Service Discovery

In this lab, we will take a look at how to route traffic between the various kinds of objects that we have created in previous labs and make them discoverable from both within and outside our cluster. This lab also introduces the concept of Kubernetes Services and explains how to use them to expose the application deployed using controllers such as Deployments. By the end of this lab, you will be able to make your application accessible to the external world. You will also know about the different types of Services and be able to use them to make different sets of pods interact with each other.

Exercise 8.01: Creating a Simple NodePort Service with Nginx Containers

In this exercise, we will create a simple NodePort Service with Nginx containers. Nginx containers, by default, expose port `80` on the Pod with an HTML page saying `Welcome to nginx!`. We will make sure that we can access that page from a browser on our local machine.

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
  strategy:
    type: Recreate
  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 using the `kubectl apply` command:

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

   You should get the following output:

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

   As we can see, `nginx-deployment` has been created.

3. Run the following command to verify that the Deployment has created three replicas:

```
kubectl get pods
```

You should see a response similar to the following:

```
NAME                                READY   STATUS    RESTARTS   AGE
nginx-deployment-588765684f-4dzvv   1/1     Running   0          113s
nginx-deployment-588765684f-n8ltl   1/1     Running   0          113s
nginx-deployment-588765684f-qxcqh   1/1     Running   0          113s
```

4. Create a file called `nginx-service-nodeport.yaml` with the following content:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx-service-nodeport
spec:
  type: NodePort
  ports:
    - port: 80
      targetPort: 80
      nodePort: 32023
  selector:
      app: nginx
      environment: production
```

5. Run the following command to create the Service:

```
kubectl create -f nginx-service-nodeport.yaml
```

You should see the following output:

```
service/nginx-service-nodeport created
```

Alternatively, we can use the `kubectl expose` command to expose a Deployment or a Pod using a Kubernetes Service. The following command will also create a NodePort Service named `nginx-service-nodeport`, with `port` and `targetPort` set to `80`. The only difference is that this command doesn't allow us to customize the `nodePort` field. `nodePort` is automatically allocated when we create the Service using the `kubectl expose` command:

```
kubectl expose deployment nginx-deployment --name=nginx-service-nodeport --
port=80 --target-port=80 --type=NodePort
```

If we use this command to create the Service, we will be able to

the Service in the following step.

6. Run the following command to verify that the Service was created:

```
kubectl get service
```

This should give a response similar to the following:

```
NAME                     TYPE        CLUSTER-IP    EXTERNAL-IP   PORT(S)        AGE
kubernetes               ClusterIP   10.96.0.1     <none>        443/TCP        54d
nginx-service-nodeport   NodePort    10.97.8.85    <none>        80:32023/TCP   3m21s
```

```
You can ignore the additional Service named `kubernetes`,
which already existed before we created our Service. This Service is
used to expose the Kubernetes API of the cluster internally.
```

7. Run the following command to verify that the Service was created with the correct configuration:

   ```
   kubectl describe service nginx-service-nodeport
   ```

   This should give us the following output:

```
Name:                     nginx-service-nodeport
Namespace:                default
Labels:                   <none>
Annotations:              <none>
Selector:                 app=nginx,environment=production
Type:                     NodePort
IP:                       10.97.8.85
Port:                     <unset>  80/TCP
TargetPort:               80/TCP
NodePort:                 <unset>  32023/TCP
Endpoints:                172.17.0.3:80,172.17.0.4:80,172.17.0.5:80
Session Affinity:         None
External Traffic Policy:  Cluster
Events:                   <none>
```

```
In the highlighted sections of the output, we can confirm that the
Service was created with the correct `Port`,
`TargetPort`, and `NodePort` fields.

There\'s also another field called `Endpoints`. We can see
that the value of this field is a list of IP addresses; that is,
`172.17.0.3:80`, `172.17.0.4:80`, and
`172.17.0.5:80`. Each of these IP addresses points to the
IP addresses allocated to the three Pods created by
`nginx-deployment`, along with the target ports exposed by
all of those Pods. We can use the `custom-columns` output
format alongside the `kubectl get pods` command to get the
IP addresses for all three pods. We can create a custom column
output using the `status.podIP` field, which contains the
IP address of a running Pod.
```

8. Run the following command to see the IP addresses of all three Pods:

```
kubectl get pods -o custom-columns=IP:status.podIP
```

You should see the following output:

```
IP
172.17.0.4
172.17.0.3
172.17.0.5
```

Hence, we can see that the `Endpoints` field of the Service actually points to the IP addresses of our three Pods.

As we know in the case of a NodePort Service, we can access the Pod's application using the IP address of the node and the port exposed by the Service on the node. To do this, we need to find out the IP address of the node in the Kubernetes cluster.

9. Run the following command to get the IP address of the Kubernetes cluster running locally:

```
minikube ip
```

You should see the following response:

```
192.168.99.100
```

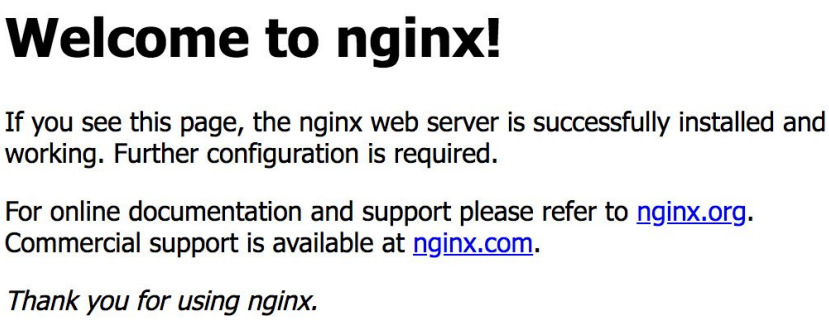
10. Run the following command to send a request to the IP address we obtained from the previous step at port `32023` using `curl`:

```
curl 192.168.99.100:32023
```

You should get a response from Nginx like so:

```
<!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>
```

11. Finally, open your browser and enter `192.168.99.100:32023` to make sure we can get to the following page:




```
Note

Ideally, you would want to create the objects for each exercise and
activity in different namespaces to keep them separate from the rest
of your objects. So, feel free to create a namespace and create the
Deployment in that namespace. Alternatively, you can ensure that you
clean up any objects shown in the following commands so that there
is no interference.
```

12. Delete both the Deployment and the Service to ensure you're working on the clean ground for the rest of the exercises in this lab:

```
kubectl delete deployment nginx-deployment
```

You should see the following response:

```
deployment.apps "nginx-deployment" deleted
```

Now, delete the Service using the following command:

```
kubectl delete service nginx-service-nodeport
```

You should see this response:

```
service "nginx-service-nodeport" deleted
```

In this exercise, we have created a Deployment with three replicas of the Nginx container (this can be replaced with any real application running in the container) and exposed the application using the NodePort Service.

Exercise 8.02: Creating a Simple ClusterIP Service with Nginx Containers

In this exercise, we will create a simple ClusterIP Service with Nginx containers. Nginx containers, by default, expose port `80` on the Pod with an HTML page saying `Welcome to nginx!`. We will make sure that we can access that page from inside the Kubernetes cluster using the `curl` command. Let's get started:

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
  strategy:
    type: Recreate
  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 using the `kubectl apply` command:

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

You should see the following response:

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

3. Run the following command to verify that the Deployment has created three replicas:

```
kubectl get pods
```

You should see output similar to the following:

```
NAME                                READY   STATUS    RESTARTS   AGE
nginx-deployment-588765684f-cg6n4   1/1     Running   0          43s
nginx-deployment-588765684f-fcsj4   1/1     Running   0          43s
nginx-deployment-588765684f-m5bdk   1/1     Running   0          43s
```

4. Create a file called `nginx-service-clusterip.yaml` with the following content:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx-service-clusterip
spec:
  type: ClusterIP
  ports:
    - port: 80
      targetPort: 80
  selector:
      app: nginx
      environment: production
```

5. Run the following command to create the Service:

```
kubectl create -f nginx-service-clusterip.yaml
```

You should see the following response:

```
service/nginx-service-clusterip created
```

