DevOps for Cloud Assignment (S2-24_CCZG507)

Student Details:

- BITS ID: 2024MT03053
- Student Name: Balasubramaniyan Murugappa

This project demonstrates a full CI/CD and monitoring setup for a backend application using FastAPI, Docker, Kubernetes, and Prometheus.

✅ Task Breakdown

Task 1: Create Backend using FastAPI

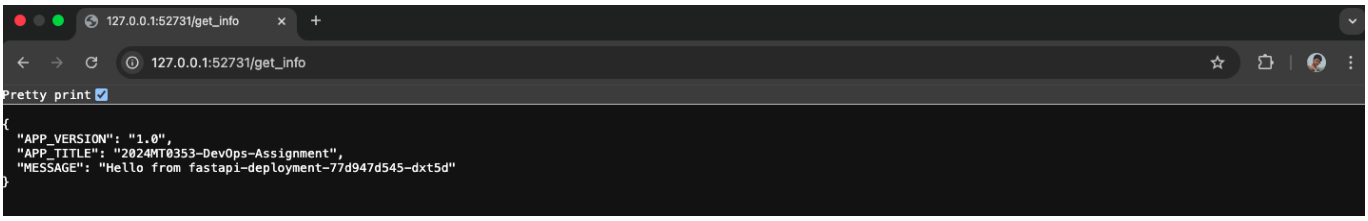
- Endpoint: `/ or /get_info`
- Returns environment variables `APP_VERSION` and `APP_TITLE` along with the pod name (load balancer)
- Requirements

```
fastapi
uvicorn
python-dotenv
prometheus_client
psutil
```


```
from fastapi import FastAPI, Response
from fastapi.responses import RedirectResponse
```

```
from prometheus_client import (
    Counter,
    generate_latest,
    Gauge,
    CONTENT_TYPE_LATEST,
)
from dotenv import load_dotenv
import os
import psutil
import threading
import time
import random
import socket

load_dotenv()
app = FastAPI()

REQUEST_COUNT = Counter("get_info_requests_total", "Total number of
GET /get_info requests")
REQUEST_COUNT_PER_VERSION = Counter(
    "get_info_requests_total_by_version",
    "GET /get_info requests by app version",
    ["version"]
)
CPU_USAGE = Gauge("cpu_usage_percent", "CPU usage percentage")
MEMORY_USAGE = Gauge("memory_usage_percent", "Memory usage
percentage")
UPTIME = Gauge("uptime_seconds", "App uptime in seconds")
THREAD_COUNT = Gauge("thread_count", "Number of active threads")
DISK_USAGE = Gauge("disk_usage_percent", "Disk usage percentage")

START_TIME = time.time()

@app.get("/")
def root():
    return RedirectResponse(url="/get_info")

@app.get("/get_info")
async def get_info():
    app_title = os.getenv("APP_TITLE", "My FastAPI App")
    app_version = os.getenv("APP_VERSION", "1.0")

    REQUEST_COUNT.inc()
    REQUEST_COUNT_PER_VERSION.labels(version=app_version).inc()

    return {
        "APP_VERSION": app_version,
        "APP_TITLE": app_title,
        "MESSAGE": "Hello from " + socket.gethostname(),
    }

@app.get("/metrics")
def metrics():
    CPU_USAGE.set(psutil.cpu_percent())
```

```
    MEMORY_USAGE.set(psutil.virtual_memory().percent)
    UPTIME.set(time.time() - START_TIME)
    THREAD_COUNT.set(threading.active_count())
    DISK_USAGE.set(psutil.disk_usage("/").percent)

    return Response(generate_latest(), media_type=CONTENT_TYPE_LATEST)
```

