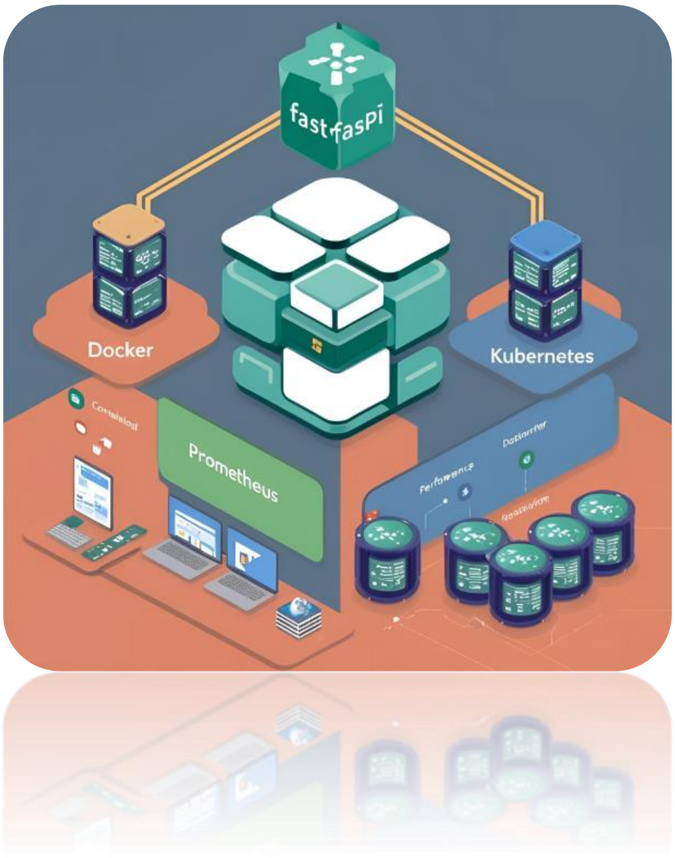

DEVOPS FOR CLOUD

Project Synopsis

Developed a backend application using FastAPI, containerized with Docker, deployed on Kubernetes, and monitored with Prometheus for performance tracking.

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Contents

Software and Platform Details

This section outlines the technologies, software, and platforms used throughout the completion of this assignment.

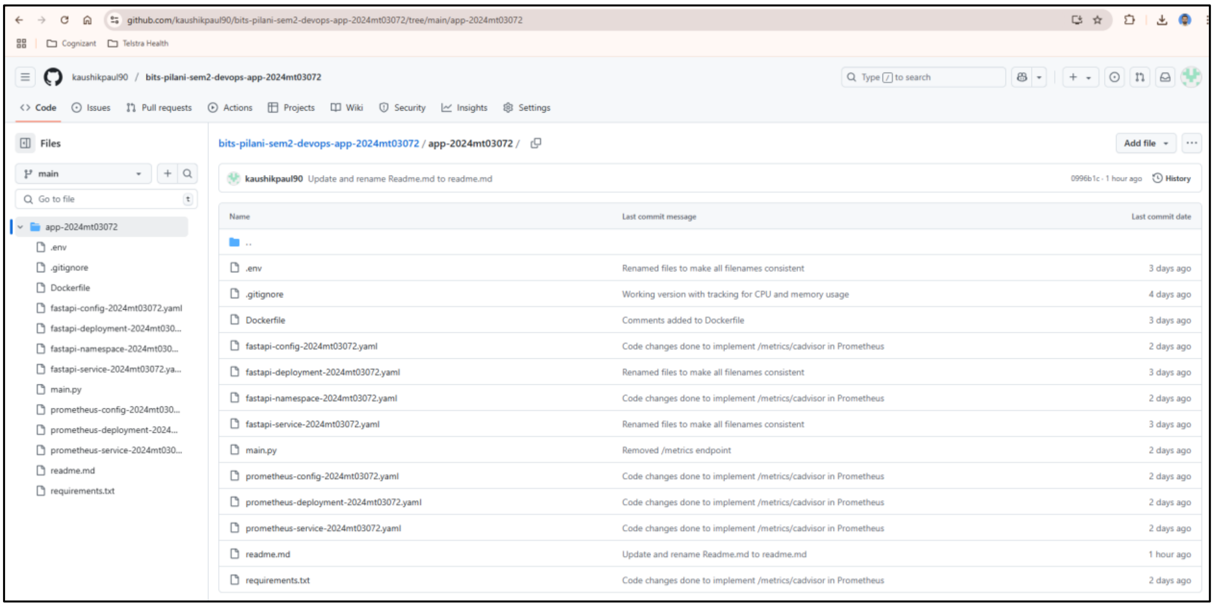
Component	Details
Operating System	Ubuntu 24.04 LTS (64-bit)
Python Version	Python 3.12.3
FastAPI Framework	FastAPI 0.115.12
ASGI Server	Uvicorn 0.34.2
Virtual Environment	venv (python -m venv .venv)
Containerization	Docker Engine (v26.1.3) installed via apt-get
Container Orchestration	Minikube v1.35.0 running Kubernetes v1.32.0
Monitoring Tool	Prometheus 3.3.1 deployed via Kubernetes YAML files
Code Editor	Visual Studio Code (VSCode) with Python and Docker extensions
Web Browser	Google Chrome
API Testing Tool	curl (command-line), browser (http://localhost:8000/get_info)
Version Control	Git + GitHub repository: link

Note: Docker Desktop was not used. Instead, Docker was installed on a native Ubuntu Linux system, and Minikube was used for local Kubernetes deployment. All functional requirements remain the same.

Project Repository

Github link → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/tree/main/app-2024mt03072

Screenshot


github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/tree/main/app-2024mt03072
Cognizant
Telstra Health
kaushikpaul90 / bits-pilani-sem2-devops-app-2024mt03072
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readme.md
requirements.txt
Add file
History

bits-pilani-sem2-devops-app-2024mt03072 / app-2024mt03072 /

kaushikpaul90 Update and rename Readme.md to readme.md 0996b1c · 1 hour ago

Name	Last commit message	Last commit date
..		
.env	Renamed files to make all filenames consistent	3 days ago
.gitignore	Working version with tracking for CPU and memory usage	4 days ago
Dockerfile	Comments added to Dockerfile	3 days ago
fastapi-config-2024mt03072.yaml	Code changes done to implement /metrics/cadvisor in Prometheus	2 days ago
fastapi-deployment-2024mt03072.yaml	Renamed files to make all filenames consistent	3 days ago
fastapi-namespace-2024mt03072.yaml	Code changes done to implement /metrics/cadvisor in Prometheus	2 days ago
fastapi-service-2024mt03072.yaml	Renamed files to make all filenames consistent	3 days ago
main.py	Removed /metrics endpoint	2 days ago
prometheus-config-2024mt03072.yaml	Code changes done to implement /metrics/cadvisor in Prometheus	2 days ago
prometheus-deployment-2024mt03072.yaml	Code changes done to implement /metrics/cadvisor in Prometheus	2 days ago
prometheus-service-2024mt03072.yaml	Code changes done to implement /metrics/cadvisor in Prometheus	2 days ago
readme.md	Update and rename Readme.md to readme.md	1 hour ago
requirements.txt	Code changes done to implement /metrics/cadvisor in Prometheus	2 days ago

Task 1: Create the Backend Application using FastAPI

1. Project Setup

a. Creating a new directory named **app-2024mt03072** for the Python project FastAPI.

```bash
mkdir app-2024mt03072
```

b. Changing the current working directory to app-2024mt03072.

```bash
cd app-2024mt03072
```

