Lab - Understanding ConfigMaps, DaemonSets, Kubernetes Services, Secrets & Persistent Volume Claims

Estimated time needed: 1 hour

In this lab, you will build and deploy an application to Kubernetes, then understand and create ConfigMaps, DaemonSets, Kubernetes Services, Secrets, and further explore Volumes & Persistent Volume Claims.

Objectives

In this Practice Project, you will build and deploy a JavaScript application to Kubernetes using Docker.
You will understand and create the following:

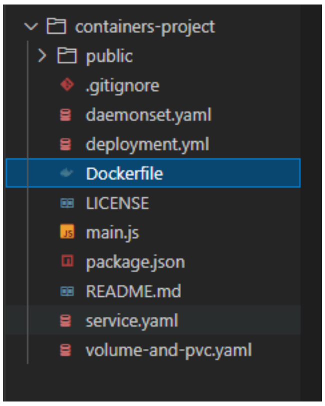
- ConfigMap
- DaemonSet
- Kubernetes Service
- Secret
- Volumes and Persistent Volume Claims

About the Dockerfile

1. Clone the repository containing the starter code to begin the project.

```
git clone https://github.com/ibm-developer-skills-network/containers-project.git
```

2. Open the `Dockerfile` located in the main project directory.



3. It's content will be as follows:

```
# Use an official Node.js runtime as a parent image
FROM node:14
# Set the working directory in the container
WORKDIR /app
# Copy the application files to the working directory
COPY main.js .
COPY public/index.html public/index.html
COPY public/style.css public/style.css
# Make port 3000 available to the world outside this container
EXPOSE 3000
# Run the application when the container launches
CMD ["node", "main.js"]
```

Here is an explanation of the code in it:

1. `FROM node:14` specifies the base image to be used, which is an official Node.js runtime version 14.
2. `WORKDIR /app` sets the working directory inside the container to /app.
3. `COPY main.js .` copies main.js from the host to the current directory (.) in the container.
4. `COPY public/index.html public/index.html` copies index.html from the public directory on the host to the public directory in the container.
5. `COPY public/style.css public/style.css` copies style.css from the public directory on the host to the public directory in the container.
6. `EXPOSE 3000` exposes port 3000 of the container to allow connections from the outside.
7. `CMD ["node", "main.js"]` specifies the command to run when the container launches, which is to execute node main.js.

Build and deploy the application to Kubernetes

The repository already has the code for the application as you have observed in the earlier section. We are just going to build the docker image and push to the registry.

You will be giving the name `myapp` to your Kubernetes deployed application.