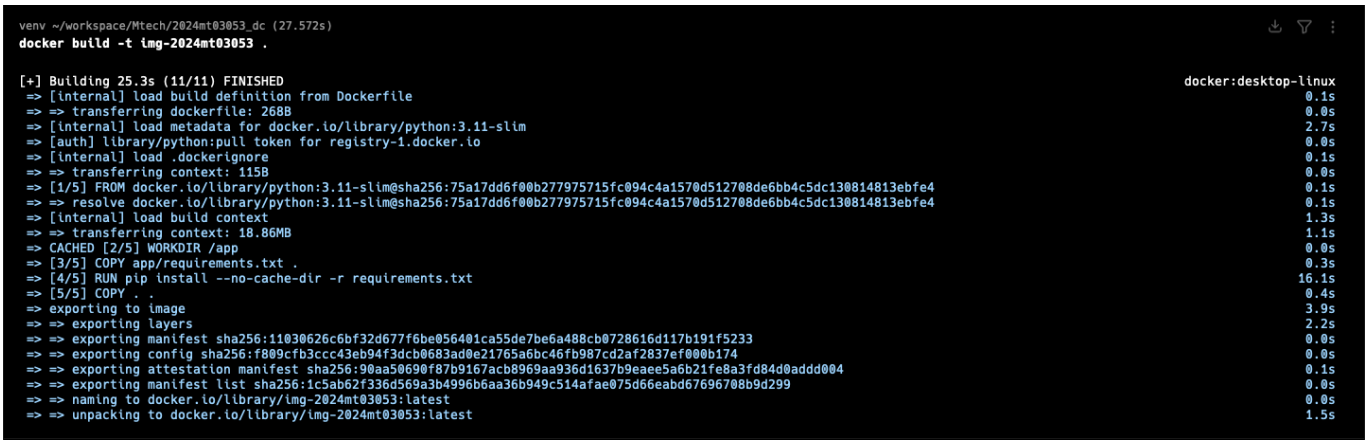


Task 2: Dockerize the Application

- Dockerfile created to containerize the FastAPI app

```
FROM python:3.11-slim

WORKDIR /app

COPY app/requirements.txt .
RUN pip install --no-cache-dir -r requirements.txt

COPY . .

EXPOSE 8000
CMD ["uvicorn", "app.main:app", "--host", "0.0.0.0", "--port", "8000",
"--workers", "2"]
```

- Image built using: `docker build -t img-2024mt03053 .`



Task 3: Run Docker Container

- Run using:

```
docker run -d --name CNR-2024MT03053 -p 8000:8000 -e APP_VERSION=1.0 -e APP_TITLE="2024MT0353-DevOps-Assignment" img-2024mt03053
```

Task 4: Deploy Image to Kubernetes (Minikube)

- Created ConfigMap with `APP_VERSION` and `APP_TITLE`
- Deployment created with 2 replicas using the image `img-2024mt03053`
- Service exposed with loadbalancer

```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: config-2024mt03053
data:
  APP_VERSION: '1.0'
  APP_TITLE: '2024MT0353-DevOps-Assignment'
```

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: fastapi-deployment
spec:
  replicas: 3
  selector:
    matchLabels:
      app: fastapi-app
  template:
    metadata:
```

```
      labels:
        app: fastapi-app
    spec:
      containers:
        - name: fastapi-container
          image: img-2024mt03053:latest
          imagePullPolicy: Never
          ports:
            - containerPort: 8000
          envFrom:
            - configMapRef:
                name: config-2024mt03053
          readinessProbe:
            httpGet:
              path: /
              port: 8000
            initialDelaySeconds: 5
            periodSeconds: 10
            failureThreshold: 3
            successThreshold: 1
```

```
apiVersion: v1
kind: Service
metadata:
  name: fastapi-service
spec:
  type: LoadBalancer
  selector:
    app: fastapi-app
  sessionAffinity: None
  ports:
    - protocol: TCP
      port: 80
      targetPort: 8000
```

- Deploy & check the kube status

```
kubectl apply -f k8s/ConfigMap.yaml
kubectl apply -f k8s/Deployment.yaml
kubectl apply -f k8s/Service.yaml
minikube dashboard
```

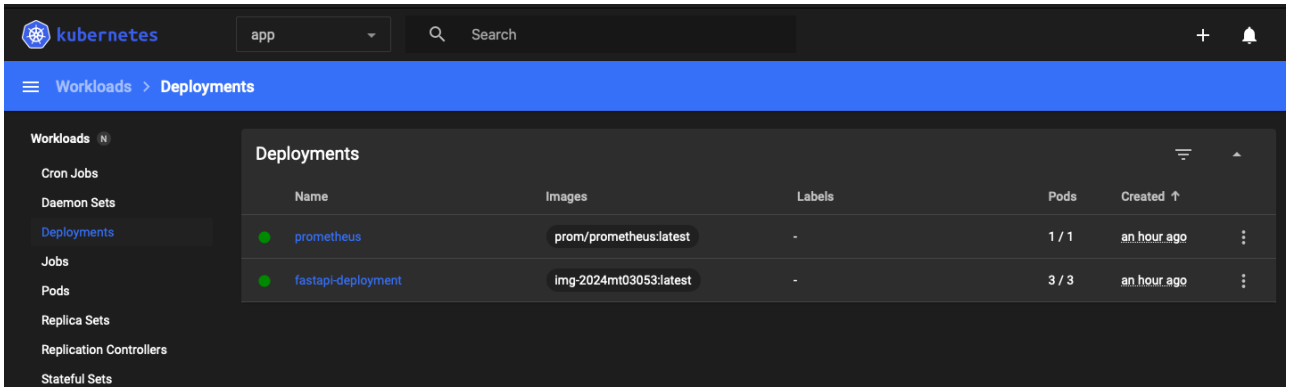
- Deployment

