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Step 1 of 7



## Introduction to Kubernetes

### Objectives

In this lab, you will:

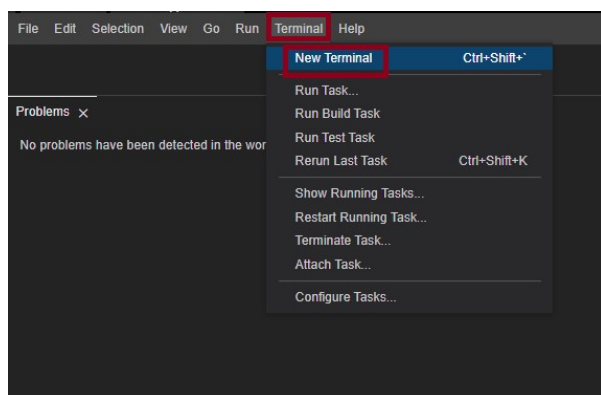
- Use the kubectl CLI
- Create a Kubernetes Pod
- Create a Kubernetes Deployment
- Create a ReplicaSet that maintains a set number of replicas
- Witness Kubernetes load balancing in action

**Note:** Kindly complete the lab in a single session without any break because the lab may go on offline mode and may cause errors. If you face any issues/errors during the lab process, please logout from the lab environment. Then clear your system cache and cookies and try to complete the lab.

## Verify the environment and command line tools

1. If a terminal is not already open, open a terminal window by using the menu in the editor: Terminal > New Terminal.

**Note:** Please skip this step if the terminal already appears.



2. Verify that kubectl CLI is installed.

```
kubectl version
```

You should see the following output, although the versions may be different:

```
theia@theiadocker /home/project$ kubectl version
Client Version: version.Info{Major:"1", Minor:"22", GitVersion:"v1.22.3", GitCommit:"c92036820499fedefec0f847e2054d824aea6cd1", GitTreeState:"clean", BuildDate:
"2021-10-27T18:41:28Z", GoVersion:"go1.16.9", Compiler:"gc", Platform:"linux/amd64"}
Server Version: version.Info{Major:"1", Minor:"21", GitVersion:"v1.21.11+IKS", GitCommit:"7d30e1c191e870ff995f9b6ba21452d0325db2ad", GitTreeState:"clean", Build
Date:"2022-03-17T16:12:51Z", GoVersion:"go1.16.15", Compiler:"gc", Platform:"linux/amd64"}
theia@theiadocker /home/project$
```

3. Change to your project folder.

**Note:** Please skip this step if you are already on the '/home/project' directory

```
cd /home/project
```

4. Clone the git repository that contains the artifacts needed for this lab, if it doesn't already exist.

```
[ ! -d 'CC201' ] && git clone https://github.com/ibm-developer-skills-network/CC201.git
```

```
theia@theiadocker /home/project$ [ ! -d 'CC201' ] && git clone https://github.com/ibm-developer-skills-network/CC201.git
Cloning into 'CC201'...
remote: Enumerating objects: 20, done.
remote: Counting objects: 100% (20/20), done.
remote: Compressing objects: 100% (13/13), done.
remote: Total 20 (delta 6), reused 19 (delta 6), pack-reused 0
Unpacking objects: 100% (20/20), done.
theia@theiadocker /home/project$
```

5. Change to the directory for this lab.

```
cd CC201/labs/2_IntroKubernetes/
```

6. List the contents of this directory to see the artifacts for this lab.

```
ls
```

```
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ ls
app.js  Dockerfile  hello-world-apply.yaml  hello-world-create.yaml  package.json
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$
```

## Use the kubectl CLI

Recall that Kubernetes namespaces enable you to virtualize a cluster. You already have access to one namespace in a Kubernetes cluster, and kubectl is already set to target that cluster and namespace.

Let's look at some basic kubectl commands.

