

Program 3: Container Orchestration with Kubernetes:

- **Tool:** Kubernetes
- **Program:**
 - Set up a Kubernetes cluster (use Minikube or a cloud provider).
 - Deploy a sample application using a Deployment and Service.
 - Scale the application using `kubectl scale`.

1. Set up a Kubernetes cluster using Minikube:

Prerequisites:

- Docker Desktop installed and running.
- Windows 10/11 (PowerShell or CMD is fine)

Manual Install

- Download Minikube for Windows:
<https://github.com/kubernetes/minikube/releases/latest>
- Download `minikube-windows-amd64.exe`
Rename it to `minikube.exe`
- Add it to a folder in your system's PATH
(e.g., `C:\tools\minikube\` and add that to environment variables > PATH)

Start Minikube Using Docker:

Once installed, start it using Docker as the driver:

Open PowerShell as Administrator. Run the following command in powershell

➤ **`minikube start --driver=docker`**

See it download the base image and initialize the cluster.

Verify its working: Check the status:

➤ **`minikube status`**

Check cluster:

➤ **`kubectl get nodes`**

You should see a node named minikube in the Ready state.

What is Kubernetes?

Kubernetes ("K8s") is an open-source platform that helps you:

- Run, Manage, Scale, Update your containerized applications automatically.

Why do people use Kubernetes?

Python web app in a Docker container.

Without Kubernetes:

- manually start containers
- monitor them yourself
- If they crash, you restart them manually
- figure out how to load balance traffic
- handle deployments by hand

With Kubernetes:

- It runs multiple copies (pods) of your app
- It restarts them if they crash
- It scales up/down based on traffic
- It load balances requests
- It updates apps with zero downtime (rolling updates)
- It manages configs & secrets securely

Key Concepts

Term	What It Is
Pod	The smallest unit – runs one or more containers
Deployment	Defines how many pods to run and how to manage them
Service	A stable IP or name to access your app (load balancing)
ConfigMap	Stores non-sensitive config (env vars)
Secret	Stores sensitive data (passwords, API keys)
Node	A worker machine (VM or physical) that runs pods
Cluster	A group of nodes controlled by Kubernetes

Deploy a sample application using a Deployment and Service.

In terminal (PowerShell or CMD): type

➤ **minikube start**

Verify with:

➤ **minikube status**

Create a simple Pod YAML

Let's make a pod that runs a basic NGINX container.

Save this as pod.yaml:

```
apiVersion: v1
kind: Pod
metadata:
  name: my-nginx
spec:
  containers:
  - name: nginx
    image: nginx:latest
    ports:
    - containerPort: 80
```

Apply the pod YAML

➤ Run: **kubectl apply -f pod.yaml**

Check if it's running:

➤ **kubectl get pods**

You should see:

NAME	READY	STATUS	RESTARTS	AGE
my-nginx	1/1	Running	0	<time>

Access the **pod (for web apps)**. You can access it inside the cluster:

➤ **kubectl get pods -o wide** (it displays complete information about the each running pods)

```
PS C:\Users\Admin\Desktop\p4\app1> kubectl get pods -o wide
NAME                                READY   STATUS    RESTARTS   AGE   IP            NODE       NOMINATED NODE   RE
ADINESS GATES
hw-deployment-9dcf4b4d6-4zwd6      1/1     Running   0           2m7s  10.244.0.88   minikube   <none>           <n
one>
hw-deployment-9dcf4b4d6-cr14m      1/1     Running   0           36m   10.244.0.86   minikube   <none>           <n
one>
hw-deployment-9dcf4b4d6-tpwkj      1/1     Running   0           36m   10.244.0.87   minikube   <none>           <n
one>
nginx                               1/1     Running   0           59m   10.244.0.81   minikube   <none>           <n
one>
Activate Windows
Go to Settings to activate Windows.
```

➤ **minikube ssh** -> it will login into the minikube cluster

Then use:

➤ **curl <nginx ip-address>** to See the NGINX welcome page inside the cluster.

Create a Kubernetes Deployment and Service for a simple Python web application (like Flask) running in Minikube.