6. Run the following command to verify that the Service was created:

```
kubectl get service
```

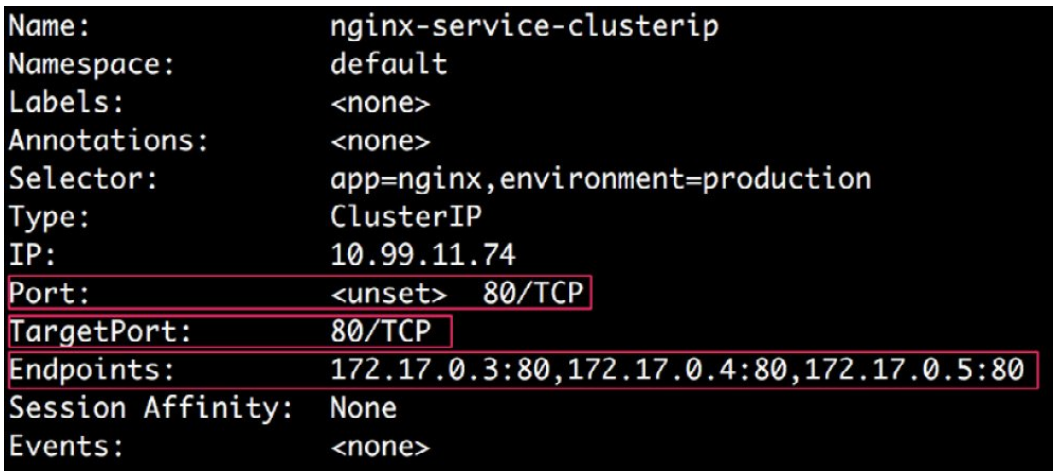
You should see the following response:

```
NAME                    TYPE        CLUSTER-IP     EXTERNAL-IP   PORT(S)   AGE
kubernetes              ClusterIP   10.96.0.1      <none>        443/TCP   54d
nginx-service-clusterip ClusterIP   10.99.11.74    <none>        80/TCP    82m
```

7. Run the following command to verify that the Service has been created with the correct configuration:

```
kubectl describe service nginx-service-clusterip
```

You should see the following response:




```
We can see that the Service has been created with the correct
`Port` and `TargetPort` fields. In the
`Endpoints` field, we can see the IP addresses of the
Pods, along with the target ports on those Pods.
```

8. Run the following command to see the IP addresses of all three Pods:

   ```
   kubectl get pods -o custom-columns=IP:status.podIP
   ```

   You should see the following response:

   ```
   IP
   172.17.0.5
   172.17.0.3
   172.17.0.4
   ```

   Hence, we can see that the `Endpoints` field of the Service actually points to the IP addresses of our three Pods.

9. Run the following command to get the cluster IP of the Service:

   ```
   kubectl get service nginx-service-clusterip
   ```

   This results in the following output:

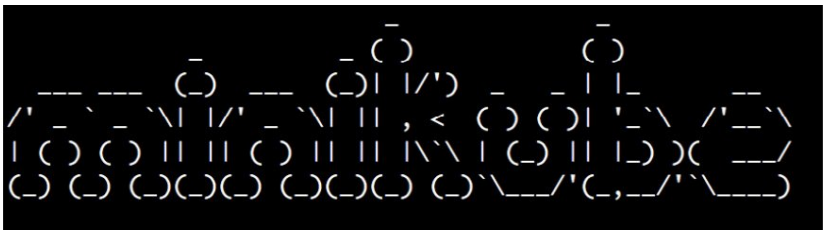

```
As we can see, the Service has a cluster IP of
`10.99.11.74`.

We know that, in the case of a ClusterIP Service, we can access the
```

```
application running on its endpoints from inside the cluster. So, we
need to go inside the cluster to be able to check whether this
really works.
```

10. Run the following command to access the `minikube` node via SSH:

    ```
    minikube ssh
    ```

    You will see the following response:

11. Now that we are inside the cluster, we can try to access the cluster IP address of the Service and see whether we can access the Pods running Nginx:

    ```
    curl 10.99.11.74
    ```

    You should see the following response from Nginx:

    ```
    <!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>
    ```

    Here, we can see that `curl` returns the HTML code for the default Nginx landing page. Thus, we can successfully access our Nginx Pods. Next, we will delete the Pods and Services.

12. Run the following command to exit the SSH session inside minikube:

    ```
    exit
    ```

13. Delete the Deployment and the Service to ensure you're working on the clean ground for the following exercises in this lab:

    ```
    kubectl delete deployment nginx-deployment
    ```

    You should see the following response:

    ```
    deployment.apps "nginx-deployment" deleted
    ```

    Delete the Service using the following command:

    ```
    kubectl delete service nginx-service-clusterip
    ```

    You should see the following response:

    ```
    service "nginx-service-clusterip" deleted
    ```

In this exercise, we were able to expose the application running on multiple Pods on a single IP address. This can be accessed by all the other Pods running inside the same cluster.