1. kubectl requires configuration so that it targets the appropriate cluster. Get cluster information with the following command:

```
kubectl config get-clusters
```

```
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ kubectl config get-clusters
NAME
labs-prod-kubernetes-sandbox/c8ana0sw0lj8gkugn50
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$
```

2. A kubectl context is a group of access parameters, including a cluster, a user, and a namespace. View your current context with the following command:

```
kubectl config get-contexts
```

```
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ kubectl config get-contexts
CURRENT  NAME          CLUSTER              AUTHINFO  NAMESPACE
*        theia-context  labs-prod-kubernetes-sandbox/c8ana0sw0lj8gkugn50  theia     sn-labs-
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$
```

3. List all the Pods in your namespace. If this is a new session for you, you will not see any Pods.

```
kubectl get pods
```

```
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ kubectl get pods
No resources found in sn-labs- namespace.
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$
```

## Create a Pod with an imperative command

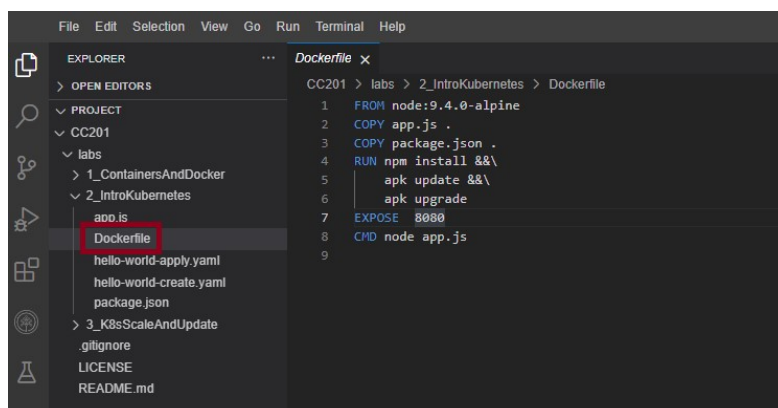
Now it's time to create your first Pod. This Pod will run the hello-world image you built and pushed to IBM Cloud Container Registry in the last lab. As explained in the videos for this module, you can create a Pod imperatively or declaratively. Let's do it imperatively first.

1. Export your namespace as an environment variable so that it can be used in subsequent commands.

```
export MY_NAMESPACE=sn-labs-$USERNAME
```

```
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ export MY_NAMESPACE=sn-labs-$USERNAME
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$
```

2. Click the Explorer icon (it looks like a sheet of paper) on the left side of the window, and then navigate to the directory for this lab: CC201 > labs > 2\_IntroKubernetes. Click on Dockerfile. This is the file that will be used to build our image.



3. Build and push the image again, as it may have been deleted automatically since you completed the first lab.

```
docker build -t us.icr.io/$MY_NAMESPACE/hello-world:1 . && docker push us.icr.io/$MY_NAMESPACE/hello-world:1
```

```

theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ docker build -t us.icr.io/$MY_NAMESPACE/hello-world:1 . && docker push us.icr.io/$MY_NAMESPACE/hello-world:1
Sending build context to Docker daemon  6.656kB
Step 1/6 : FROM node:9.4.0-alpine
9.4.0-alpine: Pulling from library/node
605ce1bd3f31: Pull complete
fe58b30348fe: Pull complete
46ef8987ccbd: Pull complete
Digest: sha256:9cd67a00ed111285460a83847720132204185e9321ec35dacec0d8b9bf674adf
Status: Downloaded newer image for node:9.4.0-alpine
--> b5f94997f35f
Step 2/6 : COPY app.js .
--> 28350e465969
Step 3/6 : COPY package.json .
--> 45bf6db4af5f
Step 4/6 : RUN npm install && apk update && apk upgrade
--> Running in a37db9ced1bc
npm notice created a lockfile as package-lock.json. You should commit this file.
npm WARN hello-world-demo@0.0.1 No repository field.
npm WARN hello-world-demo@0.0.1 No license field.

added 50 packages in 2.085s
fetch http://dl-cdn.alpinelinux.org/alpine/v3.6/main/x86_64/APKINDEX.tar.gz
fetch http://dl-cdn.alpinelinux.org/alpine/v3.6/community/x86_64/APKINDEX.tar.gz
v3.6.5-44-gda55c27396 [http://dl-cdn.alpinelinux.org/alpine/v3.6/main]
v3.6.5-34-gf0ba0b43d5 [http://dl-cdn.alpinelinux.org/alpine/v3.6/community]
OK: 848 distinct packages available
Upgrading critical system libraries and apk-tools:
(1/1) Upgrading apk-tools (2.7.5-r0 -> 2.7.6-r0)
Executing busybox-1.26.2-r9.trigger
Continuing the upgrade transaction with new apk-tools:
(1/7) Upgrading musl (1.1.16-r14 -> 1.1.16-r15)
(2/7) Upgrading busybox (1.26.2-r9 -> 1.26.2-r11)
Executing busybox-1.26.2-r11.post-upgrade
(3/7) Upgrading libressl2.5-libcrypto (2.5.5-r0 -> 2.5.5-r2)
(4/7) Upgrading libressl2.5-libssl (2.5.5-r0 -> 2.5.5-r2)
(5/7) Installing libressl2.5-libtls (2.5.5-r2)