```
venv ~/workspace/Mtech/2024mt03053_dc ❄ minikube (0.828s)
kubectl apply -f k8s/ConfigMap.yaml -n app && kubectl apply -f k8s/Deployment.yaml -n app && kubectl apply -f k8s/Service.yaml -n app
configmap/config-2024mt03053 created
deployment.apps/fastapi-deployment created
service/fastapi-service created

venv ~/workspace/Mtech/2024mt03053_dc ❄ minikube (0.839s)
kubectl apply -f prometheus/ConfigMap.yaml -n app && kubectl apply -f prometheus/Deployment.yaml -n app && kubectl apply -f prometheus/Service.yaml -n app
configmap/prometheus-config created
deployment.apps/prometheus created
service/prometheus-service created

venv ~/workspace/Mtech/2024mt03053_dc (45m 50.62s)
minikube service fastapi-service --url -n app
http://127.0.0.1:52157
❗  Because you are using a Docker driver on darwin, the terminal needs to be open to run it.
```

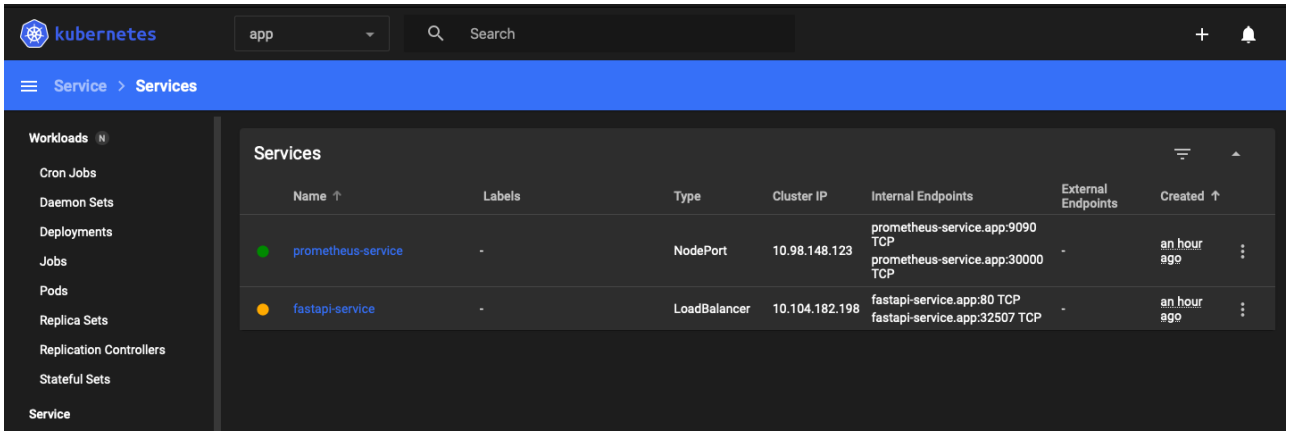
- Status

```
~/workspace/Mtech/2024mt03053_dc ❄ minikube (0.247s)
kubectl get po -A
NAMESPACE              NAME                                         READY   STATUS    RESTARTS      AGE
app                    fastapi-deployment-77d947d545-8x6gw          1/1     Running   0             37s
app                    fastapi-deployment-77d947d545-dxt5d          1/1     Running   0             37s
app                    fastapi-deployment-77d947d545-sw5ts          1/1     Running   0             37s
app                    prometheus-bb9f699bd-8tf6w                   1/1     Running   0             9s
kube-system            coredns-668d6bf9bc-2crbk                     1/1     Running   0             24m
kube-system            coredns-668d6bf9bc-c2cbc                     1/1     Running   0             24m
kube-system            etcd-minikube                                1/1     Running   0             25m
kube-system            kube-apiserver-minikube                      1/1     Running   0             25m
kube-system            kube-controller-manager-minikube             1/1     Running   0             25m
kube-system            kube-proxy-84npt                             1/1     Running   0             24m
kube-system            kube-scheduler-minikube                      1/1     Running   0             25m
kube-system            storage-provisioner                          1/1     Running   1 (24m ago)   24m
kubernetes-dashboard   dashboard-metrics-scraper-5d59dccf9b-wmprv   1/1     Running   0             24m
kubernetes-dashboard   kubernetes-dashboard-7779f9b69b-9dc5v        1/1     Running   0             24m
```

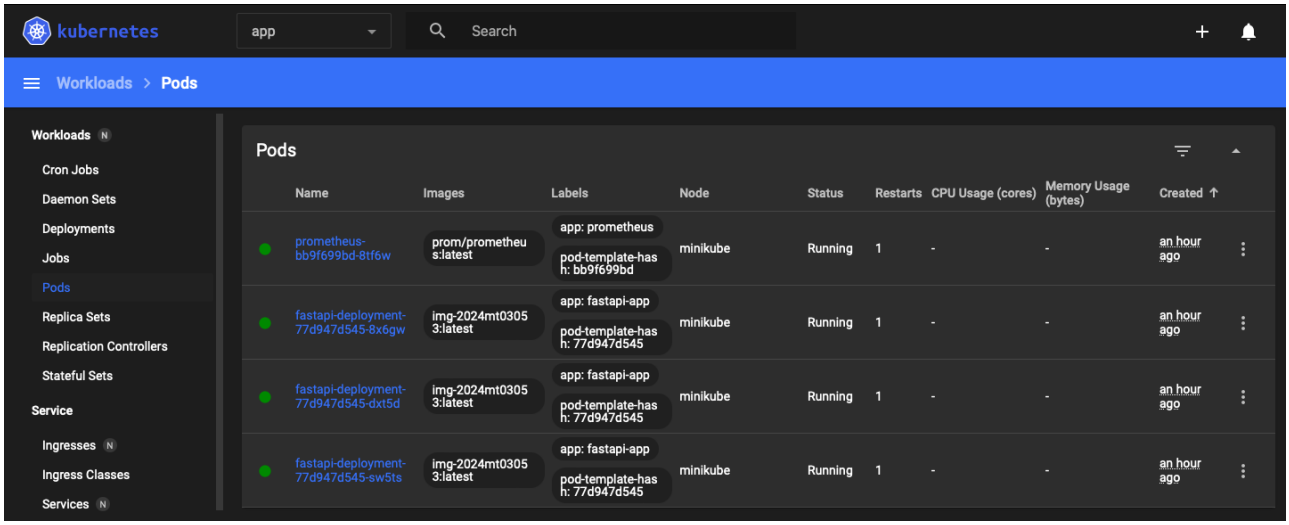
- Minikube Dashboard Deployments



- Minikube Dashboard Service



- Minikube Dashboard Pods



Task 5: Configure LoadBalancer

- Exposed app using a LoadBalancer service
- Verified service endpoint using:

```
minikube service fastapi-service --url
```

Task 6: Configure Prometheus

- ✅ Installed Prometheus and configured it with Kubernetes using a ConfigMap.
- ✅ Enabled system and application-level metrics via `prometheus_client`.
- ✅ Exposed a `/metrics` endpoint on the FastAPI app for Prometheus scraping.

```
apiVersion: v1
kind: ConfigMap
metadata:
  name: prometheus-config
data:
  prometheus.yml: |
    global:
      scrape_interval: 15s
    scrape_configs:
      - job_name: 'fastapi'
        static_configs:
          - targets: ['fastapi-service:80']
```

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: prometheus
spec:
  replicas: 1
  selector:
    matchLabels:
      app: prometheus
  template:
    metadata:
      labels:
        app: prometheus
    spec:
      containers:
        - name: prometheus
          image: prom/prometheus:latest
          ports:
            - containerPort: 9090
          volumeMounts:
            - name: config-volume
              mountPath: /etc/prometheus/
      volumes:
        - name: config-volume
          configMap:
            name: prometheus-config
```

```yaml
apiVersion: v1
kind: Service
metadata:
  name: prometheus-service
spec:
  type: NodePort
  selector:
    app: prometheus
  ports:
    - port: 9090
      targetPort: 9090
      nodePort: 30000
```