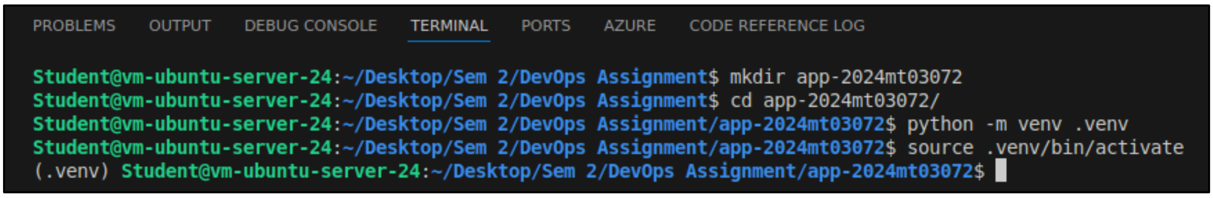
c. Creating a virtual environment for the project app-2024mt03072.

```bash
python -m venv .venv
```

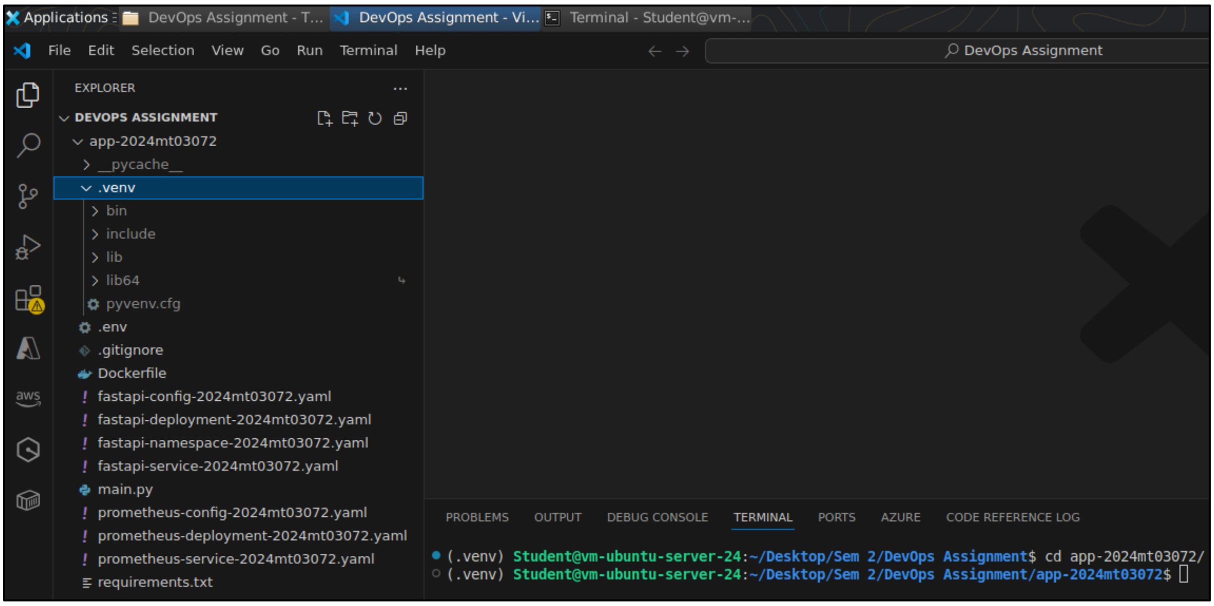
d. Activating the Python virtual environment named “.venv”.

```bash
source .venv/bin/activate
```

1.1. Screenshot



```
Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment$ mkdir app-2024mt03072
Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment$ cd app-2024mt03072/
Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ python -m venv .venv
Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ source .venv/bin/activate
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ 
```


Applications
DevOps Assignment - T...
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.venv
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lib64
pyvenv.cfg
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prometheus-service-2024mt03072.yaml
requirements.txt
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TERMINAL
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```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment$ cd app-2024mt03072/
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```

2. Dependency Installation

a. Adding required packages to requirements.txt file for installation.

File link → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/blob/main/app-2024mt03072/requirements.txt

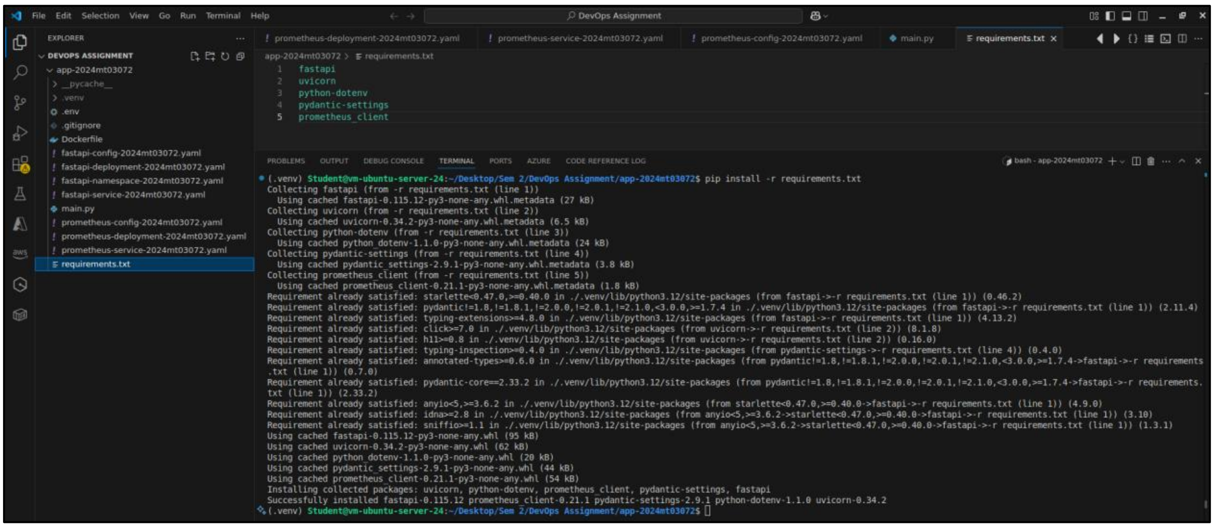
b. Installing the packages listed in requirements.txt using pip install.

```bash
pip install -r requirements.txt
```

Note:

- **fastapi**: A modern, high-performance web framework for building APIs with Python 3.7+ based on standard Python type hints.
- **python-dotenv**: A tool that loads environment variables from a .env file into the Python environment.
- **pydantic-settings**: A library to manage application settings using Pydantic models with support for environment variable loading.
- **uvicorn**: A lightning-fast ASGI server for serving FastAPI and other ASGI-compatible Python web apps.
- **prometheus_client**: A Python client for exposing metrics in a format Prometheus can scrape for monitoring and alerting.