1. Navigate to the project directory.

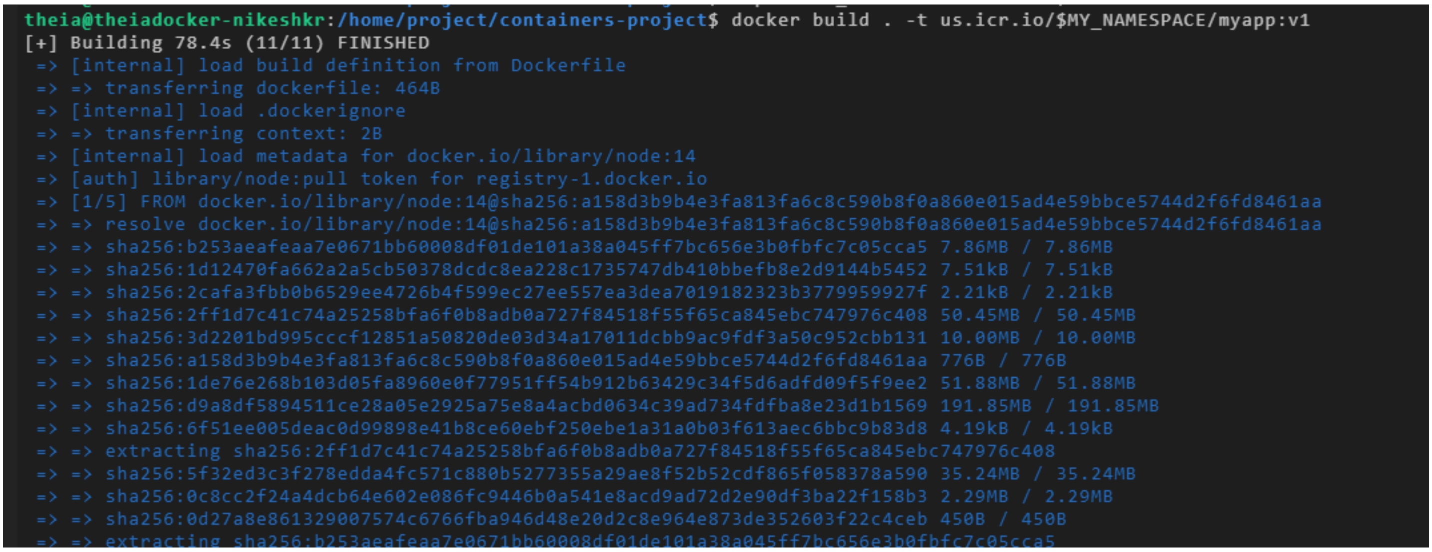
```
cd containers-project/
```

2. Export your namespace.

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

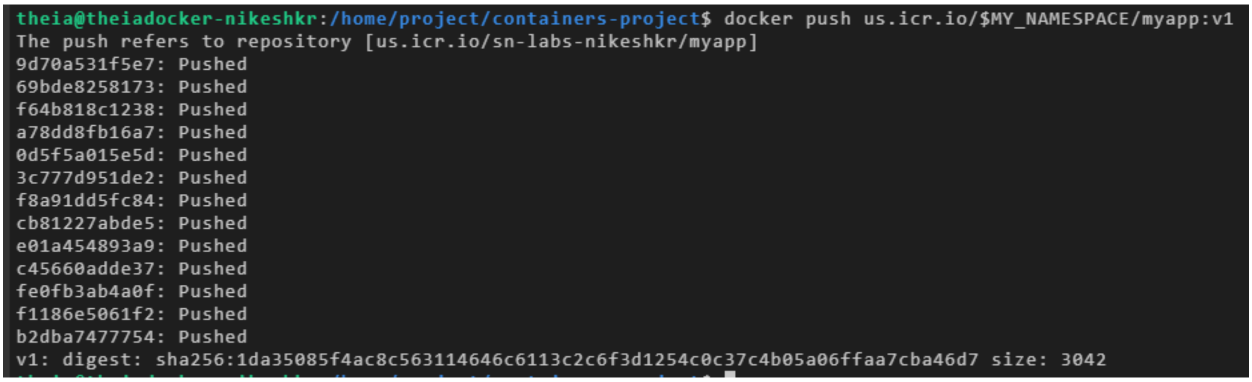
3. Build the Docker image.

```
docker build . -t us.icr.io/$MY_NAMESPACE/myapp:v1
```



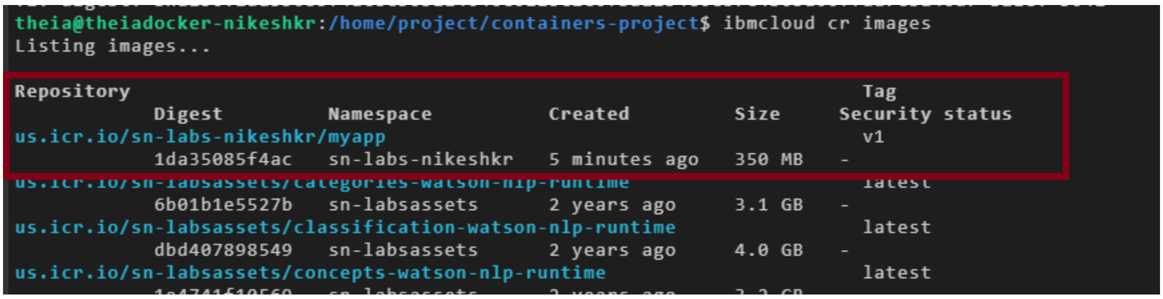
4. Push the tagged image to the IBM Cloud container registry.

```
docker push us.icr.io/$MY_NAMESPACE/myapp:v1
```