```

4. Run the hello-world image as a container in Kubernetes.

```
kubectl run hello-world --image us.icr.io/$MY_NAMESPACE/hello-world:1 --overrides='{ "spec": { "template": { "spec": { "imagePullSecrets": [ { "name": "icr" } ] } } } }
```

The --overrides option here enables us to specify the needed credentials to pull this image from IBM Cloud Container Registry. Note that this is an imperative command, as we told Kubernetes explicitly what to do: run hello-world.

```

theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ kubectl run hello-world --image us.icr.io/$MY_NAMESPACE/hello-world:1 --overrides='{ "spec": { "template": { "spec": { "imagePullSecrets": [ { "name": "icr" } ] } } } }'
pod/hello-world created
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$

```

5. List the Pods in your namespace.

```
kubectl get pods
```

```

theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ kubectl get pods
NAME          READY   STATUS    RESTARTS   AGE
hello-world   1/1     Running   0           34s
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$

```

Great, the previous command indeed created a Pod for us. You can see an auto-generated name was given to this Pod.

You can also specify the wide option for the output to get more details about the resource.

```
kubectl get pods -o wide
```

```

theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ kubectl get pods -o wide
NAME          READY   STATUS    RESTARTS   AGE   IP              NODE          NOMINATED NODE   READINESS GATES
hello-world   1/1     Running   0           59s   172.17.183.177  10.241.64.24   <none>            <none>
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$

```

6. Describe the Pod to get more details about it.

```
kubectl describe pod hello-world
```

```

theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ kubectl describe pod hello-world
Name:          hello-world
Namespace:     sn-labs-
Priority:       1
Priority Class Name: normal
Node:          10.241.64.24/10.241.64.24
Start Time:    Fri, 08 Apr 2022 05:15:40 +0000
Labels:        run=hello-world
Annotations:    cnf.projectcalico.org/containerID: c89fd419d56a582514d497f0b01b939cf745343036e9a45f135235e7d5bc528e
                cnf.projectcalico.org/podIP: 172.17.183.177/32
                cnf.projectcalico.org/podIPs: 172.17.183.177/32
                kubernetes.io/limit-ranger:
                  limitRanger plugin set: cpu, ephemeral-storage, memory request for container hello-world; cpu, ephemeral-storage, memory limit for contain...
Status:        Running
IP:            172.17.183.177
IPs:           IP: 172.17.183.177
Containers:
  hello-world:
    Container ID:  containerd://31c934f489c232a36729b3e3f013a5619f11fc8f95ee8a1007f9f540dc4d420a
    Image:          us.icr.io/sn-labs- /hello-world:1
    Image ID:       us.icr.io/sn-labs- /hello-world@sha256:a04a56181ae9136e4b7033d5284ce9d68fe812c21b28592ffb292d8b496b6b81
    Port:          <none>
    Host Port:     <none>
    State:         Running
      Started:     Fri, 08 Apr 2022 05:15:46 +0000
    Ready:         True
    Restart Count:  0
    Limits:
      cpu:          500m
      ephemeral-storage: 5Gi
      memory:       512Mi
    Requests:
      cpu:          200m
      ephemeral-storage: 512Mi
      memory:       128Mi
    Environment:   <none>
    Mounts:
      /var/run/secrets/kubernetes.io/serviceaccount from kube-api-access-bjdzp (ro)
Conditions:
  Type            Status

```

Note: The output shows the pod parameters like **Namespace**, **Pod Name**, **IP address**, the time when the pod started running and also the container parameters like **container ID**, **image name & ID**, **running status** and the **memory/CPU limits**.