Sample Python App (Flask)

```
from flask import Flask

app = Flask(__name__)

@app.route('/')
def hello():
    return "Hello from App 1!! Kubernetes, also known as K8s, is an open source system for automating deployment, scaling, and management of containerized applications"

if __name__ == '__main__':
    app.run(host='0.0.0.0', port=5000)
```

requirement.txt

```
flask==3.0.0
```

Dockerfile:

```
FROM python:3.12-slim
WORKDIR /app
COPY requirements.txt .
RUN pip install --no-cache-dir -r requirements.txt
COPY app.py .
EXPOSE 5000
CMD ["python", "app.py"]
```

Build and Push Docker Image

Make sure Docker is running. Then build:

- **docker build -t chethanaravi/app1-k8s:latest .**
- **docker push chethanaravi/app1-k8s:latest**

Now the image is locally available inside Minikube.

Kubernetes Deployment (deployment.yaml)

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: hw-deployment
spec:
  replicas: 2
  selector:
    matchLabels:
      app: hello-world
  template:
    metadata:
      labels:
        app: hello-world
    spec:
      containers:
        - name: hw-container
          image: chethanaravi/app1-k8s:latest
          ports:
            - containerPort: 5000
```

Kubernetes Service (service.yaml)

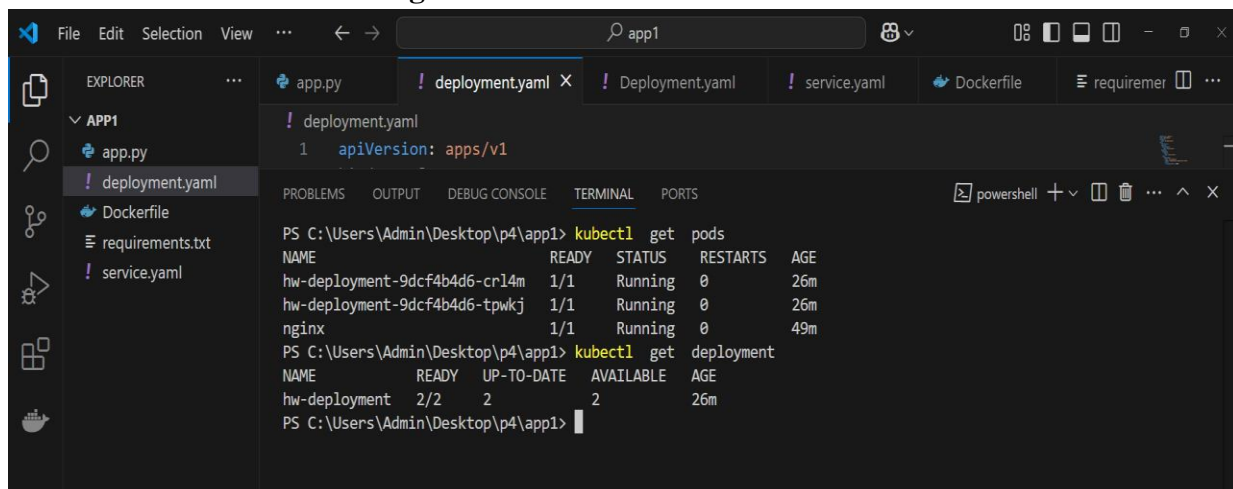
```
apiVersion: v1
kind: Service
metadata:
  name: hello-world
spec:
  type: NodePort
  selector:
    app: hello-world
  ports:
    - port: 5000
      targetPort: 5000
```

This makes your app accessible via NodePort on port 30005. Apply the Manifests

- **kubectl apply -f deployment.yaml**
- **kubectl apply -f service.yaml**

Verify:

- **kubectl get pods**
- **kubectl get svc**



The screenshot shows a Visual Studio Code editor with a terminal window open. The terminal displays the output of two kubectl commands. The first command, `kubectl get pods`, shows three pods: `hw-deployment-9dcf4b4d6-cr14m`, `hw-deployment-9dcf4b4d6-tpwkj`, and `nginx`, all in a `Running` state. The second command, `kubectl get deployment`, shows a single deployment named `hw-deployment` with 2 replicas, 2 updates, and 2 available pods.