2.1. Screenshot



File Edit Selection View Go Run Terminal Help
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fastapi-service-2024mt03072.yaml
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prometheus-service-2024mt03072.yaml
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prometheus-deployment-2024mt03072.yaml
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prometheus-config-2024mt03072.yaml
main.py
requirements.txt
app-2024mt03072 > requirements.txt
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS AZURE CODE REFERENCE LOG
bash - app-2024mt03072

```
fastapi
uvicorn
python-dotenv
pydantic-settings
prometheus_client
```

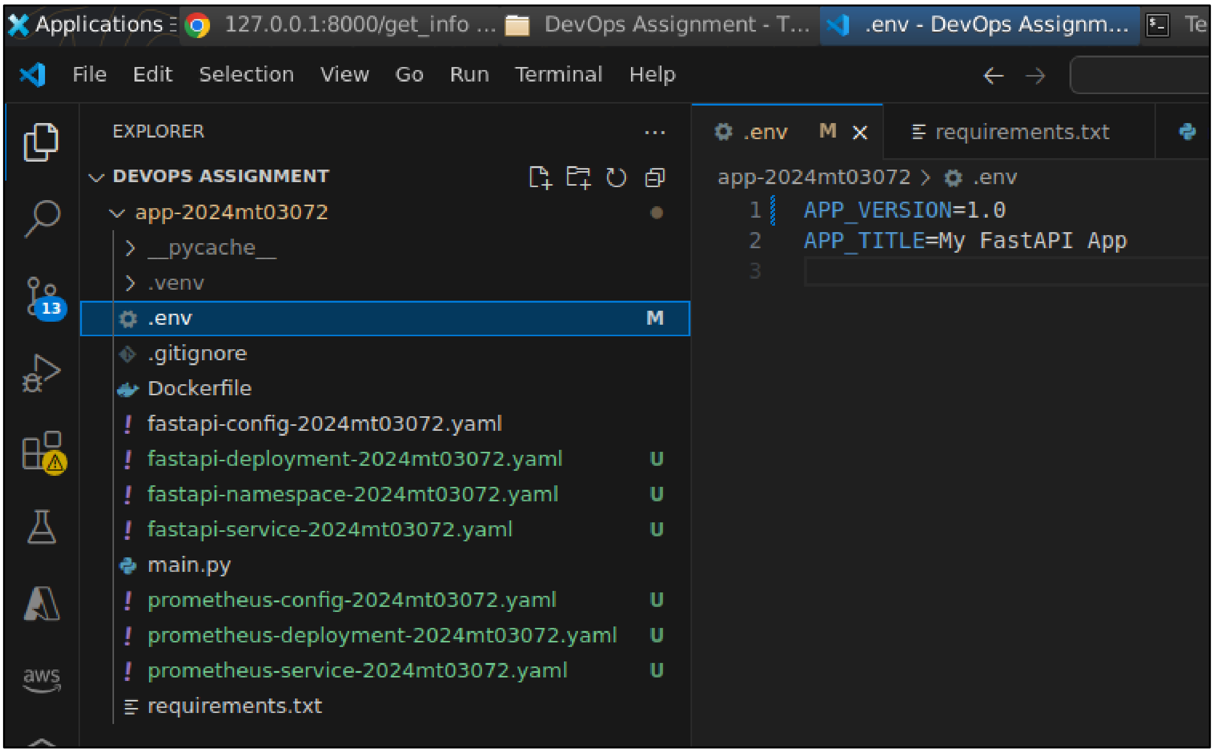
```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ pip install -r requirements.txt
Collecting fastapi (from -r requirements.txt (line 1))
  Using cached fastapi-0.115.12-py3-none-any.whl.metadata (27 kB)
Collecting uvicorn (from -r requirements.txt (line 2))
  Using cached uvicorn-0.34.2-py3-none-any.whl.metadata (6.5 kB)
Collecting python-dotenv (from -r requirements.txt (line 3))
  Using cached python_dotenv-1.1.0-py3-none-any.whl.metadata (24 kB)
Collecting pydantic-settings (from -r requirements.txt (line 4))
  Using cached pydantic_settings-2.9.1-py3-none-any.whl.metadata (3.8 kB)
Collecting prometheus_client (from -r requirements.txt (line 5))
  Using cached prometheus_client-0.21.1-py3-none-any.whl.metadata (1.8 kB)
Requirement already satisfied: starlette<0.47.0,>=0.40.0 in ./.venv/lib/python3.12/site-packages (from fastapi->-r requirements.txt (line 1)) (0.46.2)
Requirement already satisfied: pydantic!=1.8,!=1.8.1,!=2.0.0,!=2.0.1,!=2.1.0,<3.0.0,>=1.7.4 in ./.venv/lib/python3.12/site-packages (from fastapi->-r requirements.txt (line 1)) (2.11.4)
Requirement already satisfied: typing-extensions>=4.8.0 in ./.venv/lib/python3.12/site-packages (from fastapi->-r requirements.txt (line 1)) (4.13.2)
Requirement already satisfied: click>=7.0 in ./.venv/lib/python3.12/site-packages (from uvicorn->-r requirements.txt (line 2)) (8.1.8)
Requirement already satisfied: h11>=0.8 in ./.venv/lib/python3.12/site-packages (from uvicorn->-r requirements.txt (line 2)) (0.16.0)
Requirement already satisfied: typing-inspection>=0.4.0 in ./.venv/lib/python3.12/site-packages (from pydantic-settings->-r requirements.txt (line 4)) (0.4.0)
Requirement already satisfied: annotated-types>=0.6.0 in ./.venv/lib/python3.12/site-packages (from pydantic!=1.8,!=1.8.1,!=2.0.0,!=2.0.1,!=2.1.0,<3.0.0,>=1.7.4->fastapi->-r requirements
.txt (line 1)) (0.7.0)
Requirement already satisfied: pydantic-core==2.33.2 in ./.venv/lib/python3.12/site-packages (from pydantic!=1.8,!=1.8.1,!=2.0.0,!=2.0.1,!=2.1.0,<3.0.0,>=1.7.4->fastapi->-r requirements.
txt (line 1)) (2.33.2)
Requirement already satisfied: anyio<5,>=3.6.2 in ./.venv/lib/python3.12/site-packages (from starlette<0.47.0,>=0.40.0->fastapi->-r requirements.txt (line 1)) (4.9.0)
Requirement already satisfied: idna>=2.8 in ./.venv/lib/python3.12/site-packages (from anyio<5,>=3.6.2->starlette<0.47.0,>=0.40.0->fastapi->-r requirements.txt (line 1)) (3.10)
Requirement already satisfied: sniffio>=1.1 in ./.venv/lib/python3.12/site-packages (from anyio<5,>=3.6.2->starlette<0.47.0,>=0.40.0->fastapi->-r requirements.txt (line 1)) (1.3.1)
Using cached fastapi-0.115.12-py3-none-any.whl (95 kB)
Using cached uvicorn-0.34.2-py3-none-any.whl (62 kB)
Using cached python_dotenv-1.1.0-py3-none-any.whl (20 kB)
Using cached pydantic_settings-2.9.1-py3-none-any.whl (44 kB)
Using cached prometheus_client-0.21.1-py3-none-any.whl (54 kB)
Installing collected packages: uvicorn, python-dotenv, prometheus_client, pydantic-settings, fastapi
Successfully installed fastapi-0.115.12 prometheus_client-0.21.1 pydantic-settings-2.9.1 python-dotenv-1.1.0 uvicorn-0.34.2
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ 
```

3. Environment Variables Setup

a. Creating a .env file in the project directory app-2024mt03072 to store the values of APP_VERSION and APP_TITLE.