7. Delete the Pod.

```
kubectl delete pod hello-world
```

This command takes a while to execute the deletion of the pod. Please wait till the terminal prompt appears again.

```
theia@theiadocker-...:/home/project/CC201/labs/2_IntroKubernetes$ kubectl delete pod hello-world
pod "hello-world" deleted
theia@theiadocker-...:/home/project/CC201/labs/2_IntroKubernetes$
```

8. List the Pods to verify that none exist.

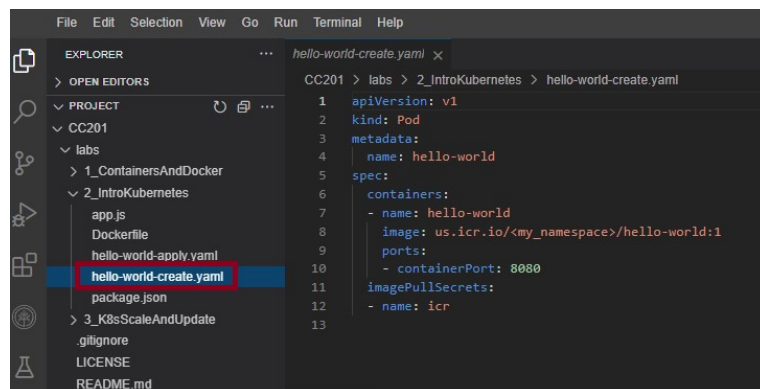
```
kubectl get pods
```

```
theia@theiadocker-...:/home/project/CC201/labs/2_IntroKubernetes$ kubectl get pods
No resources found in sn-labs-... namespace.
theia@theiadocker-...:/home/project/CC201/labs/2_IntroKubernetes$
```

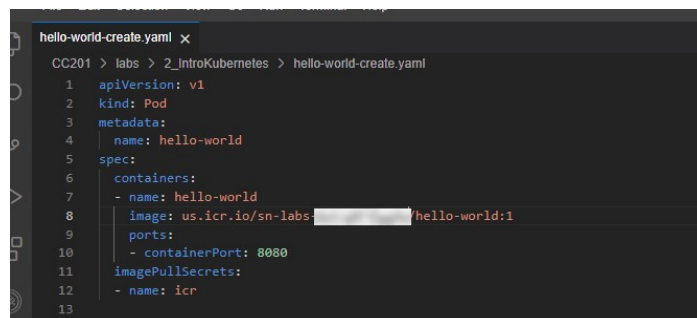
## Create a Pod with imperative object configuration

Imperative object configuration lets you create objects by specifying the action to take (e.g., create, update, delete) while using a configuration file. A configuration file, `hello-world-create.yaml`, is provided to you in this directory.

1. Use the Explorer to view and edit the configuration file. Click the Explorer icon (it looks like a sheet of paper) on the left side of the window, and then navigate to the directory for this lab: `CC201 > labs > 2_IntroKubernetes`. Click `hello-world-create.yaml` to view the configuration file.



2. Use the Explorer to edit `hello-world-create.yaml`. You need to insert your namespace where it says `<my_namespace>`. Make sure to save the file when you're done.



3. Imperatively create a Pod using the provided configuration file.

```
kubectl create -f hello-world-create.yaml
```

Note that this is indeed imperative, as you explicitly told Kubernetes to *create* the resources defined in the file.

```
theia@theiadocker-...:/home/project/CC201/labs/2_IntroKubernetes$ kubectl create -f hello-world-create.yaml
pod/hello-world created
theia@theiadocker-...:/home/project/CC201/labs/2_IntroKubernetes$
```

4. List the Pods in your namespace.

```
kubectl get pods
```

```
theia@theiadocker-...:/home/project/CC201/labs/2_IntroKubernetes$ kubectl get pods
NAME      READY   STATUS    RESTARTS   AGE
hello-world 1/1     Running   0           17s
theia@theiadocker-...:/home/project/CC201/labs/2_IntroKubernetes$
```

5. Delete the Pod.

```
kubectl delete pod hello-world
```

This command takes a while to execute the deletion of the pod. Please wait till the terminal prompt appears again.

```
theia@theiadocker-...:/home/project/CC201/labs/2_IntroKubernetes$ kubectl delete pod hello-world
pod "hello-world" deleted
theia@theiadocker-...:/home/project/CC201/labs/2_IntroKubernetes$
```