Choosing a Custom IP Address for the Service

In the previous exercise, we saw that the Service was created with a random available IP address inside the Kubernetes cluster. We can also specify an IP address if we want. This may be particularly useful if we already have a DNS entry for a particular address and we want to reuse that for our Service.

We can do this by setting the `spec.clusterIP` field with a value of the IP address we want the Service to use. The IP address specified in this field should be a valid IPv4 or IPv6 address. If an invalid IP address is used to create the Service, the API server will return an error.

Exercise 8.03: Creating a ClusterIP Service with a Custom IP

In this exercise, we will create a ClusterIP Service with a custom IP address. We will try a random IP address. As in the previous exercise, we will make sure that we can access the default Nginx page from inside the Kubernetes cluster by using the `curl` command to the set IP address. Let's get started:

1. Create a file called `nginx-deployment.yaml` with the same content that we used in the previous exercises in this lab.

2. Run the following command to create the Deployment:

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

    You should see the following response:

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

3. Create a file named `nginx-service-custom-clusterip.yaml` with the following content:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx-service-custom-clusterip
spec:
  type: ClusterIP
  ports:
    - port: 80
      targetPort: 80
  clusterIP: 10.90.10.70
  selector:
      app: nginx
      environment: production
```

This uses a random ClusterIP value at the moment.

4. Run the following command to create a Service with the preceding configuration:

```
kubectl create -f nginx-service-custom-clusterip.yaml
```

You should see the following response:

```
The Service "nginx-service-custom-clusterip" is invalid: spec.clusterIP: Inva
lid value: "10.90.10.70": provided IP is not in the valid range. The range of
 valid IPs is 10.96.0.0/12
```

As we can see, the command gives us an error because the IP address we used (`10.90.10.70`) isn't in the valid IP range. As highlighted in the preceding output, the valid IP range is `10.96.0.0/12` .

We can actually find this valid range of IP addresses before creating the Service using the `kubectl cluster-info dump` command. It provides a lot of information that can be used for cluster debugging and diagnosis. We can filter for the `service-cluster-ip-range` string in the output of the command to find out the valid ranges of IP addresses we can use in a cluster. The following command will output the valid IP range:

```
kubectl cluster-info dump | grep -m 1 service-cluster-ip-range
```

You should see the following output:

```
"--service-cluster-ip-range=10.96.0.0/12",
```

We can then use the appropriate IP address for `clusterIP` for our Service.

5. Modify the `nginx-service-custom-clusterip.yaml` file by changing the value of `clusterIP` to `10.96.0.5` since that's one of the valid values:

```
apiVersion: v1
kind: Service
metadata:
  name: nginx-service-custom-clusterip
spec:
  type: ClusterIP
```

```
  ports:
    - port: 80
      targetPort: 80
  clusterIP: 10.96.0.5
  selector:
      app: nginx
      environment: production
```

6. Run the following command to create the Service again:

   ```
   kubectl create -f nginx-service-custom-clusterip.yaml
   ```

   You should see the following output:

   ```
   service/nginx-service-custom-clusterip created
   ```

   We can see that the Service has been created successfully.

7. Run the following command to ensure that the Service was created with the custom ClusterIP we specified in the configuration:

   ```
   kubectl get service nginx-service-custom-clusterip
   ```

   You should see the following output:

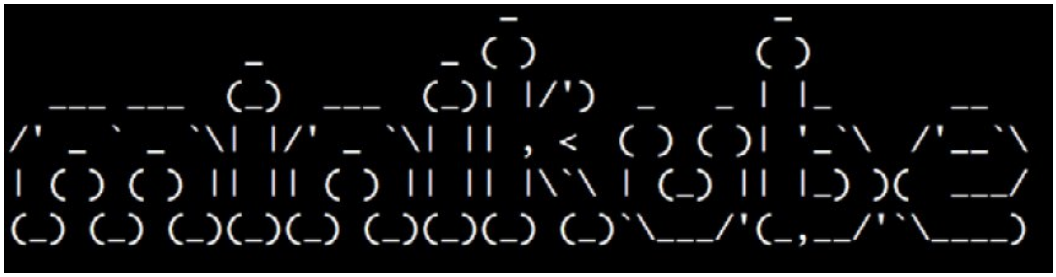
   ```
   NAME                           TYPE        CLUSTER-IP    EXTERNAL-IP   PORT(S)   AGE
   nginx-service-custom-clusterip ClusterIP   10.96.0.5     <none>        80/TCP    14m
   ```