File link → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/blob/main/app-2024mt03072/.env

3.1. Screenshot



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fastapi-service-2024mt03072.yaml U
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prometheus-service-2024mt03072.yaml U
requirements.txt
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aws
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requirements.txt
app-2024mt03072 > .env

```
APP_VERSION=1.0
APP_TITLE=My FastAPI App
```

4. Creation of main.py

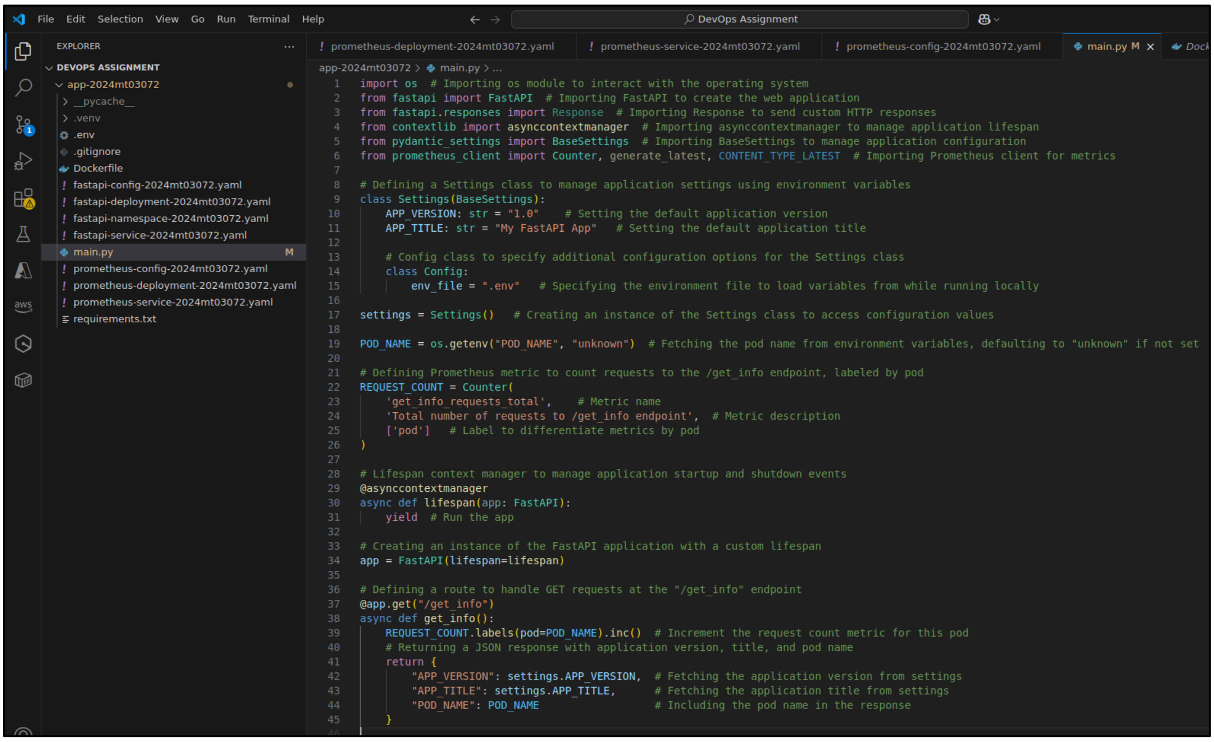
a. Creating Python file named main.py in the project directory app-2024mt03072.

File link → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/blob/main/app-2024mt03072/main.py

Note:

- The POD_NAME attribute has been included in the returned JSON object to indicate which pod replica is processing the request.
- When running the application locally or in a containerized environment, POD_NAME is displayed as “unknown”.
- When the application is deployed and browsed from Minikube cluster, it shows the actual pod replica name.

4.1. Screenshot



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requirements.txt
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prometheus-service-2024mt03072.yaml
prometheus-config-2024mt03072.yaml
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Dock
app-2024mt03072 > main.py > ...

```python
import os  # Importing os module to interact with the operating system
from fastapi import FastAPI  # Importing FastAPI to create the web application
from fastapi.responses import Response  # Importing Response to send custom HTTP responses
from contextlib import asynccontextmanager  # Importing asynccontextmanager to manage application lifespan
from pydantic_settings import BaseSettings  # Importing BaseSettings to manage application configuration
from prometheus_client import Counter, generate_latest, CONTENT_TYPE_LATEST  # Importing Prometheus client for metrics

# Defining a Settings class to manage application settings using environment variables
class Settings(BaseSettings):
    APP_VERSION: str = "1.0"    # Setting the default application version
    APP_TITLE: str = "My FastAPI App"   # Setting the default application title

    # Config class to specify additional configuration options for the Settings class
    class Config:
        env_file = ".env"   # Specifying the environment file to load variables from while running locally

settings = Settings()   # Creating an instance of the Settings class to access configuration values

POD_NAME = os.getenv("POD_NAME", "unknown")  # Fetching the pod name from environment variables, defaulting to "unknown" if not set

# Defining Prometheus metric to count requests to the /get_info endpoint, labeled by pod
REQUEST_COUNT = Counter(
    'get_info_requests_total',    # Metric name
    'Total number of requests to /get_info endpoint',  # Metric description
    ['pod']   # Label to differentiate metrics by pod
)

# Lifespan context manager to manage application startup and shutdown events
@asynccontextmanager
async def lifespan(app: FastAPI):
    yield  # Run the app

# Creating an instance of the FastAPI application with a custom lifespan
app = FastAPI(lifespan=lifespan)

# Defining a route to handle GET requests at the "/get_info" endpoint
@app.get("/get_info")
async def get_info():
    REQUEST_COUNT.labels(pod=POD_NAME).inc()  # Increment the request count metric for this pod
    # Returning a JSON response with application version, title, and pod name
    return {
        "APP_VERSION": settings.APP_VERSION,  # Fetching the application version from settings
        "APP_TITLE": settings.APP_TITLE,      # Fetching the application title from settings
        "POD_NAME": POD_NAME                  # Including the pod name in the response
    }
```

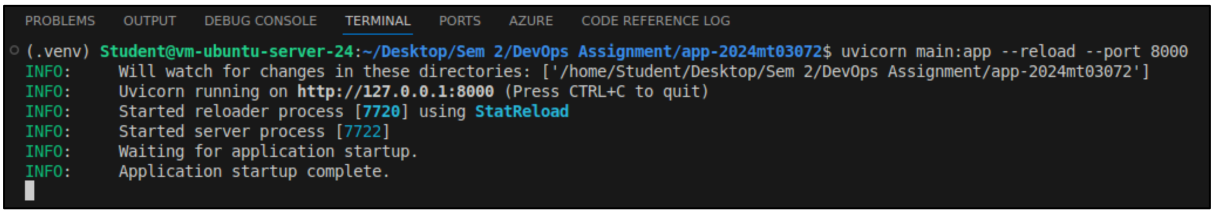
5. Testing FastAPI Application Locally

a. Running the application locally on Uvicorn.