6. List the Pods to verify that none exist.



```
kubectl get pods
```

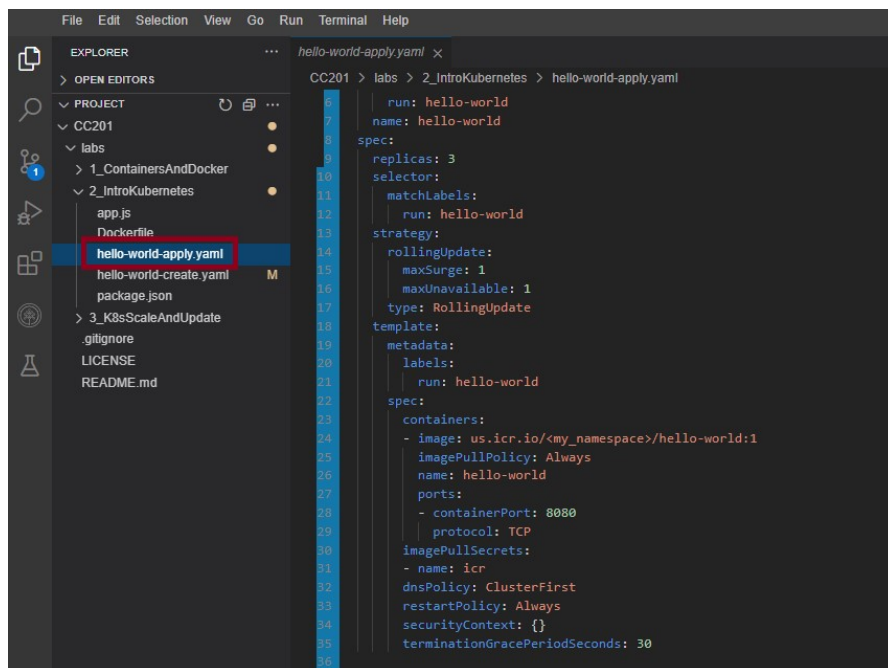
```
theia@theiadocker- /home/project/CC201/labs/2_IntroKubernetes$ kubectl get pods
No resources found in sn-labs- namespace.
theia@theiadocker- /home/project/CC201/labs/2_IntroKubernetes$
```

## Create a Pod with a declarative command

The previous two ways to create a Pod were imperative -- we explicitly told kubectl what to do. While the imperative commands are easy to understand and run, they are not ideal for a production environment. Let's look at declarative commands.

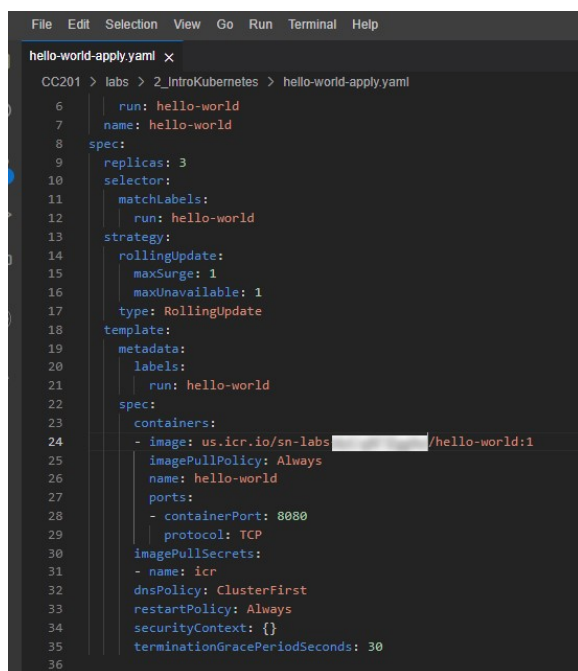
1. A sample hello-world-apply.yaml file is provided in this directory. Use the Explorer again to open this file. Notice the following:

- We are creating a Deployment (kind: Deployment).
- There will be three replica Pods for this Deployment (replicas: 3).
- The Pods should run the hello-world image (- image: us.icr.io/<my\_namespace>/hello-world:1).



You can ignore the rest for now. We will get to a lot of those concepts in the next lab.