5. List all the images available. You will see the newly created `myapp` image.

```
ibmcloud cr images
```



6. Open the `deployment.yml` file located in the main project directory. It's content will be as follows:

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: myapp
  labels:
    app: myapp
spec:
  replicas: 1
  selector:
    matchLabels:
      app: myapp
```

```
  strategy:
    rollingUpdate:
      maxSurge: 25%
      maxUnavailable: 25%
    type: RollingUpdate
  template:
    metadata:
      labels:
        app: myapp
    spec:
      containers:
      - image: us.icr.io/<your SN labs namespace>/myapp:v1
        imagePullPolicy: Always
        name: myapp
        ports:
        - containerPort: 3000
          name: http
        resources:
          limits:
            cpu: 50m
          requests:
            cpu: 20m
```

Here is an explanation of the code within it.

- apiVersion: apps/v1 specifies the version of the Kubernetes API being used and the resource type (Deployment).
- kind: Deployment indicates that this YAML defines a Deployment object.
- metadata section includes metadata about the Deployment, such as its name and labels.
- spec section defines the desired state for the Deployment, including the number of replicas, update strategy, and pod template.
- replicas: 1 specifies that there should be one replica of the application running.
- selector defines how the Deployment finds which Pods to manage, using labels.
- strategy specifies the update strategy for the Deployment, here using rolling updates with certain constraints.
- template describes the Pod template used for creating new Pods.
- containers lists the containers within the Pod.
- image specifies the Docker image to use for the container.
- imagePullPolicy: Always ensures that the latest image is always pulled from the registry.
- name assigns a name to the container.
- ports section specifies which ports should be exposed by the container.
- resources defines resource requests and limits for the container, such as CPU.

7. Replace <your SN labs namespace> with your actual SN labs namespace.

▶ Click here for the ways to get your namespace

8. Apply the deployment.

```
kubectl apply -f deployment.yml
```

```
theia@theiadocker-nikeshkr:/home/project/containers-project$ kubectl apply -f deployment.yml
deployment.apps/myapp created
```

9. Verify that the application pods are running and accessible.

```
kubectl get pods
```

```
theia@theiadocker-nikeshkr:/home/project/containers-project$ kubectl get pods
NAME                     READY   STATUS    RESTARTS   AGE
myapp-6c9c7b7cf9-kg4px   1/1     Running   0          15s
```

10. Start the application on port-forward:

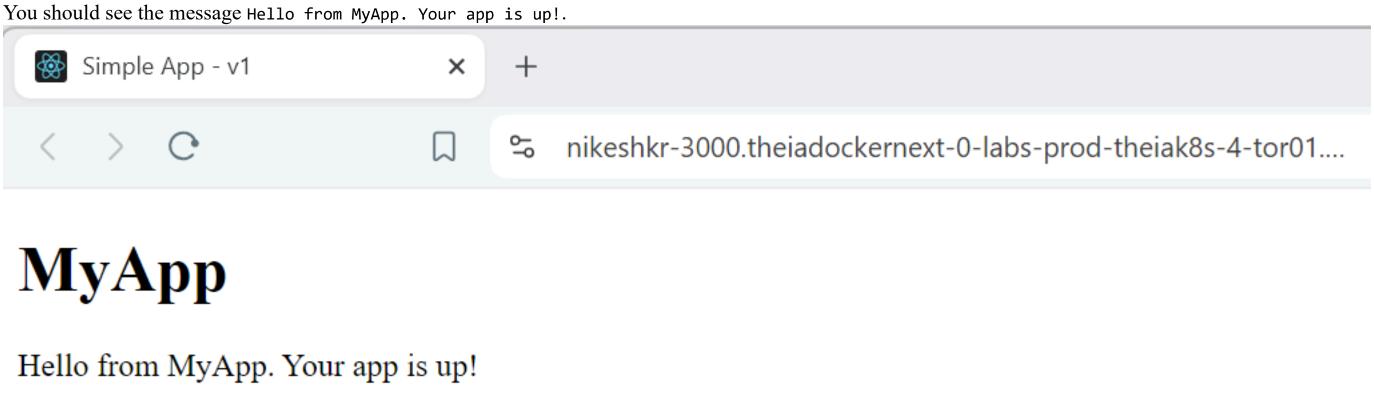
```
kubectl port-forward deployment.apps/myapp 3000:3000
```