```
PS C:\Users\Admin\Desktop\p4\app1> kubectl get pods
NAME                                READY   STATUS    RESTARTS   AGE
hw-deployment-9dcf4b4d6-cr14m       1/1     Running   0           26m
hw-deployment-9dcf4b4d6-tpwkj       1/1     Running   0           26m
nginx                                1/1     Running   0           49m

PS C:\Users\Admin\Desktop\p4\app1> kubectl get deployment
NAME             READY   UP-TO-DATE   AVAILABLE   AGE
hw-deployment    2/2     2             2           26m

PS C:\Users\Admin\Desktop\p4\app1>
```

Replicating pods in Kubernetes is easy using **Deployments**. This is to tell Kubernetes how many **replicas** (copies) of your pod you want.

Syntax:

- **kubectl scale deployment <deployment-name> --replicas=<number>**
- **Example: kubectl scale deployment/hw-deployment --replicas=3**

The screenshot shows a VS Code editor with a file explorer on the left containing 'app.py', 'deployment.yaml', 'Dockerfile', 'requirements.txt', and 'service.yaml'. The main editor displays 'deployment.yaml' with the content: `1 apiVersion: apps/v1`. The terminal at the bottom shows the following commands and output:

```
PS C:\Users\Admin\Desktop\p4\app1> kubectl get pods
NAME                                READY   STATUS    RESTARTS   AGE
hw-deployment-9dcf4b4d6-cr14m      1/1     Running   0           26m
hw-deployment-9dcf4b4d6-tpwkj      1/1     Running   0           26m
nginx                               1/1     Running   0           49m

PS C:\Users\Admin\Desktop\p4\app1> kubectl get deployment
NAME          READY   UP-TO-DATE   AVAILABLE   AGE
hw-deployment 2/2     2            2           26m

PS C:\Users\Admin\Desktop\p4\app1> kubectl scale deployment/hw-deployment --replicas=3
deployment.apps/hw-deployment scaled

PS C:\Users\Admin\Desktop\p4\app1> kubectl get pods
NAME                                READY   STATUS    RESTARTS   AGE
hw-deployment-9dcf4b4d6-4zwdb      1/1     Running   0           7s
hw-deployment-9dcf4b4d6-cr14m      1/1     Running   0           34m
hw-deployment-9dcf4b4d6-tpwkj      1/1     Running   0           34m
nginx                               1/1     Running   0           57m
```

To see how many replicas are running:

- **kubectl get deployment**
- **kubectl get pods**

Output:

NAME	READY	UP-TO-DATE	AVAILABLE	AGE
hw-deployment	3/3	3	3	5m

The screenshot shows the same VS Code editor. The terminal shows the following commands and output:

```
PS C:\Users\Admin\Desktop\p4\app1> kubectl get pods
NAME                                READY   STATUS    RESTARTS   AGE
hw-deployment-9dcf4b4d6-4zwdb      1/1     Running   0           7m25s
hw-deployment-9dcf4b4d6-cr14m      1/1     Running   0           41m
hw-deployment-9dcf4b4d6-tpwkj      1/1     Running   0           41m
nginx                               1/1     Running   0           64m