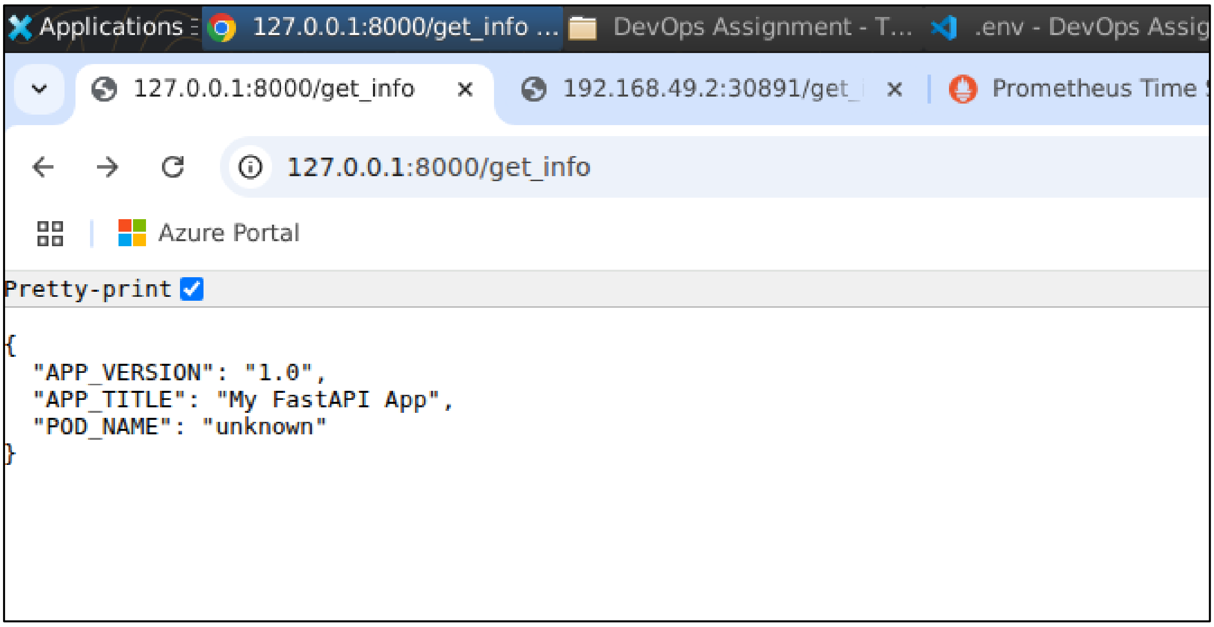
```bash
uvicorn main:app --reload --port 8000
```

b. Accessing the application via http://localhost:8000/get_info on Google Chrome.

5.1. Screenshot



```
○ (.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ uvicorn main:app --reload --port 8000
  INFO:     Will watch for changes in these directories: ['/home/Student/Desktop/Sem 2/DevOps Assignment/app-2024mt03072']
  INFO:     Uvicorn running on http://127.0.0.1:8000 (Press CTRL+C to quit)
  INFO:     Started reloader process [7720] using StatReload
  INFO:     Started server process [7722]
  INFO:     Waiting for application startup.
  INFO:     Application startup complete.
```



```
{
  "APP_VERSION": "1.0",
  "APP_TITLE": "My FastAPI App",
  "POD_NAME": "unknown"
}
```

6. Challenges Faced

a. No challenges faced while creating the backend application using FastAPI.

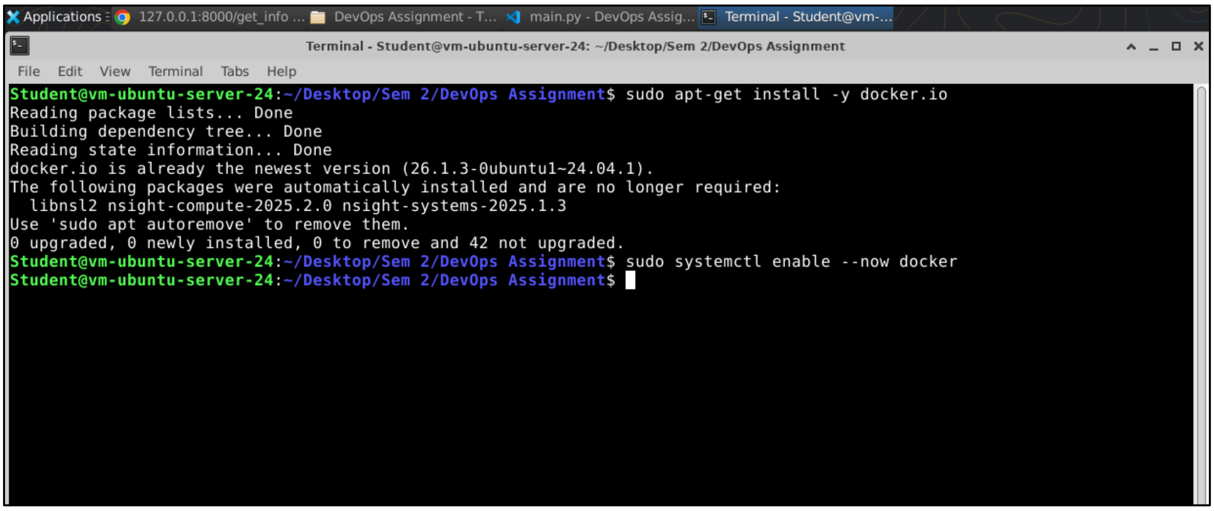
Task 2: Dockerize the Backend Application

1. Docker Setup

a. Installing and enabling Docker on Linux OS.

```bash
sudo apt-get install -y docker.io
sudo systemctl enable --now docker
```

1.1. Screenshot


Applications
127.0.0.1:8000/get_info ...
DevOps Assignment - T...
main.py - DevOps Assig...
Terminal - Student@vm-...
Terminal - Student@vm-ubuntu-server-24: ~/Desktop/Sem 2/DevOps Assignment
File
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View
Terminal
Tabs
Help

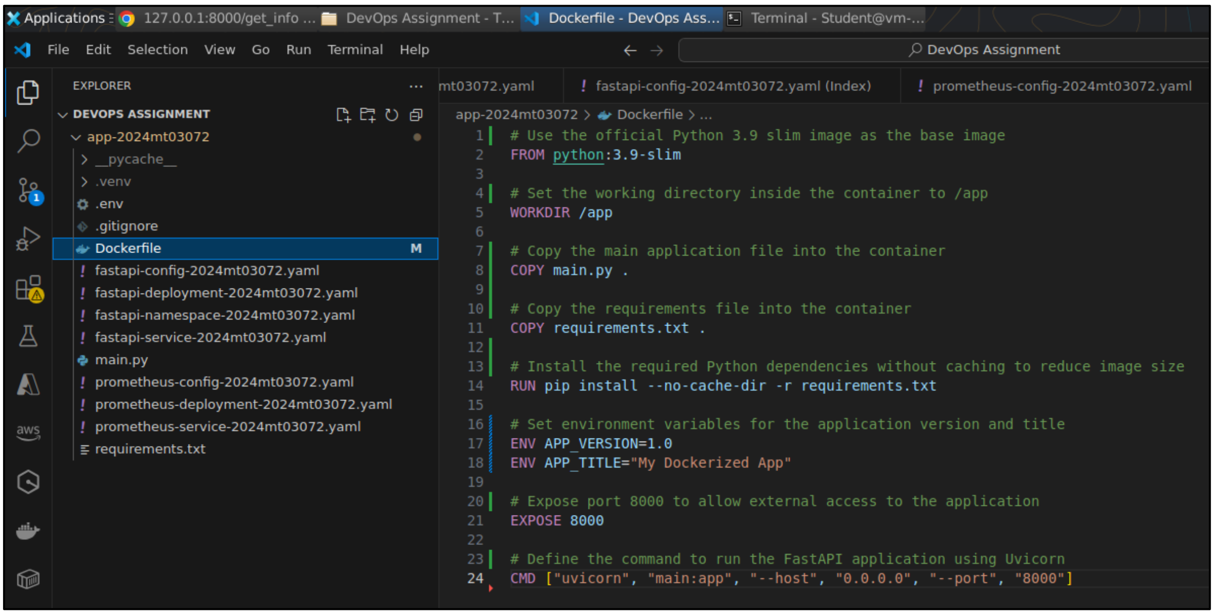
```
Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment$ sudo apt-get install -y docker.io
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
docker.io is already the newest version (26.1.3-0ubuntu1~24.04.1).
The following packages were automatically installed and are no longer required:
  libnsl2 nsight-compute-2025.2.0 nsight-systems-2025.1.3
Use 'sudo apt autoremove' to remove them.
0 upgraded, 0 newly installed, 0 to remove and 42 not upgraded.
Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment$ sudo systemctl enable --now docker
Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment$
```

2. Dockerfile Creation

a. Creating a file named Dockerfile inside the project directory app-2024mt03072.