```
Here, we can confirm that the Service was indeed created with the IP
address mentioned in the configuration; that is,
`10.96.0.5`.
```

8. Next, let's confirm that we can access the Service using the custom IP address from inside the cluster:

   ```
   minikube ssh
   ```

   You should see the following response:

9. Now, run the following command to send a request to `10.96.0.5:80` using `curl`:

   ```
   curl 10.96.0.5
   ```

We intentionally skipped the port number (`80`) in the `curl` request because, by default, curl assumes the port number to be `80` . If the Service were using a different port number, we would have to specify that in the curl request explicitly. 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>
```

Thus, we can see that we are able to access our Service from inside the cluster and that that service can be accessed at the IP address that we defined for `clusterIP` .

Now that we have learned about the different types of Services in Kubernetes, we will implement all of them to get an idea of how they would work together in a real-life scenario.

Activity 8.01: Creating a Service to Expose the Application Running on a Pod

Consider a scenario where the product team you're working with has created a survey application that has two independent and decoupled components -- a frontend and a backend. The frontend component of the survey application renders the survey forms and needs to be exposed to external users. It also needs to communicate with the backend component, which is responsible for validating and storing the survey's responses.

For the scope of this activity, consider the following tasks:

1. To avoid overcomplicating this activity, you can deploy the Apache server (https://hub.docker.com/_/httpd) as the frontend, and we can treat its default placeholder home page as the component that should be visible to the survey applicants. Expose the frontend application so that it's accessible on the host node at port `31000` .
2. For the backend application, deploy an Nginx server. We will treat the default home page of Nginx as the page that you should be able to see from the backend. Expose the backend application so that it's

accessible for the frontend application Pods in the same cluster.

Both Apache and Nginx are exposed at port `80` on the Pods by default.

Note

We are using Apache and Nginx here to keep the activity simple. In a real-world scenario, these two would be replaced with the frontend survey site and the backend data analysis component of your survey application, along with a database component for storing all the survey data.

3. To make sure frontend applications are aware of the backend application Service, add an environment variable to the frontend application Pods that contain the IP and the port address of the backend Service. This will ensure that the frontend applications know where to send a request to backend applications.

   To add environment variables to a Pod, we can add a field named `env` to the `spec` section of a Pod configuration that contains a list of name and value pairs for all the environment variables we want to add. Here's an example of how to add an environment variable called `APPLICATION_TYPE` with a value of `Frontend`:

   ```
   apiVersion: v1
   kind: Pod
   metadata:
     name: environment-variables-example
     labels:
       application: frontend
   spec:
     containers:
     - name: apache-httpd
       image: httpd
       env:
       - name: APPLICATION_TYPE
         value: "Frontend"
   ```

   Note

   We used something called a `ConfigMap` to add an environment variable here. We will learn more about them in *Lab 10*, *ConfigMaps and Secrets*.

4. Let's assume that, based on load testing the application, you have estimated that you'll initially need five replicas of the frontend application and four replicas of the backend application.

The following are the high-level steps you will need to perform in order to complete this activity:

1. Create a namespace for this activity.
2. Write an appropriate Deployment configuration for the backend application and create the Deployment.
3. Write an appropriate Service configuration for the backend application with the appropriate Service type and create the Service.
4. Ensure that the backend application is accessible, as expected.
5. Write an appropriate Deployment configuration for the frontend application. Make sure it has the environment variables set for the IP address and the port address for the backend application Service.
6. Create a deployment for the frontend application.
7. Write an appropriate Service configuration for the frontend application with the appropriate service type and create the Service.
8. Ensure that the frontend application is accessible as expected on port `31000` on the host node.

Expected Output:

At the end of the exercise, you should be able to access the frontend application in the browser using the host IP address at port `31000`. You should see the following output in your browser:

Note

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

Summary

In this lab, we covered the different ways in which we can expose our application running on Pods. We have seen how we can use a ClusterIP Service to expose an application inside the cluster. We have also seen how we can use a NodePort Service to expose an application outside the cluster. We have also covered the LoadBalancer and ExternalName Services in brief.

Now that we have created a Deployment and learned how to make it accessible from the external world, in the next lab, we will focus on storage aspects. There, we will cover reading and storing data on disk, in and across Pods.