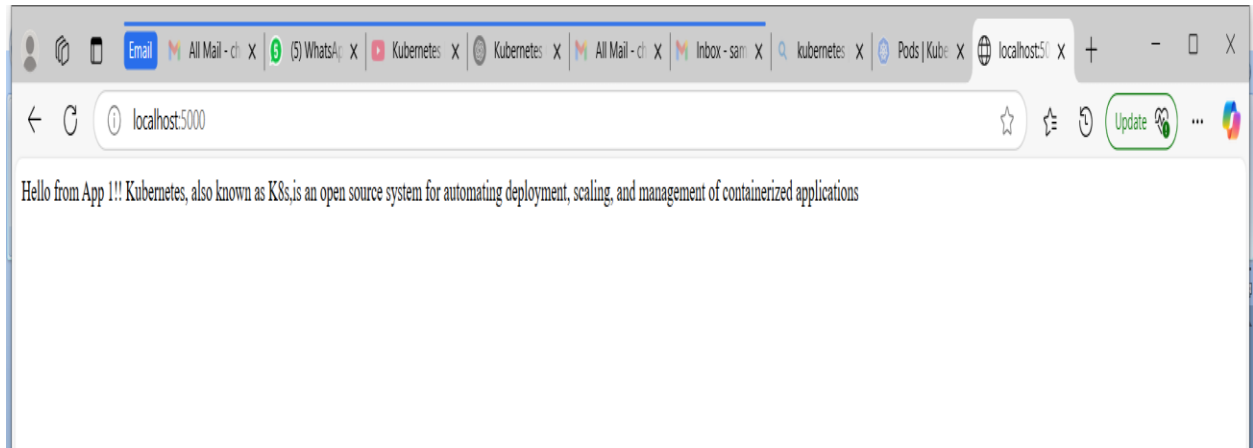
PS C:\Users\Admin\Desktop\p4\app1> kubectl delete pod hw-deployment-9dcf4b4d6-4zwdb
pod "hw-deployment-9dcf4b4d6-4zwdb" deleted

PS C:\Users\Admin\Desktop\p4\app1> kubectl get pods
NAME                                READY   STATUS    RESTARTS   AGE
hw-deployment-9dcf4b4d6-cr14m      1/1     Running   0           42m
hw-deployment-9dcf4b4d6-f6qz7      1/1     Running   0           37s
hw-deployment-9dcf4b4d6-tpwkj      1/1     Running   0           42m
nginx                               1/1     Running   0           65m

PS C:\Users\Admin\Desktop\p4\app1>
```

Forwards container port 5000 to host port 5000

- **kubectrl port-forward svc/hello-world 5000:5000**
- **Goto browser and type <http://localhost:5000>**



Simple Python application in Kubernetes using ConfigMap and Secret.

- Python App (app.py)

```
from flask import Flask
import os

app = Flask(__name__)

@app.route('/')
def index():
    app_env = os.getenv("APP_ENV", "not set")
    db_password = os.getenv("DB_PASSWORD", "not set")
    return f"APP_ENV: {app_env} <br> DB_PASSWORD: {db_password}"

if __name__ == '__main__':
    app.run(host='0.0.0.0', port=5000)
```

- Dockerfile

```
FROM python:3.9-slim

WORKDIR /app
COPY app1.py .
RUN pip install flask
CMD ["python", "app1.py"]
```

- Kubernetes Deployment (deployment.yaml)

```
apiVersion: apps/v1
kind: Deployment
metadata:
  name: python-app
spec:
  replicas: 1
  selector:
    matchLabels:
      app: python-app
  template:
    metadata:
      labels:
        app: python-app
    spec:
      containers:
        - name: app-container
          image: chethanaravi/python-app:latest
          ports:
```

```
- containerPort: 5000
env:
  - name: APP_ENV
    valueFrom:
      configMapKeyRef:
        name: my-config
        key: APP_ENV
  - name: DB_PASSWORD
    valueFrom:
      secretKeyRef:
        name: my-secret
        key: DB_PASSWORD
```

- Service.yaml

```
apiVersion: v1
kind: Service
metadata:
  name: python-service
spec:
  type: NodePort
  selector:
    app: python-app
  ports:
    - protocol: TCP
      port: 80
      targetPort: 5000
      nodePort: 30005
```

- ConfigMap.yaml

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: my-config
data:
  APP_ENV: production
```

- Secret.yaml

```
apiVersion: v1
kind: Secret
metadata:
  name: my-secret
type: Opaque
stringData:
  DB_PASSWORD: mypassword123
```

Build and Push Docker Image

- **docker built -t python-app .**
- **docker built -t chethanaravi/python-app:latest**

Apply Everything

- **kubecttl apply -f configmap.yaml**
- **kubecttl apply -f secret.yaml**
- **kubecttl apply -f deployment.yaml**
- **kubecttl apply -f service.yaml**