- Deploy & check the kube status

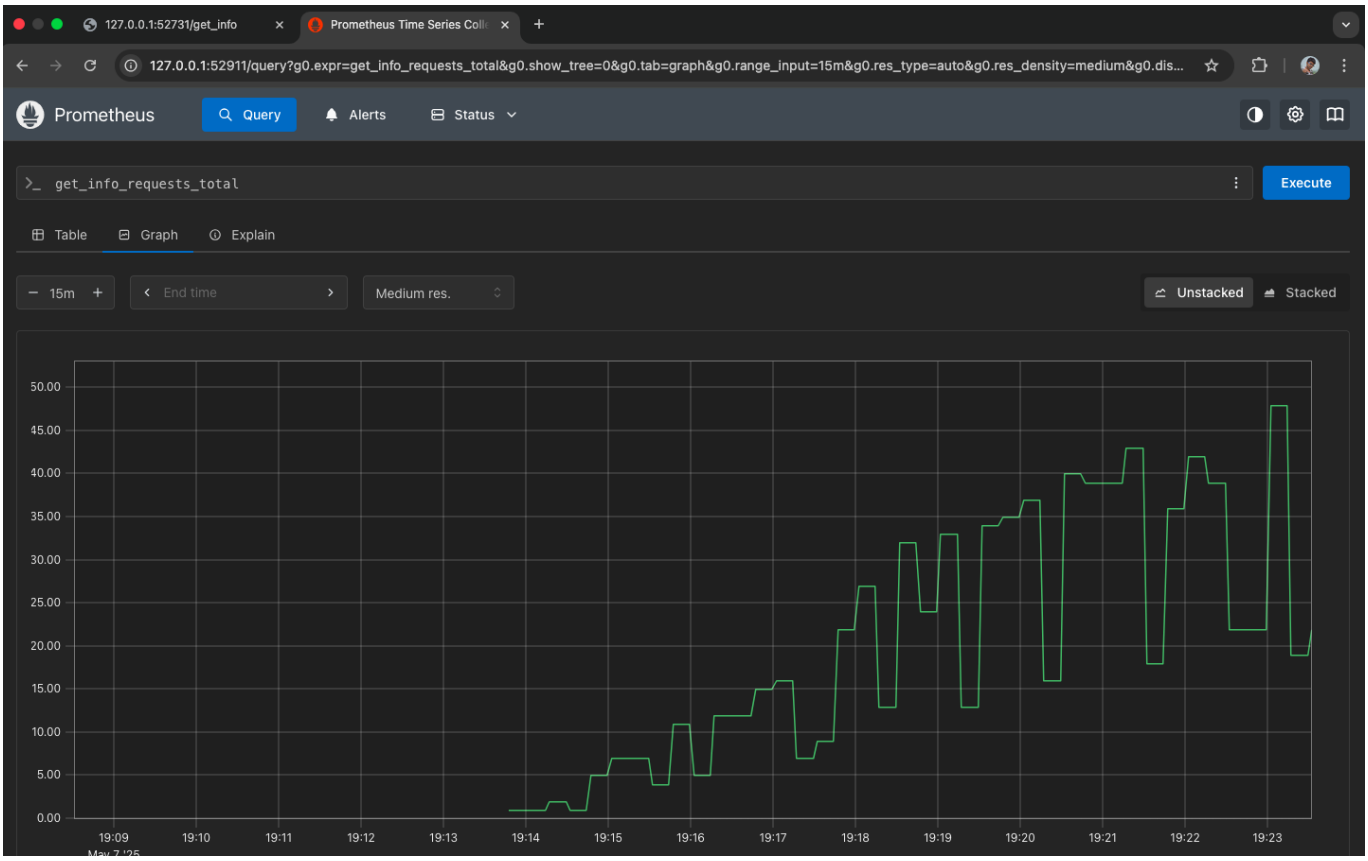
```
kubectl apply -f prometheus/ConfigMap.yaml
kubectl apply -f prometheus/Deployment.yaml
kubectl apply -f prometheus/Service.yaml
```

🔍 Visualized Metrics

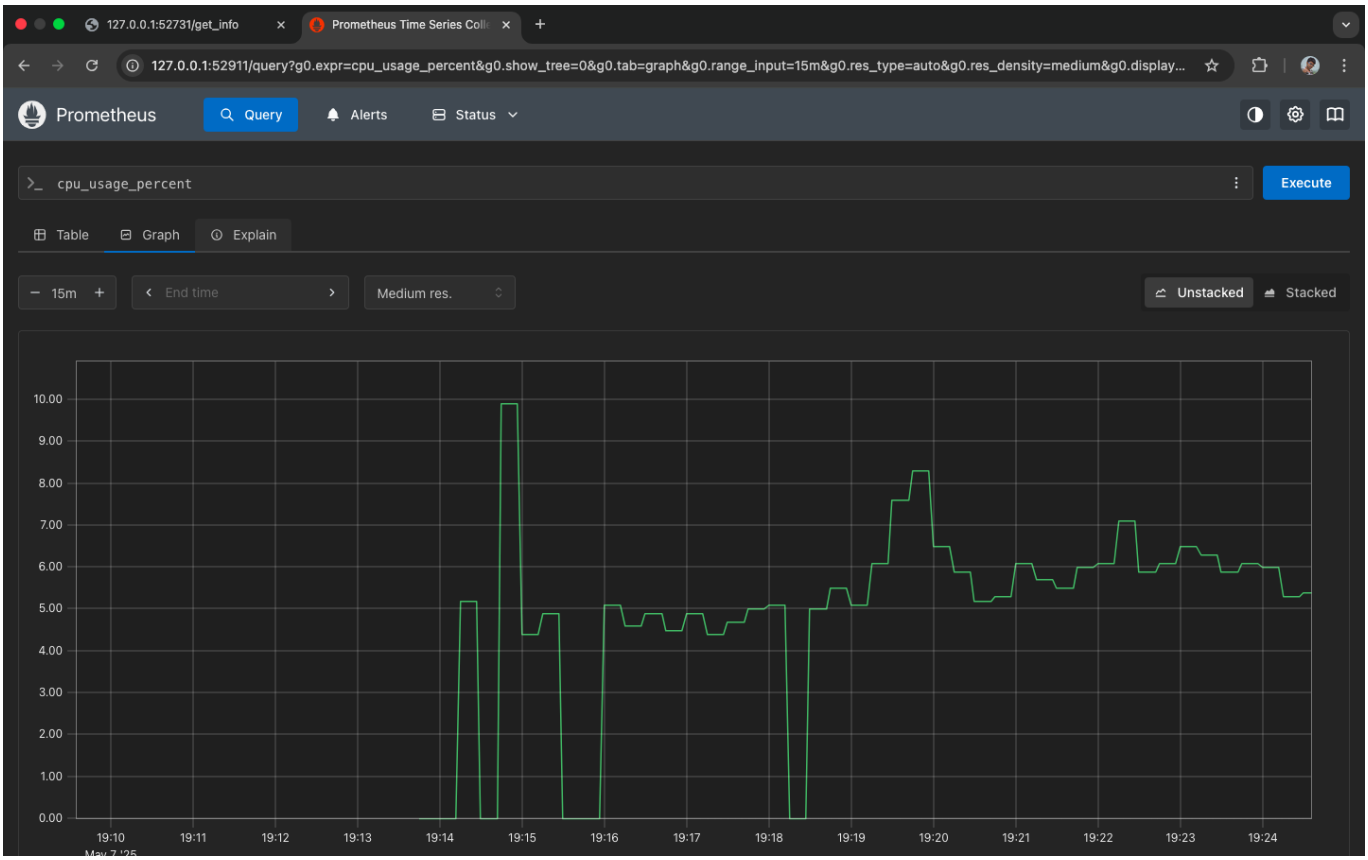
Metric Name	Description
`get_info_requests_total`	Total number of `GET /get_info` requests
`get_info_requests_total_by_version`	Requests to `/get_info` labeled by app version
`cpu_usage_percent`	Current CPU usage percentage
`memory_usage_percent`	Current memory usage percentage
`uptime_seconds`	Uptime of the application in seconds
`thread_count`	Number of active threads
`disk_usage_percent`	Disk usage percentage of root filesystem