File link → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/blob/main/app-2024mt03072/Dockerfile

2.1. Screenshot


Applications
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requirements.txt
mt03072.yaml
fastapi-config-2024mt03072.yaml (Index)
prometheus-config-2024mt03072.yaml
app-2024mt03072 > Dockerfile > ...

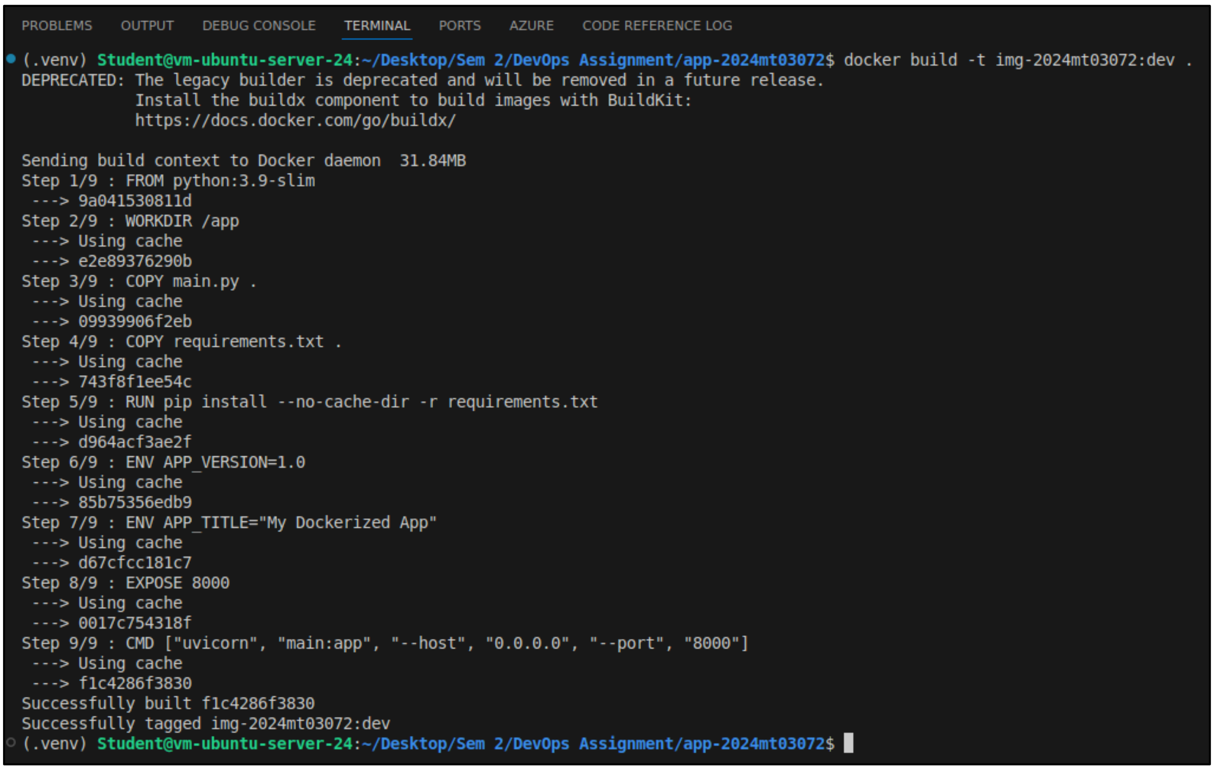
```
# Use the official Python 3.9 slim image as the base image
FROM python:3.9-slim

# Set the working directory inside the container to /app
WORKDIR /app

# Copy the main application file into the container
COPY main.py .

# Copy the requirements file into the container
COPY requirements.txt .

# Install the required Python dependencies without caching to reduce image size
RUN pip install --no-cache-dir -r requirements.txt

# Set environment variables for the application version and title
ENV APP_VERSION=1.0
ENV APP_TITLE="My Dockerized App"

# Expose port 8000 to allow external access to the application
EXPOSE 8000

# Define the command to run the FastAPI application using Uvicorn
CMD ["uvicorn", "main:app", "--host", "0.0.0.0", "--port", "8000"]
```

3. Docker Image Build

a. Building the Docker image using Dockerfile. Docker image is named as **img-2024mt03072** and tag is set to **dev**.

```bash
docker build -t img-2024mt03072:dev .
```

3.1. Screenshot



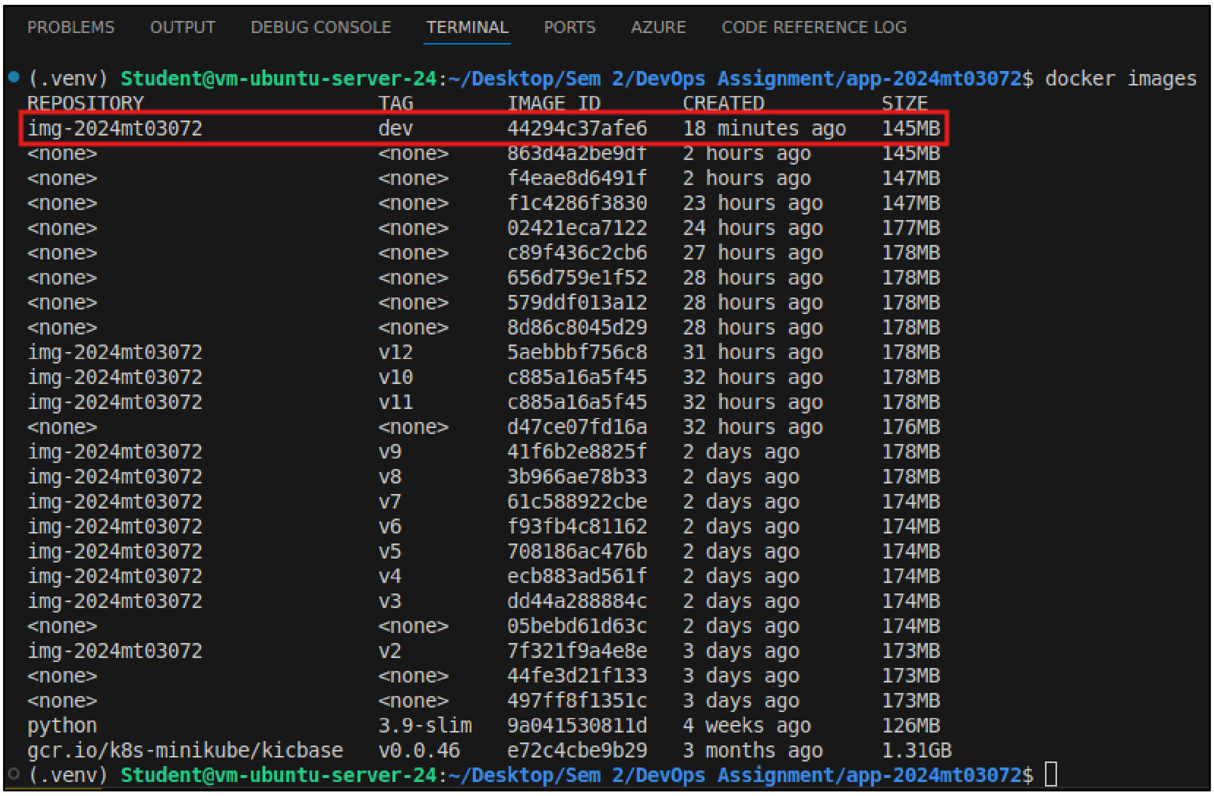
```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ docker build -t img-2024mt03072:dev .
DEPRECATED: The legacy builder is deprecated and will be removed in a future release.
            Install the buildx component to build images with BuildKit:
            https://docs.docker.com/go/buildx/

Sending build context to Docker daemon  31.84MB
Step 1/9 : FROM python:3.9-slim
 ---> 9a041530811d
Step 2/9 : WORKDIR /app
 ---> Using cache
 ---> e2e89376290b
Step 3/9 : COPY main.py .
 ---> Using cache
 ---> 09939906f2eb
Step 4/9 : COPY requirements.txt .
 ---> Using cache
 ---> 743f8f1ee54c
Step 5/9 : RUN pip install --no-cache-dir -r requirements.txt
 ---> Using cache
 ---> d964acf3ae2f
Step 6/9 : ENV APP_VERSION=1.0
 ---> Using cache
 ---> 85b75356edb9
Step 7/9 : ENV APP_TITLE="My Dockerized App"
 ---> Using cache
 ---> d67cfcc181c7
Step 8/9 : EXPOSE 8000
 ---> Using cache
 ---> 0017c754318f
Step 9/9 : CMD ["uvicorn", "main:app", "--host", "0.0.0.0", "--port", "8000"]
 ---> Using cache
 ---> f1c4286f3830
Successfully built f1c4286f3830
Successfully tagged img-2024mt03072:dev
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ 
```