Check the Pod and Service Status

- **kubecttl get pods**
- **kubecttl get svc**

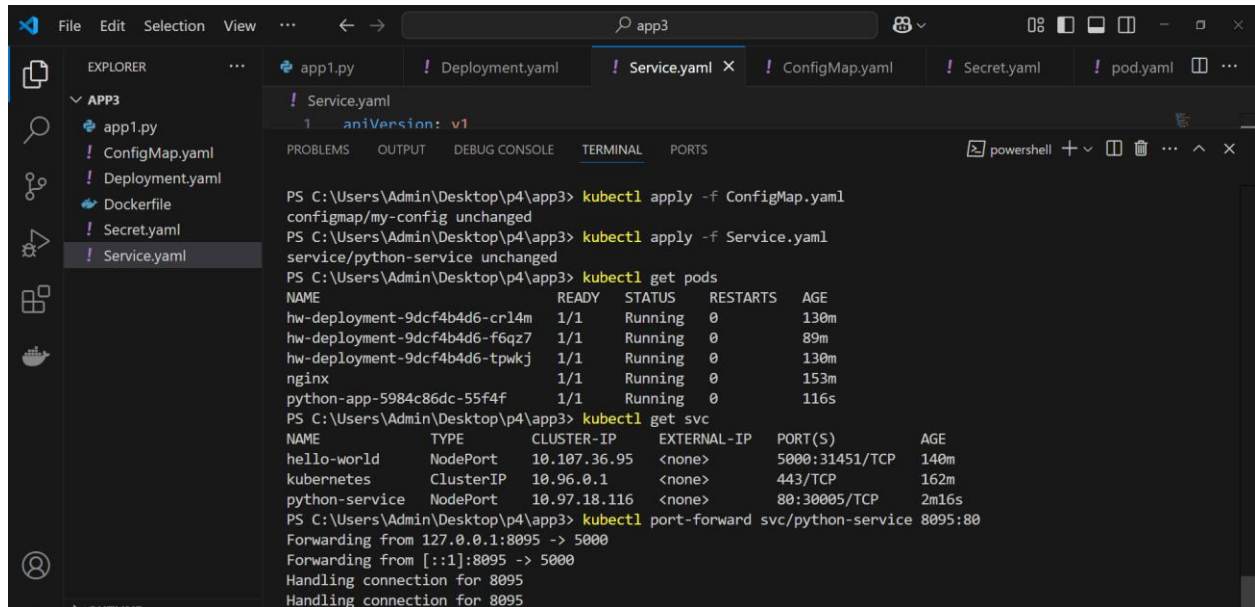
```
! Service.yaml
1  apiVersion: v1

PROBLEMS  OUTPUT  DEBUG CONSOLE  TERMINAL  PORTS
powershell + - x

nginx 1/1 Running 0 151m
PS C:\Users\Admin\Desktop\p4\app3> kubecttl apply -f deployment.yaml
deployment.apps/python-app created
PS C:\Users\Admin\Desktop\p4\app3> kubecttl apply -f service.yaml
service/python-service created
PS C:\Users\Admin\Desktop\p4\app3> kubecttl apply -f ConfigMap.yaml
configmap/my-config unchanged
PS C:\Users\Admin\Desktop\p4\app3> kubecttl apply -f Service.yaml
service/python-service unchanged
PS C:\Users\Admin\Desktop\p4\app3> kubecttl get pods
NAME READY STATUS RESTARTS AGE
hw-deployment-9dcf4b4d6-cr14m 1/1 Running 0 130m
hw-deployment-9dcf4b4d6-f6qz7 1/1 Running 0 89m
hw-deployment-9dcf4b4d6-tpwkj 1/1 Running 0 130m
nginx 1/1 Running 0 153m
python-app-5984c86dc-55f4f 1/1 Running 0 116s
PS C:\Users\Admin\Desktop\p4\app3> kubecttl get svc
NAME TYPE CLUSTER-IP EXTERNAL-IP PORT(S) AGE
hello-world NodePort 10.107.36.95 <none> 5000:31451/TCP 140m
kubernetes ClusterIP 10.96.0.1 <none> 443/TCP 162m
python-service NodePort 10.97.18.116 <none> 80:30005/TCP 2m16s
PS C:\Users\Admin\Desktop\p4\app3>
```