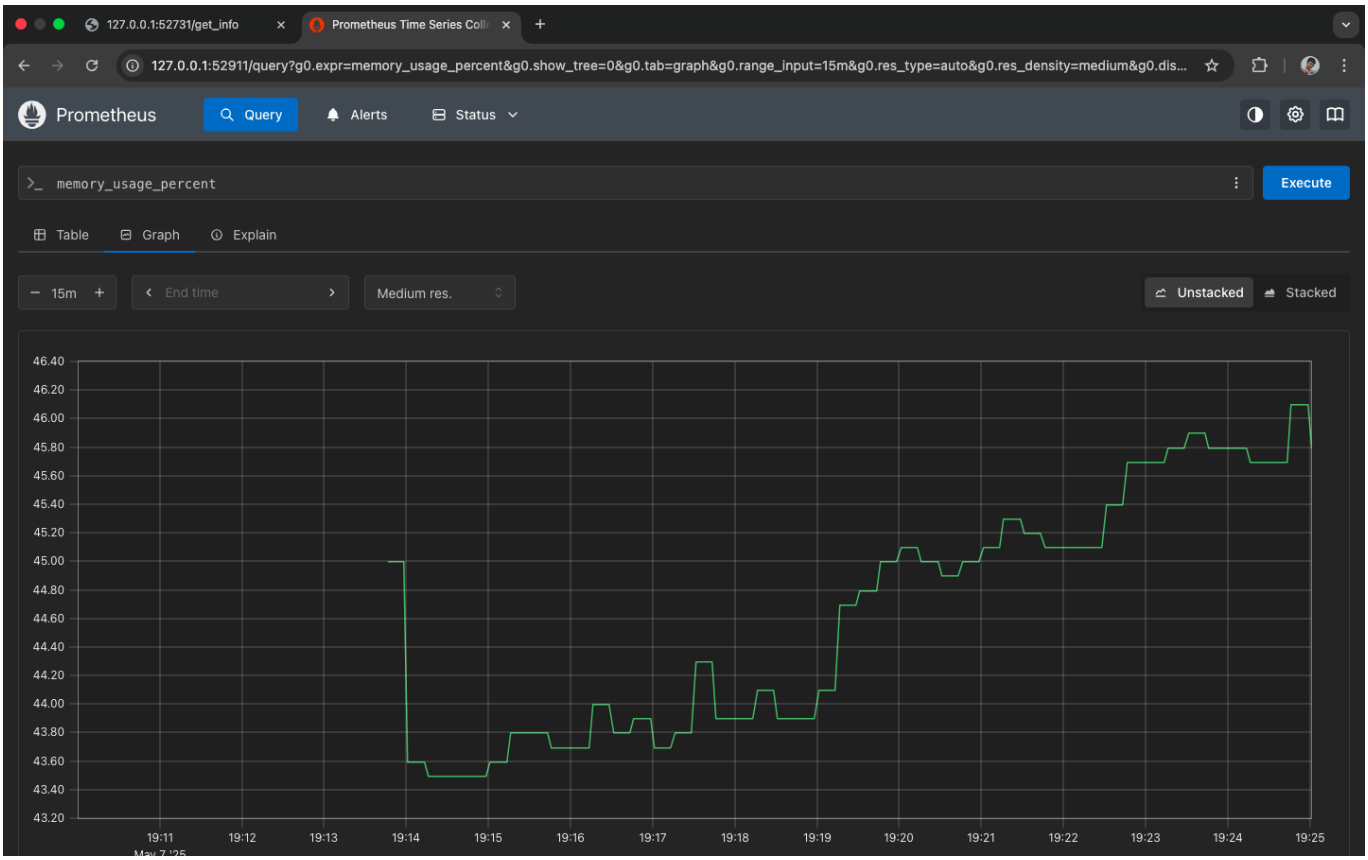
📈 Sample Prometheus Queries

```
# Total requests
get_info_requests_total
```

