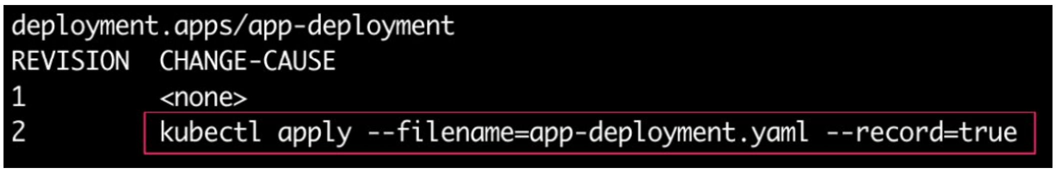
   ```
   deployment.apps/app-deployment configured
   ```

   Note that the rollout history maintained by the `--record` flag is different from the past configs stored in the annotations, which we saw in the *Labels and Annotations on the Deployment* subsection.

6. Wait for a few seconds to allow the Deployment to recreate the Pods with the updated Pod configuration, and then run the following command to check the rollout history of the Deployment:

   ```
   kubectl rollout history deployment app-deployment
   ```

   You should see the following response:



```
deployment.apps/app-deployment
REVISION  CHANGE-CAUSE
1         <none>
2         kubectl apply --filename=app-deployment.yaml --record=true
```

```
In the output, we can see that the second revision of the Deployment
was created. It also keeps track of what command was used to update
the Deployment.
```

7. Next, let's update the Deployment and assume that we made a mistake while doing so. In this example, we will update the container image to `ngnx` (note the intentional spelling error) instead of `nginx` using the `set image` command:

   ```
   kubectl set image deployment app-deployment nginx=ngnx --record
   ```

You should see the following response:

```
deployment.apps/app-deployment image updated
```

8. Wait for a few seconds for Kubernetes to recreate the new containers, and then check the status of the Deployment rollout using the `kubectl rollout status` command:

```
kubectl rollout status deployment app-deployment
```

You should see the following response:

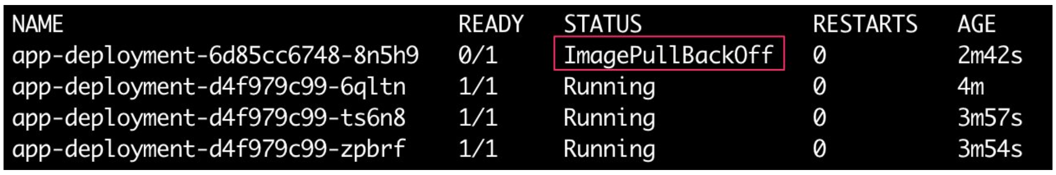
```
Waiting for deployment "app-deployment" rollout to finish: 1 out of 3 new
replicas have been updated...
```

In this output, we can see that none of the new replicas are ready yet. Press *Ctrl* + *C* to exit and proceed.

9. Run the following command to check the state of the Pods:

```
kubectl get pods
```

You should see the following output:



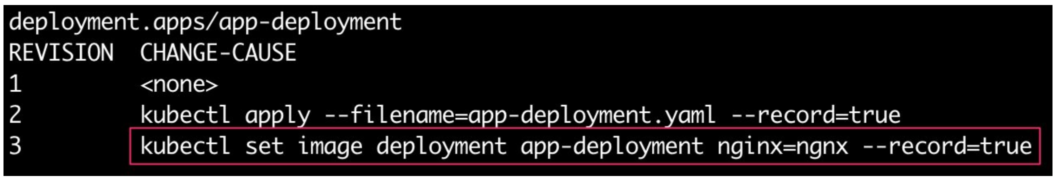
```
NAME                              READY   STATUS             RESTARTS   AGE
app-deployment-6d85cc6748-8n5h9   0/1     ImagePullBackOff   0          2m42s
app-deployment-d4f979c99-6qltn    1/1     Running            0          4m
app-deployment-d4f979c99-ts6n8    1/1     Running            0          3m57s
app-deployment-d4f979c99-zpbrf    1/1     Running            0          3m54s
```

```
We can see in the output that the newly created Pod has failed with
an `ImagePullBackOff` error, which means that the Pods
aren\'t able to pull the image. This is expected because we have a
typo in the name of the image.
```