```
theia@theiadocker-nikeshkr:/home/project/containers-project$ kubectl port-forward deployment.apps/myapp 3000:3000

Forwarding from 127.0.0.1:3000 -> 3000
Forwarding from [::1]:3000 -> 3000
Handling connection for 3000
```

11. Launch the app on Port 3000 to view the application output.

12. You should see the message `Hello from MyApp. Your app is up!`.



13. Stop the server before proceeding further, by pressing `CTRL + C`.

Exercise 1: ConfigMap

In this exercise, you will cover how to set up a ConfigMap to manage configuration data for the myapp application.

1. The following command is the syntax (with placeholder values) for creating a ConfigMap named `myapp-config`.

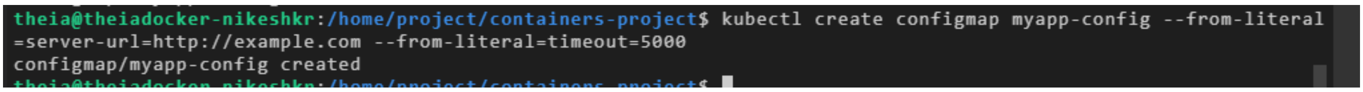
```
kubectl create configmap myapp-config --from-literal=env-var1=value1 --from-literal=env-var2=value2
```

- This command creates a ConfigMap named `myapp-config` that stores environment-related configuration data for the myapp application.
- The `--from-literal` flag indicates that the data for the ConfigMap will be provided directly on the command line.
- It specifies key-value pairs, which define environment variables and their corresponding values within the ConfigMap.

2. As an example, you can use the following key-value pairs:
   env-var1: `server-url` ; value1: `http://example.com`
   env-var2: `timeout` ; value2: `5000`

3. As per these, execute the following command to create a configmap:

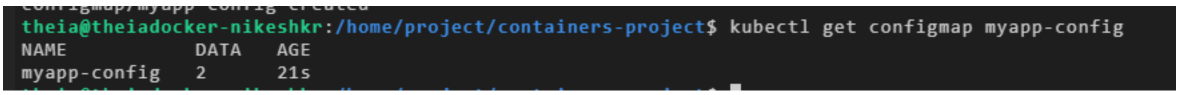
```
kubectl create configmap myapp-config --from-literal=server-url=http://example.com --from-literal=timeout=5000
```



- Here, the **server-url** is set to `http://example.com` and **timeout** is set to `5000`.
- **server-url** might store the URL of an external server that the application needs to communicate with, and **timeout** might represent the maximum time the application waits for a response before timing out.

4. Verify the successful creation of the ConfigMap by executing the below command:

```
kubectl get configmap myapp-config
```



- The output here indicates the presence of a ConfigMap named `myapp-config`, which contains two key-value pairs and was created `26 seconds` ago.

Exercise 2: DaemonSets

In this exercise, you'll create a DaemonSet to ensure that a pod runs on each node in the cluster, including the nodes where the 'myapp' pods are deployed. Creating a DaemonSet enhances the availability and fault tolerance of your application (`myapp`) by ensuring that it runs on every node in the cluster, providing redundancy and load distribution.

1. Open the`daemonset.yaml` file located in the main project directory. It's content will be as below:

```
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: myapp-daemonset
  labels:
    app: myapp
spec:
  selector:
    matchLabels:
      app: myapp
  template:
    metadata:
      labels:
        app: myapp
    spec:
      containers:
      - name: myapp-container
        image: us.icr.io/<your SN labs namespace>/myapp:v1
        ports:
        - containerPort: 3000
```

```
        name: http
      tolerations:
      - key: node-role.kubernetes.io/master
        effect: NoSchedule
```

Given below is an explanation of the code in it:

- `apiVersion: apps/v1`: This line specifies the Kubernetes API version that this YAML file adheres to. In this case, it uses the API version for Kubernetes applications, which is `apps/v1`.
- `kind: DaemonSet`: This line specifies the Kubernetes resource type being defined in this YAML file. In this case, it is a DaemonSet. DaemonSet ensures that all (or some) nodes run a copy of a specific pod.