4. Docker Image Verification

a. Verifying the Docker image creation.

```bash
docker images
```

4.1. Screenshot



```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ docker images
REPOSITORY                    TAG        IMAGE ID       CREATED          SIZE
img-2024mt03072               dev        44294c37afe6   18 minutes ago   145MB
<none>                        <none>     863d4a2be9df   2 hours ago      145MB
<none>                        <none>     f4eae8d6491f   2 hours ago      147MB
<none>                        <none>     f1c4286f3830   23 hours ago     147MB
<none>                        <none>     02421eca7122   24 hours ago     177MB
<none>                        <none>     c89f436c2cb6   27 hours ago     178MB
<none>                        <none>     656d759e1f52   28 hours ago     178MB
<none>                        <none>     579ddf013a12   28 hours ago     178MB
<none>                        <none>     8d86c8045d29   28 hours ago     178MB
img-2024mt03072               v12        5aebbbf756c8   31 hours ago     178MB
img-2024mt03072               v10        c885a16a5f45   32 hours ago     178MB
img-2024mt03072               v11        c885a16a5f45   32 hours ago     178MB
<none>                        <none>     d47ce07fd16a   32 hours ago     176MB
img-2024mt03072               v9         41f6b2e8825f   2 days ago       178MB
img-2024mt03072               v8         3b966ae78b33   2 days ago       178MB
img-2024mt03072               v7         61c588922cbe   2 days ago       174MB
img-2024mt03072               v6         f93fb4c81162   2 days ago       174MB
img-2024mt03072               v5         708186ac476b   2 days ago       174MB
img-2024mt03072               v4         ecb883ad561f   2 days ago       174MB
img-2024mt03072               v3         dd44a288884c   2 days ago       174MB
<none>                        <none>     05bebd61d63c   2 days ago       174MB
img-2024mt03072               v2         7f321f9a4e8e   3 days ago       173MB
<none>                        <none>     44fe3d21f133   3 days ago       173MB
<none>                        <none>     497ff8f1351c   3 days ago       173MB
python                        3.9-slim   9a041530811d   4 weeks ago      126MB
gcr.io/k8s-minikube/kicbase   v0.0.46    e72c4cbe9b29   3 months ago     1.31GB
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ 
```

5. Challenges Faced

a. No challenges faced while dockerizing the backend application.

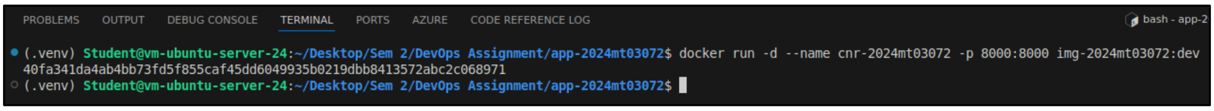
Task 3: Run the Docker Container

1. Docker Container Creation

a. Creating Docker container using the built image img-2024mt03072. Container is named as **cnr-2024mt03072:dev**.

```bash
docker run -d --name cnr-2024mt03072 -p 8000:8000 img-2024mt03072:dev
```

1.1. Screenshot



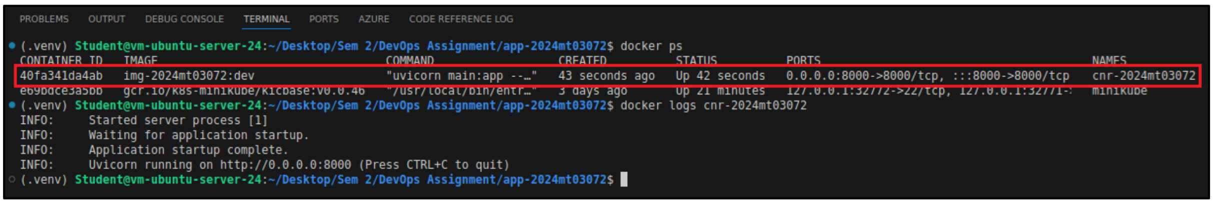
```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ docker run -d --name cnr-2024mt03072 -p 8000:8000 img-2024mt03072:dev
40fa341da4ab4bb73fd5f855caf45dd6049935b0219dbb8413572abc2c068971
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```

2. Docker Container Verification

a. Verifying the created Docker container.