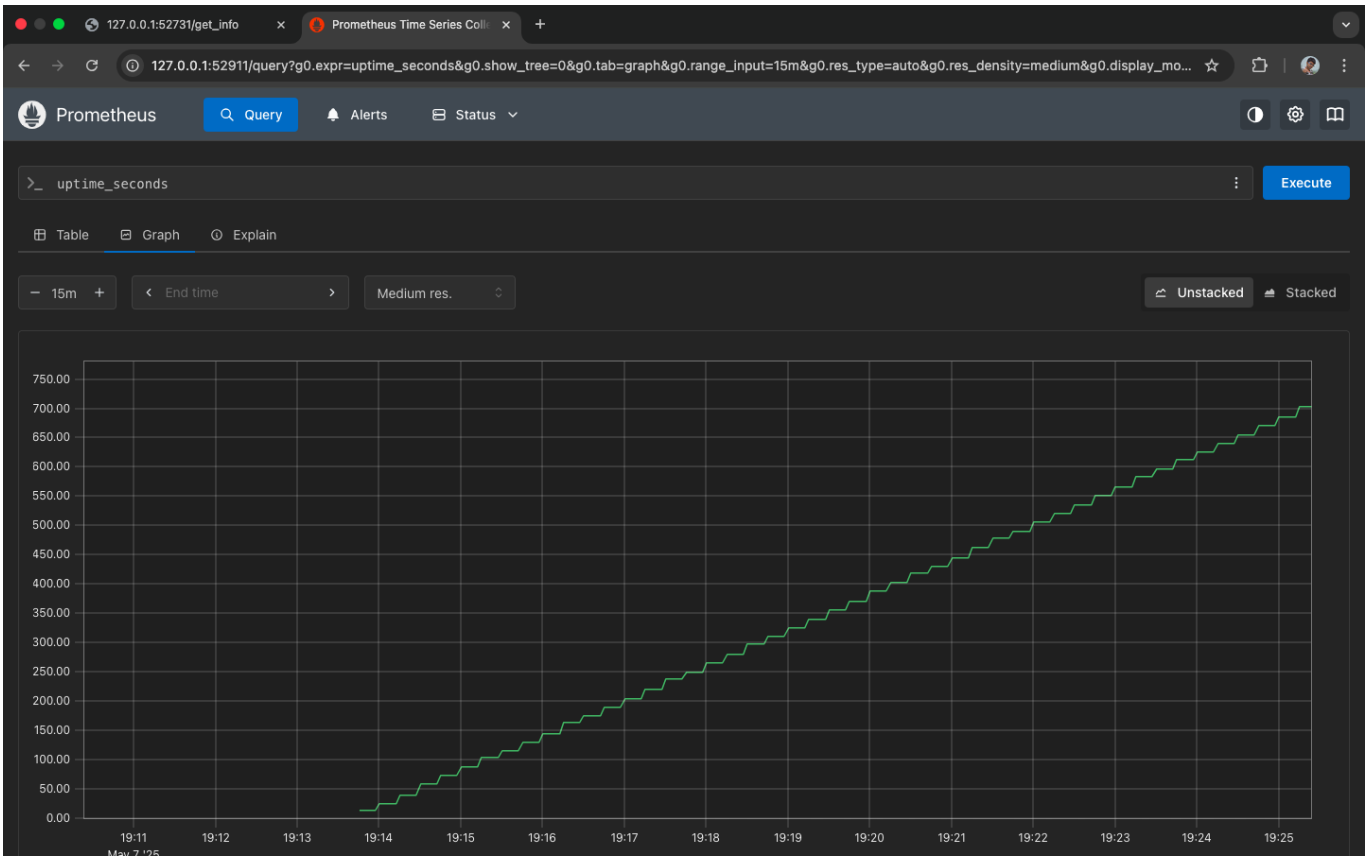



```
# Current CPU and memory usage
cpu_usage_percent
memory_usage_percent
```