```
metadata:
  name: myapp-daemonset
  labels:
    app: myapp
```

- The above lines specify metadata about the DaemonSet. It gives the DaemonSet a name (`myapp-daemonset`) and attaches labels to it. Labels are key-value pairs used to organize and select subsets of objects. In this case, the label `app: myapp` is attached to this DaemonSet.

```
spec:
  selector:
    matchLabels:
      app: myapp
```

- The above lines define the selector for the DaemonSet. It specifies how the DaemonSet identifies which pods it should manage. Here, it selects pods with the label `app: myapp`.

```
    spec:
      containers:
      - name: myapp-container
        image: us.icr.io/<your SN labs namespace>/myapp:v1
        ports:
        - containerPort: 3000
          name: http
```

- The above lines define the specification for the containers within the pods. It specifies the name of the container (`myapp-container`), the Docker image to use, and the ports to expose. In this case, it exposes port `3000` with the name `http`.

```
      tolerations:
      - key: node-role.kubernetes.io/master
        effect: NoSchedule
```

- The above lines define tolerations for the DaemonSet pods. Tolerations allow pods to be scheduled onto nodes with matching taints. Here, it tolerates the taint with the key `node-role.kubernetes.io/master` and the effect `NoSchedule`, meaning it can be scheduled on nodes with the master role.

2. Apply `daemonset.yaml` to your Kubernetes cluster using the following command:

```
kubectl apply -f daemonset.yaml
```

```
theia@theiadocker-nikeshkr:/home/project/containers-project$ kubectl apply -f daemonset.yaml
daemonset.apps/myapp-daemonset created
```

3. After applying the DaemonSet, verify its status to ensure that it has been successfully deployed and is running as expected. Use the following command to check the status of DaemonSets:

```
kubectl get daemonsets
```

```
theia@theiadocker-nikeshkr:/home/project/containers-project$ kubectl get daemonsets
NAME              DESIRED   CURRENT   READY   UP-TO-DATE   AVAILABLE   NODE SELECTOR   AGE
myapp-daemonset   6         6         6       6            6           <none>          23s
```

This command shows information about the DaemonSets in the Kubernetes cluster.

For example, in the provided output:

`DESIRED : 6` indicates the desired number of DaemonSet pods.
`CURRENT : 6` signifies the current number of DaemonSet pods.
`READY : 6` represents the number of DaemonSet pods that are ready.
`UP-TO-DATE : 6` implies that all DaemonSet pods are up-to-date.
`AVAILABLE : 6` denotes that all DaemonSet pods are available for service.
`NODE SELECTOR : <none>` means there is no node selector specified.
`AGE : 23s` indicates the age of the DaemonSet since its creation, which is **23 seconds**.

Exercise 3: Kubernetes services

In this exercise, you will create a Kubernetes Service to expose your application within the cluster.

1. Open the `service.yaml` file located in the main project directory. It's content will be as below:

```
apiVersion: v1
kind: Service
metadata:
  name: myapp-service
spec:
  selector:
    app: myapp
  ports:
    - protocol: TCP
      port: 80
      targetPort: 3000
```

```
  type: NodePort
```

Given below is an explanation of the code in it:

`apiVersion: v1`: This line specifies the Kubernetes API version that this YAML file adheres to. In this case, it's using the **core/v1** API version, which is the most basic Kubernetes API version.

`kind: Service`: This line specifies the Kubernetes resource type being defined in this YAML file. In this case, it's a Service. A Service in Kubernetes is an abstraction that defines a logical set of pods and defines a policy for accessing them.