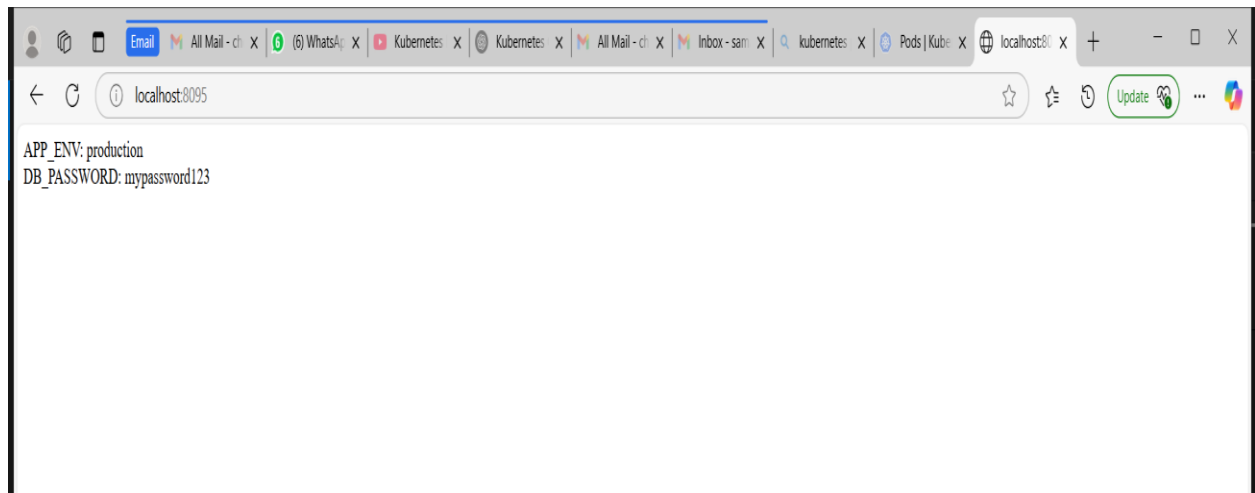
Port Forwarding

- **kubectl port-forward svc/python-service 8095:80**
- <http://localhost:8095>



```
PS C:\Users\Admin\Desktop\p4\app3> kubectl apply -f ConfigMap.yaml
configmap/my-config unchanged
PS C:\Users\Admin\Desktop\p4\app3> kubectl apply -f Service.yaml
service/python-service unchanged
PS C:\Users\Admin\Desktop\p4\app3> kubectl get pods
NAME                                READY   STATUS    RESTARTS   AGE
hw-deployment-9dcf4b4d6-cr14m       1/1     Running   0           130m
hw-deployment-9dcf4b4d6-f6qz7       1/1     Running   0           89m
hw-deployment-9dcf4b4d6-tpwkj       1/1     Running   0           130m
nginx                                1/1     Running   0           153m
python-app-5984c86dc-55f4f          1/1     Running   0           116s
PS C:\Users\Admin\Desktop\p4\app3> kubectl get svc
NAME                TYPE        CLUSTER-IP   EXTERNAL-IP   PORT(S)          AGE
hello-world         NodePort    10.107.36.95 <none>        5000:31451/TCP   140m
kubernetes           ClusterIP   10.96.0.1    <none>        443/TCP          162m
python-service       NodePort    10.97.18.116 <none>        80:30005/TCP     2m16s
PS C:\Users\Admin\Desktop\p4\app3> kubectl port-forward svc/python-service 8095:80
Forwarding from 127.0.0.1:8095 -> 5000
Forwarding from [::1]:8095 -> 5000
Handling connection for 8095
Handling connection for 8095
```

This bypasses NodePort and goes directly to the service inside the cluster.



Note:

- Delete All Pods in the Current Namespace (usually default):

kubectrl delete pods --all

- Delete Everything (Pods, Deployments, Services, etc.)

kubectrl delete all --all

- Prevent Pods from Coming Back

kubectrl delete deployment <deployment-name> / kubectrl delete deployments --all