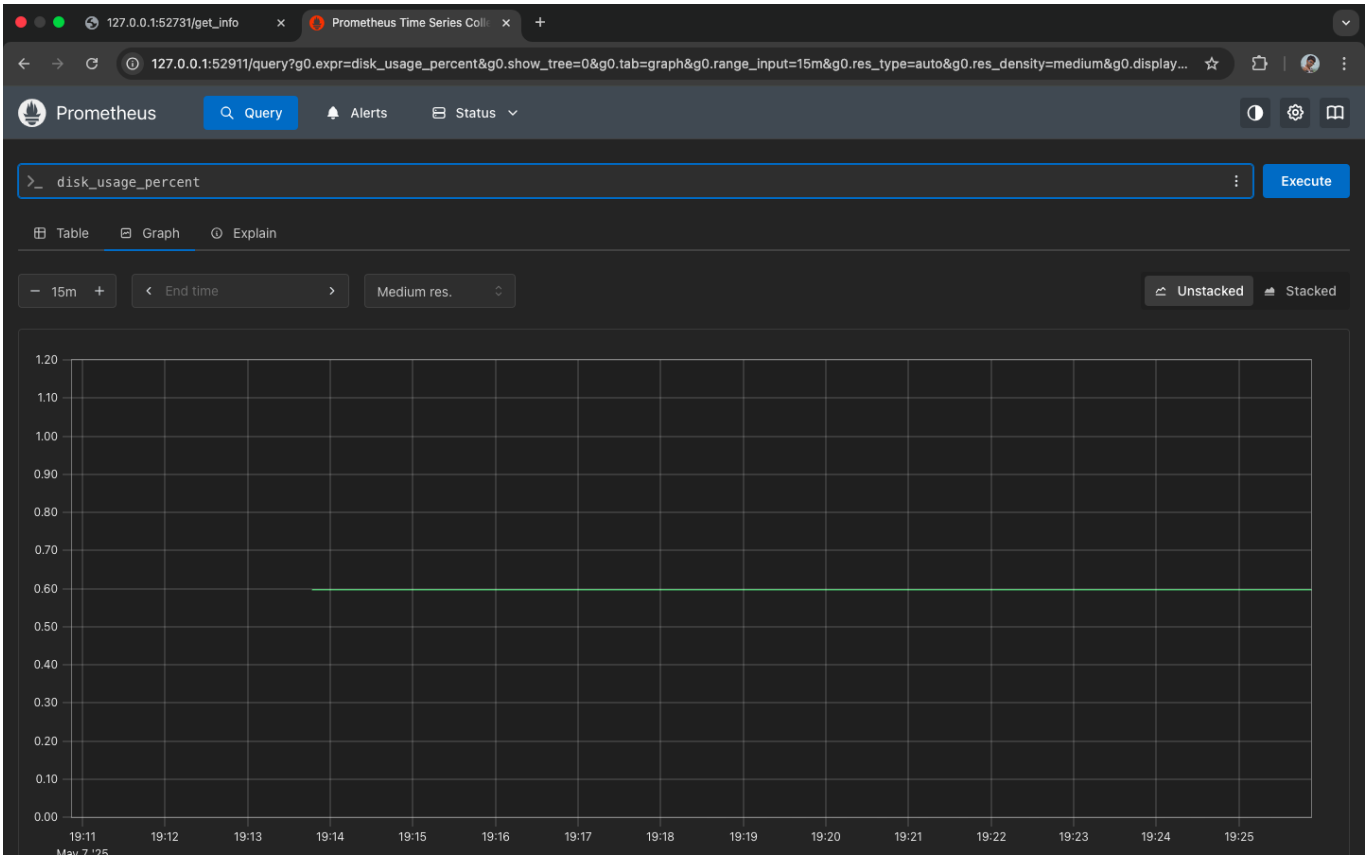





```
# App uptime
uptime_seconds
```




```
# Disk usage
disk_usage_percent
```



🧪 Accessing Prometheus

If running via NodePort:

```
http://<your-node-ip>:30000
```

Or using `kubectl` port-forward:

```
kubectl port-forward svc/prometheus-service 9090:9090
```

Then open your browser to:

```
http://localhost:9090
```

📁 Directory Structure

```
ROLL_NUMBER_dc/

├── Dockerfile
├── README.md
├── app
│   ├── main.py
│   └── requirements.txt
├── k8s
│   ├── ConfigMap.yaml
│   ├── Deployment.yaml
│   └── Service.yaml
├── prometheus
│   ├── ConfigMap.yaml
│   ├── Deployment.yaml
│   └── Service.yaml
└── screenshots
    ├── app-response.png
    ├── application-init.png
    ├── application-running-local.png
    ├── cpu-usage.png
    ├── curl-logs.png
    ├── curl-test.png
    ├── disk-usage.png
    ├── docker-image-build.png
    ├── get-total-requests.png
    ├── kube-deployments.png
    ├── kube-pods.png
    ├── kube-services.png
    ├── kubectl-pods-deploy.png
    ├── kubectl-pods-status.png
    ├── memory-usage.png
```

```
    ├── minikube-start.png
    ├── target-status.png
    └── uptime-seconds.png
```

📝 Challenges faced

- Helm installation: Tried Helm but faced some env issues
- K3s: Lightweight K8s again env issues
- Minikube: worked in both linux and mac.