```
metadata:
  name: myapp-service
```

- The above lines specify metadata about the Service, giving it a name (`myapp-service`).

```
spec:
  selector:
    app: myapp
```

- These lines define the selector for the Service, specifying which pods the Service should target based on their labels. In this case, it selects pods with the label `app: myapp`.

```
  ports:
    - protocol: TCP
      port: 80
      targetPort: 3000
```

- These lines define the ports configuration for the Service. It specifies the ports to expose on the Service and where to forward the traffic. Here, it exposes port 80 on the Service and forwards traffic to port 3000 on the pods.

```
  type: NodePort
```

- This line specifies the type of Service as `NodePort`. It is a Kubernetes Services that exposes the Service on a specific port of each node in the cluster for clients to access it.

2. Apply this configuration to your Kubernetes cluster.

```
kubectl apply -f service.yaml
```

```
theia@theiadocker-nikeshkr:/home/project/containers-project$ kubectl apply -f service.yaml
service/myapp-service created
```

3. Retrieve all the services present.

```
kubectl get services
```

```
theia@theiadocker-nikeshkr:/home/project/containers-project$ kubectl get services
NAME            TYPE       CLUSTER-IP      EXTERNAL-IP   PORT(S)        AGE
myapp-service   NodePort   172.21.26.244   <none>        80:30016/TCP   25s
```

- This command will display both the 'openshift-web-console' (already existing in the lab environment) service and the myapp-service that you have just created.

For example, in the provided output for the `myapp-service`:

`TYPE: NodePort`: It specifies that this service is of type NodePort, meaning it exposes the service on a port on all nodes in the cluster.

`CLUSTER-IP: 172.21.26.244`: This is the internal Cluster IP address assigned to the service. It is used for communication within the Kubernetes cluster.

`EXTERNAL-IP: <none>`: It indicates that there is no external IP address assigned to this service. External clients cannot directly access this service from outside the Kubernetes cluster.

`PORT(S): 80:30016/TCP`: This indicates that port **80** is exposed internally by the service, and externally it is accessible on port **30016** using the **TCP protocol**. The format is `externalPort/protocol`.

`AGE: 25s`: It shows that the service has been running for 25 seconds since its creation.

Note : Based on the availability of Cluster-IP addresses or ports this value may differ in your lab Environment.

Exercise 4: Secrets

In this exercise, you will learn how to create and manage secrets in Kubernetes to securely store sensitive information, such as passwords, tokens, and SSH keys.

1. The following command helps create a secret named `myapp-secret`, providing key-value pairs for sensitive data:

```
kubectl create secret generic <secret-name> --from-literal=<key1>=<value1> --from-literal=<key2>=<value2> ...
```

2. For example, you can use the following key-value pairs:
   key1: `username` ; value1: `myuser`
   key2: `password` ; value2: `mysecretpassword`

3. As per these, run the below command to create a secret:

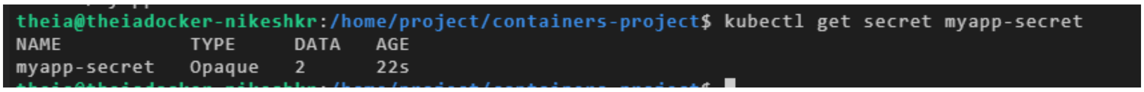
```
kubectl create secret generic myapp-secret --from-literal=username=myuser --from-literal=password=mysecretpassword
```

```
theia@theiadocker-nikeshkr:/home/project/containers-project$ kubectl create secret generic myapp-secret --from-li
teral=username=myuser --from-literal=password=mysecretpassword
secret/myapp-secret created
```

- This command creates a Secret named `myapp-secret` and populates it with key-value pairs, where `username` is set to `myuser` and `password` is set to `mysecretpassword`.

4. To verify the successful creation of the Secret, execute the following command:

```
kubectl get secret myapp-secret
```



```
theia@theiadocker-nikeshkr:/home/project/containers-project$ kubectl get secret myapp-secret
NAME           TYPE     DATA   AGE
myapp-secret   Opaque   2      22s
```

The output displays the following information about the `myapp-secret` Secret:

`NAME`: This column displays the name of the secret, which in this case is myapp-secret.

`TYPE`: This column specifies the type of secret. Here, it shows **Opaque**, which indicating it's a generic secret and does not have a specific type associated with it.

`DATA`: This column indicates the number of data entries stored within the secret. In this case, it shows **2**, indicating there are two pieces of data stored within the secret.

`AGE`: This column indicates how long it has been since the secret was created or last updated. In this case, it is *22 seconds**.

Exercise 5: Volumes and persistent volume claims

In this exercise, you will explore how to define volumes and persistent volume claims (PVCs) in Kubernetes to provide storage for your application.

A `PersistentVolume (PV)` is a storage resource provisioned by an administrator in the cluster that exists independently of any Pod that might use it. It is a cluster-wide resource that can be dynamically provisioned or statically defined, and has a lifecycle managed by the cluster administrator.

A `PersistentVolumeClaim (PVC)` is a request for storage by a user or a Pod which consumes PersistentVolume(s). PVCs provide a way for users to request the storage resources they need. They are namespace-specific and can only request storage within their namespace, with their lifecycle managed by the user or developer who creates them.

1. Explore the file named `volume-and-pvc.yaml` that defines **both a PV and a PVC**.

2. The following code snippet creates a PV:

```
apiVersion: v1
kind: PersistentVolume
metadata:
  name: myapp-volume
spec:
  capacity:
    storage: 1Gi
  accessModes:
    - ReadWriteOnce
  hostPath:
    path: /data
```

Here is an explanation of the code:

- `apiVersion: v1`: It specifies the Kubernetes API version being used.
- `kind: PersistentVolume`: It indicates that this YAML describes a PersistentVolume resource.
- `metadata`: It contains metadata about the PersistentVolume.
- `name: myapp-volume`: It specifies the name of the PersistentVolume, which is 'myapp-volume' in this case.
- `spec`: This defines the specification of the PersistentVolume.
- `capacity`: It specifies the capacity of the PersistentVolume.
- `storage: 1Gi`: This indicates that the PersistentVolume has a storage capacity of 1 gigabyte.
- `accessModes: It defines the access modes for the PersistentVolume.
  - `ReadWriteOnce`: Specifies that the volume can be mounted as read-write by a single node.
  - `hostPath`: Specifies a host path volume source.
  - `path: /data`: Indicates that the PersistentVolume is backed by a directory on the host (/data in this case).

3. Three dashes (i.e., `---`) separate the definition of the PV from the definition of the PVC.

4. The following code snippet creates a PVC:

```
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: myapp-pvc
spec:
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 1Gi
```

Here is an explanation of the code:

- `apiVersion: v1`: Specifies the Kubernetes API version being used for the PersistentVolumeClaim.

- `kind: PersistentVolumeClaim`: Indicates that this YAML describes a PersistentVolumeClaim resource.

- `metadata`: Contains metadata about the PersistentVolumeClaim.

- `name: myapp-pvc`: Specifies the name of the PersistentVolumeClaim, which is `myapp-pvc` in this case.

- `spec`: Defines the specification of the PersistentVolumeClaim.

- `accessModes`: Defines the access modes for the PersistentVolumeClaim.
    - `ReadWriteOnce`: Specifies that the volume can be mounted as read-write by a single node.
    - `resources`: Specifies the resource requirements for the PersistentVolumeClaim.
    - `requests`: Indicates the requested resources.
    - `storage: 1Gi`: Specifies that the PersistentVolumeClaim requests a storage capacity of **1 gigabyte**.

Conclusion

In this Practice Project, you started by building and deploying a Javascript application to Kubernetes using Docker.
You further created and understood a ConfigMap to manage configuration data for the application, a DaemonSet to ensure that a pod runs on each node in the cluster, a Kubernetes Service to expose your application within the cluster, and a Secret to securely store sensitive information.
Further, you explored how to define volumes and persistent volume claims to provide storage for your application.

Author(s)

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