2. Use the Explorer to edit hello-world-apply.yaml. You need to insert your namespace where it says <my\_namespace>. Make sure to save the file when you're done.



3. Use the kubectl apply command to set this configuration as the desired state in Kubernetes.

```
kubectl apply -f hello-world-apply.yaml
```

```
theia@theiadocker- /home/project/CC201/labs/2_IntroKubernetes$ kubectl apply -f hello-world-apply.yaml
deployment.apps/hello-world created
```

4. Get the Deployments to ensure that a Deployment was created.

```
kubect1 get deployments
```

```
theia@theiadocker:~/project/CC201/labs/2_IntroKubernetes$ kubect1 get deployments
NAME      READY   UP-TO-DATE   AVAILABLE   AGE
hello-world 3/3      3            3           22s
```

5. List the Pods to ensure that three replicas exist.

```
kubect1 get pods
```

```
theia@theiadocker:~/project/CC201/labs/2_IntroKubernetes$ kubect1 get pods
NAME                                READY   STATUS    RESTARTS   AGE
hello-world-774ddf45b5-86gn6        1/1     Running   0           42s
hello-world-774ddf45b5-9cbv2        1/1     Running   0           41s
hello-world-774ddf45b5-svpf7        1/1     Running   0           41s
theia@theiadocker:~/project/CC201/labs/2_IntroKubernetes$
```

With declarative management, we did not tell Kubernetes which actions to perform. Instead, kubect1 inferred that this Deployment needed to be created. If you delete a Pod now, a new one will be created in its place to maintain three replicas.

6. Note one of the Pod names from the previous step, and delete that Pod.

```
kubect1 delete pod <pod_name>
```

This command takes a while to execute the deletion of the pod. Please wait till the terminal prompt appears again.

```
theia@theiadocker:~/project/CC201/labs/2_IntroKubernetes$ kubect1 delete pod hello-world-774ddf45b5-86gn6
pod "hello-world-774ddf45b5-86gn6" deleted
```

7. List the Pods to see a new one being created.

```
kubect1 get pods
```

If you do this quickly enough, you can see one Pod being terminated and another Pod being created.

```
NAME                                READY   STATUS    RESTARTS   AGE
hello-world-774ddf45b5-86gn6        0/1     Terminating   0           35s
hello-world-774ddf45b5-9cbv2        1/1     Running        0           35s
hello-world-774ddf45b5-28k7j        0/1     ContainerCreating   0           8s
hello-world-774ddf45b5-svpf7        1/1     Running        0           35s
```

**\*\* Note:** In case you are not able to see the above output, you can move on to the next step\*\*

Otherwise, the status of each will be the same, but the age of one Pod will be less than the others and the Pod name will be a new name.

```
NAME                                READY   STATUS    RESTARTS   AGE
hello-world-774ddf45b5-28k7j        1/1     Running    0           36s
hello-world-774ddf45b5-9cbv2        1/1     Running    0           112s
hello-world-774ddf45b5-svpf7        1/1     Running    0           112s
```

## Load balancing the application

Since there are three replicas of this application deployed in the cluster, Kubernetes will load balance requests across these three instances. Let's expose our application to the internet and see how Kubernetes load balances requests.

1. In order to access the application, we have to expose it to the internet using a Kubernetes Service.

```
kubect1 expose deployment/hello-world
```

This command creates what is called a ClusterIP Service. This creates an IP address that accessible within the cluster.

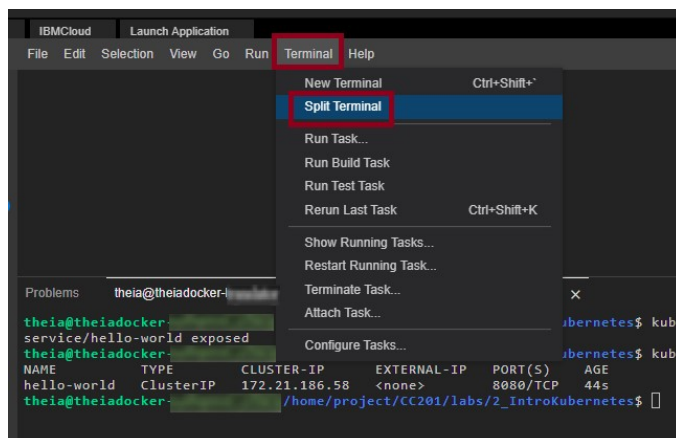
```
theia@theiadocker:~/project/CC201/labs/2_IntroKubernetes$ kubect1 expose deployment/hello-world
service/hello-world exposed
```