10. Next, check the revision history of the Deployment again by using the following command:

```
kubectl rollout history deployment app-deployment
```

You should see the following response:



```
deployment.apps/app-deployment
REVISION  CHANGE-CAUSE
1         <none>
2         kubectl apply --filename=app-deployment.yaml --record=true
3         kubectl set image deployment app-deployment nginx=ngnx --record=true
```

```
We can see that a third revision of the Deployment was created using
the `set image` command containing the typo. Now that we
have pretended to have made a mistake in updating the Deployment, we
will see how to undo this and roll back to the last stable revision
of the Deployment.
```

11. Run the following command to roll back to the previous revision:

    ```
    kubectl rollout undo deployment app-deployment
    ```

    You should see the following response:

    ```
    deployment.apps/app-deployment rolled back
    ```

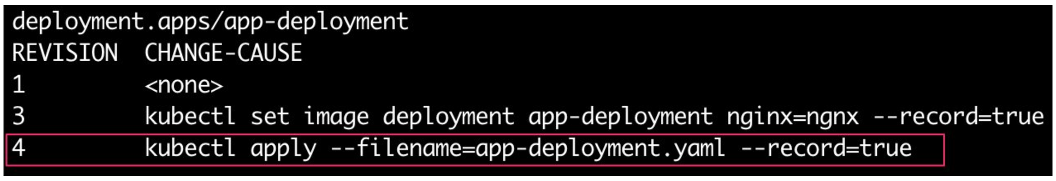
    As we can see in this output, the Deployment has not been rolled back to the previous revision. To practice, we may want to roll back to a revision different from the previous revision. We can use the `--to-revision` flag to specify the revision number to which we want to roll back. For example, in the preceding case, we could have used the following command and the result would have been exactly the same:

    ```
    kubectl rollout undo deployment app-deployment --to-revision=2
    ```

12. Run the following command to check the rollout history of the Deployment again:

    ```
    kubectl rollout history deployment app-deployment
    ```

    You should see the following output:



```
deployment.apps/app-deployment
REVISION  CHANGE-CAUSE
1         <none>
3         kubectl set image deployment app-deployment nginx=ngnx --record=true
4         kubectl apply --filename=app-deployment.yaml --record=true
```

We can see in this output that a new revision was created, which applied the revision that was previously revision 2. We can see that revision 2 is no longer present in the list of revisions. This is because rollouts are always done in a rolling-forward manner. This means that any time we update a revision, a new revision of a higher number is created. Similarly, in the case of a rollback to revision 2, revision 2 became revision 4.

In this exercise, we explored a lot of different possible operations relating to updating a Deployment, rolling it forward with some changes, tracking the history of a Deployment, undoing some changes, and rolling back to a previous revision.

Exercise 7.07: Creating a Simple Job That Finishes in Finite Time

In this exercise, we will create our first Job, which will run a container that simply waits for 10 seconds and then finishes.

To successfully complete this exercise, perform the following steps:

1. Create a file called `one-time-job.yaml` with the following content:

    ```
    apiVersion: batch/v1
    kind: Job
    metadata:
      name: one-time-job
    spec:
      template:
        spec:
    ```

```
      containers:
      - name: busybox-container
        image: busybox
        args:
        - /bin/sh
        - -c
        - date; sleep 20; echo "Bye"
      restartPolicy: OnFailure
```

2. Run the following command to create the Deployment using the `kubectl apply` command:

   ```
   kubectl apply -f one-time-job.yaml
   ```

   You should see the following response:

   ```
   job.batch/one-time-job created
   ```

3. Run the following command to check the status of the Job:

   ```
   kubectl get jobs
   ```

   You should see a response similar to this:

   ```
   NAME           COMPLETIONS    DURATION    AGE
   one-time-job   0/1            3s          3s
   ```

   We can see that the Job requires one completion and is not yet completed.