2. List Services in order to see that this service was created.

```
kubect1 get services
```

```
theia@theiadocker:~/project/CC201/labs/2_IntroKubernetes$ kubect1 get services
NAME      TYPE      CLUSTER-IP   EXTERNAL-IP   PORT(S)   AGE
hello-world ClusterIP  172.21.186.58 <none>        8080/TCP   44s
theia@theiadocker:~/project/CC201/labs/2_IntroKubernetes$
```

3. Open a new terminal window using Terminal > Split Terminal.



4. Since the cluster IP is not accessible outside of the cluster, we need to create a proxy. Note that this is not how you would make an application externally accessible in a production scenario. Run this command in the new terminal window since your environment variables need to be accessible in the original window for subsequent commands.

```
kubect1 proxy
```

This command doesn't terminate until you terminate it. Keep it running so that you can continue to access your app.

```

theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ kubectl get services
NAME         TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)    AGE
hello-world  ClusterIP   172.21.186.58 <none>        8080/TCP    44s
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ kubectl proxy
Starting to serve on 127.0.0.1:8001

```

5. In the original terminal window, ping the application to get a response.

```
curl -L localhost:8001/api/v1/namespaces/sn-labs-$USERNAME/services/hello-world/proxy
```

```

theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ curl -L localhost:8001/api/v1/namespaces/sn-labs-$USERNAME/services/hello-world/proxy
Hello world from hello-world-774ddf45b5-28k7j! Your app is up and running!
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$

```

Notice that this output includes the Pod name.

6. Run the command ten times and note the different Pod names in each line of output.

```
for i in `seq 10`; do curl -L localhost:8001/api/v1/namespaces/sn-labs-$USERNAME/services/hello-world/proxy; done
```

You should see more than one Pod name, and quite possibly all three Pod names, in the output. This is because Kubernetes load balances the requests across the three replicas, so each request could hit a different instance of our application.

```

theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ for i in `seq 10`; do curl -L localhost:8001/api/v1/namespaces/sn-labs-$USERNAME/services/hello-world/proxy; done
Hello world from hello-world-774ddf45b5-svpf7! Your app is up and running!
Hello world from hello-world-774ddf45b5-9cbv2! Your app is up and running!
Hello world from hello-world-774ddf45b5-28k7j! Your app is up and running!
Hello world from hello-world-774ddf45b5-28k7j! Your app is up and running!
Hello world from hello-world-774ddf45b5-28k7j! Your app is up and running!
Hello world from hello-world-774ddf45b5-28k7j! Your app is up and running!
Hello world from hello-world-774ddf45b5-28k7j! Your app is up and running!
Hello world from hello-world-774ddf45b5-28k7j! Your app is up and running!
Hello world from hello-world-774ddf45b5-28k7j! Your app is up and running!
Hello world from hello-world-774ddf45b5-svpf7! Your app is up and running!
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$

```

7. Delete the Deployment and Service. This can be done in a single command by using slashes.

```
kubectl delete deployment/hello-world service/hello-world
```

```

theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$ kubectl delete deployment/hello-world service/hello-world
deployment.apps "hello-world" deleted
service "hello-world" deleted
theia@theiadocker: /home/project/CC201/labs/2_IntroKubernetes$

```

**Note:** If you face any issues in typing further commands in the terminal, press Enter.

8. Return to the terminal window running the proxy command and kill it using Ctrl+C.

```

theia@theiadocker: /home/project$ kubectl proxy
Starting to serve on 127.0.0.1:8001
^C
theia@theiadocker: /home/project$

```

Congratulations! You have completed the lab for the second module of this course.

**Note:** Please delete your project from SN labs environment before signing out to ensure that further labs run correctly. To do the same, click on this [link](#)

## Changelog

Date	Version	Changed by	Change Description
2022-04-08	1.1	K Sundararajan	Updated Lab instructions
2022-04-12	1.2	K Sundararajan	Updated Lab instructions
2022-04-19	1.3	K Sundararajan	Updated Lab instructions

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Continue