4. Run the following command to check the Pod running the Job:

   ```
   kubectl get pods
   ```

   Note that you should run this before the Job is complete to see the response shown here:

   ```
   NAME                 READY    STATUS     RESTARTS    AGE
   one-time-job-bzz8l   1/1      Running    0           7s
   ```

   We can see that the Job has created a Pod named `one-time-job-bzz8l` to run the task specified in the Job template.

5. Next, run the following command to check the logs for the Pod created by the Job:

   ```
   kubectl logs -f <pod_name>
   ```

   You should see logs similar to the following:

   ```
   Sun   Nov 10 15:20:19 UTC 2019
   Bye
   ```

   We can see that the Pod printed the date, waited for 20 seconds, and then printed `Bye` in the terminal.

6. Let's check the status of the Job again by using the following command:

   ```
   kubectl get job one-time-job
   ```

You should see a response similar to this:

```
NAME           COMPLETIONS     DURATION    AGE
one-time-job   1/1             24s         14m
```

We can see that the Job has now been completed.

7. Run the following command to verify that the Pod has run to completion:

   ```
   kubectl get pods
   ```

   You should see a response similar to this:

   ```
   NAME                  READY    STATUS     RESTARTS    AGE
   one-time-job-whw79    0/1      Completed  0           32m
   ```

   We can see that the Pod has a `Completed` status.

8. Run the following command to delete the job (as well as the Pod it created) for cleanup:

   ```
   kubectl delete job one-time-job
   ```

   You should see the following response:

   ```
   job.batch "one-time-job" deleted
   ```

In this exercise, we created a one-time Job and verified that the Pod created by the Job runs to completion. Implementing Jobs for parallel tasks is a bit more complicated, and we will leave that out of this workshop for brevity.

Next, let's wrap this chapter up with an activity where we will create a Deployment and bring together several ideas learned in this chapter.

Activity 7.01: Creating a Deployment Running an Application

Consider a scenario where the product/application team you're working with is now ready to put their application in production and they need your help to deploy it in a replicated and reliable manner. For the scope of this exercise, consider the following requirements for the application:

- The default number of replicas should be 6.
- For simplicity, you can use the `nginx` image for the container running in the Pod.
- Make sure all the Pods have the following two labels with corresponding values:

  ```
  chapter=controllers
  activity=1
  ```

- The update strategy for the Deployment should be `RollingUpdate`. At worst, no more than half of the Pods can be down, and similarly, at no point should there be more than 150% of the desired count of Pods.

You should be able to perform the following tasks once the Deployment has been created:

- Scale up the number of replicas to 10.

- Scale down the number of replicas to 5.

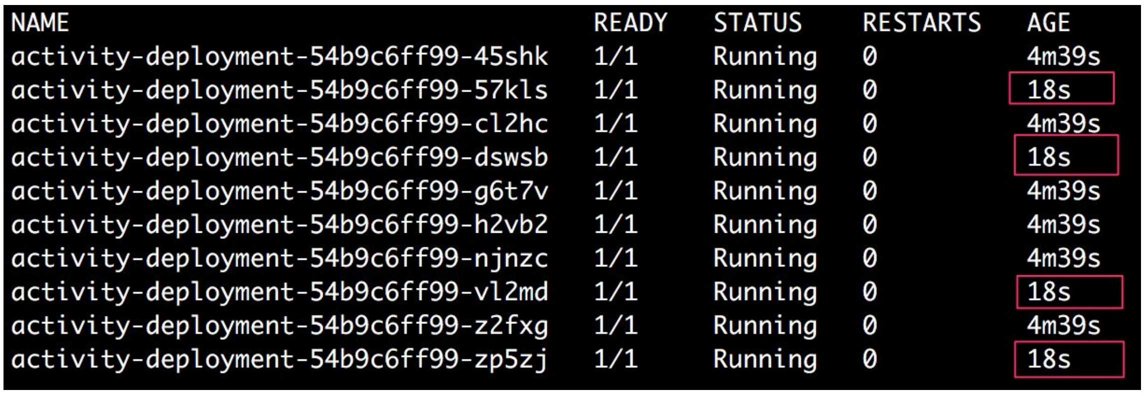
  Note

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

The following are the high-level steps to perform this activity:

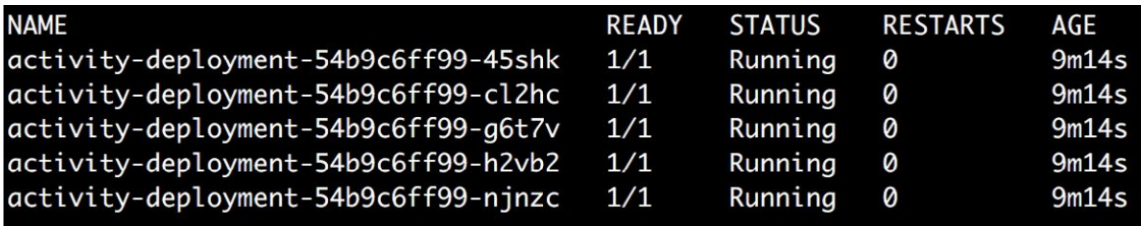
1. Create a namespace for this activity.
2. Write the Deployment configuration. Ensure that it meets all the requirements that are specified.
3. Create the Deployment using the configuration from the previous step.
4. Verify that six Pods were created by the Deployment.
5. Perform both of the tasks mentioned previously and verify the number of Pods after performing each step.

You should be able to get the list of Pods to check whether you can scale up the number of Pods, as shown in the following image:



```
NAME                                 READY   STATUS    RESTARTS   AGE
activity-deployment-54b9c6ff99-45shk   1/1     Running   0          4m39s
activity-deployment-54b9c6ff99-57kls   1/1     Running   0          18s
activity-deployment-54b9c6ff99-cl2hc   1/1     Running   0          4m39s
activity-deployment-54b9c6ff99-dswsb   1/1     Running   0          18s
activity-deployment-54b9c6ff99-g6t7v   1/1     Running   0          4m39s
activity-deployment-54b9c6ff99-h2vb2   1/1     Running   0          4m39s
activity-deployment-54b9c6ff99-njnzc   1/1     Running   0          4m39s
activity-deployment-54b9c6ff99-vl2md   1/1     Running   0          18s
activity-deployment-54b9c6ff99-z2fxg   1/1     Running   0          4m39s
activity-deployment-54b9c6ff99-zp5zj   1/1     Running   0          18s
```

Similarly, you should also be able to scale down and check the number of Pods, as shown here:



```
NAME                                 READY   STATUS    RESTARTS   AGE
activity-deployment-54b9c6ff99-45shk   1/1     Running   0          9m14s
activity-deployment-54b9c6ff99-cl2hc   1/1     Running   0          9m14s
activity-deployment-54b9c6ff99-g6t7v   1/1     Running   0          9m14s
activity-deployment-54b9c6ff99-h2vb2   1/1     Running   0          9m14s
activity-deployment-54b9c6ff99-njnzc   1/1     Running   0          9m14s
```

Note

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

Summary

Kubernetes treats Pods as ephemeral entities, and ideally you would not deploy any application or a microservice in an individual Pod. Kubernetes offers various controllers to leverage various benefits, including automatic replication, health monitoring, and automatic scaling.

In this chapter, we covered different kinds of controllers and understood when to use each of them. We created ReplicaSets and observed how they manage Pods. We learned when to use DaemonSets and StatefulSets. We also created a Deployment and learned how we can scale up and down the number of replicas and roll back to an earlier version of the Deployment. Finally, we learned how to create Jobs for one-time tasks. All of these controllers come into play when you want to deploy a production-ready application or workload, as you will see in the upcoming chapters.

In the next chapter, we will see how we can discover and access the Pods or replicas managed by a Deployment or a ReplicaSet.