```bash
docker ps
docker logs cnr-2024mt03072
```

2.1. Screenshot

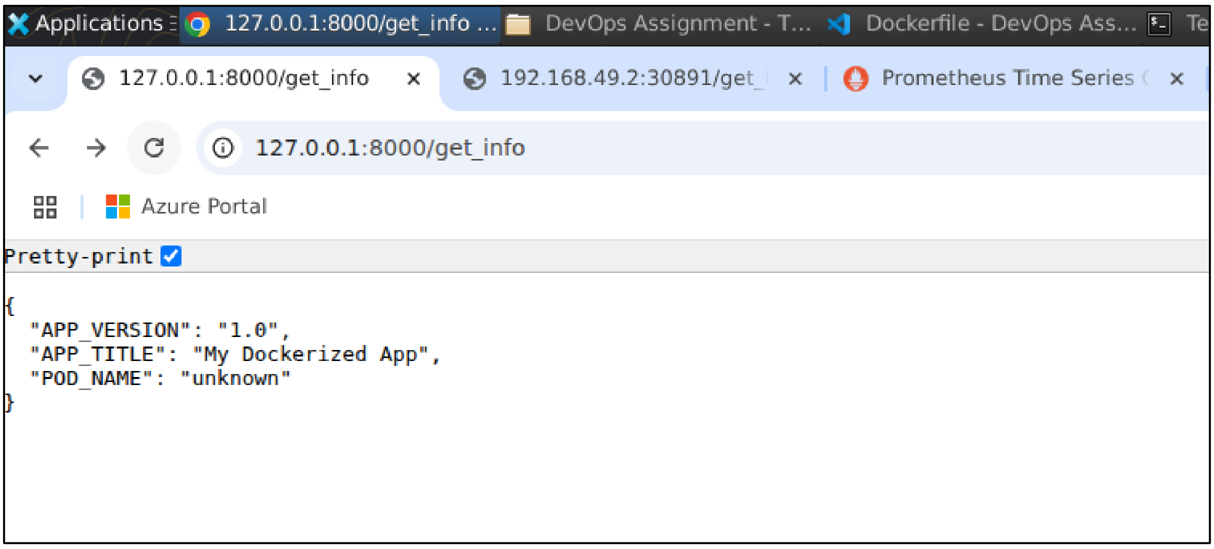


```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ docker ps
CONTAINER ID   IMAGE                                 COMMAND                  CREATED          STATUS           PORTS                                         NAMES
40fa341da4ab   img-2024mt03072:dev                   "uvicorn main:app --…"   43 seconds ago   Up 42 seconds    0.0.0.0:8000->8000/tcp, :::8000->8000/tcp     cnr-2024mt03072
e69bdce3a5bb   gcr.io/k8s-minikube/kicbase:v0.0.46   "/usr/local/bin/entr…"   3 days ago       Up 21 minutes    127.0.0.1:32772->22/tcp, 127.0.0.1:32771-:    minikube
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ docker logs cnr-2024mt03072
INFO:     Started server process [1]
INFO:     Waiting for application startup.
INFO:     Application startup complete.
INFO:     Uvicorn running on http://0.0.0.0:8000 (Press CTRL+C to quit)
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```

3. Testing the Containerized Application

a. Accessing the containerized application via http://localhost:8000/get_info on Google Chrome.

3.1. Screenshot



```
{
  "APP_VERSION": "1.0",
  "APP_TITLE": "My Dockerized App",
  "POD_NAME": "unknown"
}
```

4. Challenges Faced

a. No challenges faced while running the dockerized backend application over Google Chrome.

Task 4: Deploy Docker Image to Kubernetes Cluster

1. Minikube Setup

a. Downloading Minikube.

```bash
curl -LO
https://storage.googleapis.com/minikube/releases/latest/minikube-linux-amd64
```

b. Installing Minikube.

```bash
sudo install minikube-linux-amd64 /usr/local/bin/minikube
```

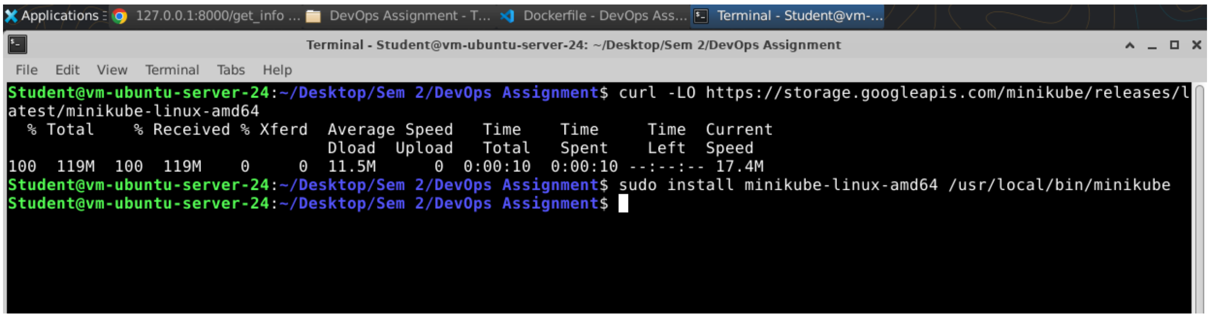
c. Starting Minikube.

```bash
minikube start
```

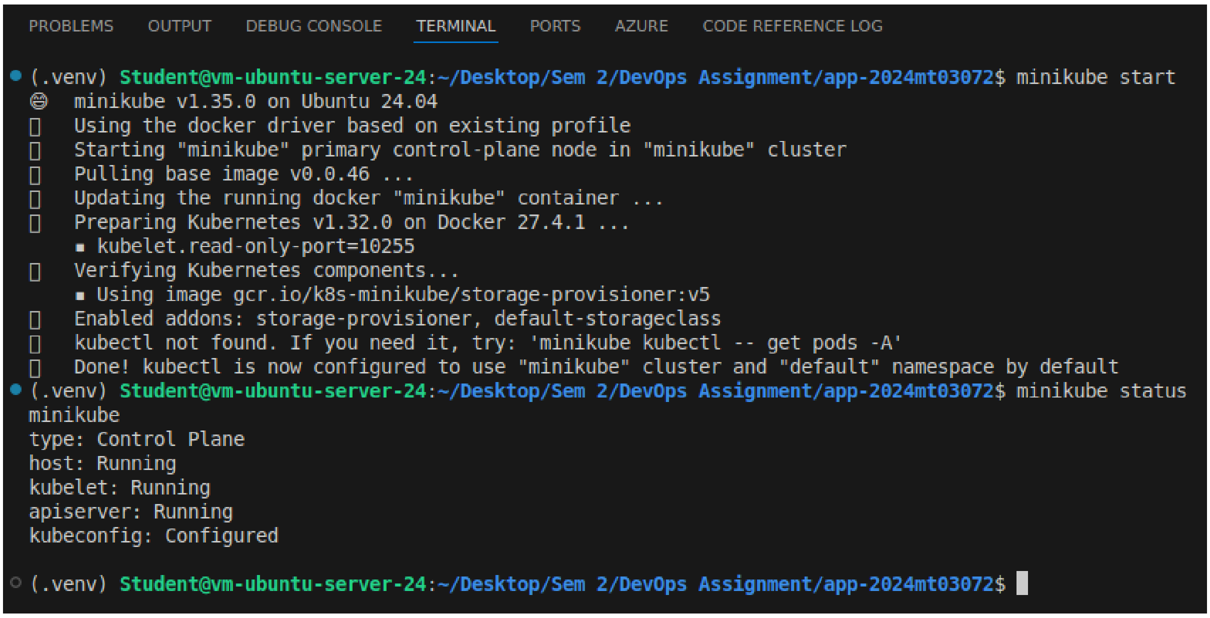
d. Verifying if the Minikube cluster is running properly.

```bash
minikube status
```

1.1. Screenshot


Applications
127.0.0.1:8000/get_info ...
DevOps Assignment - T...
Dockerfile - DevOps Ass...
Terminal - Student@vm-...
Terminal - Student@vm-ubuntu-server-24: ~/Desktop/Sem 2/DevOps Assignment
File Edit View Terminal Tabs Help

```
Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment$ curl -LO https://storage.googleapis.com/minikube/releases/l
atest/minikube-linux-amd64
  % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100  119M  100  119M    0     0  11.5M      0  0:00:10  0:00:10 --:--:-- 17.4M
Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment$ sudo install minikube-linux-amd64 /usr/local/bin/minikube
Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment$ 
```



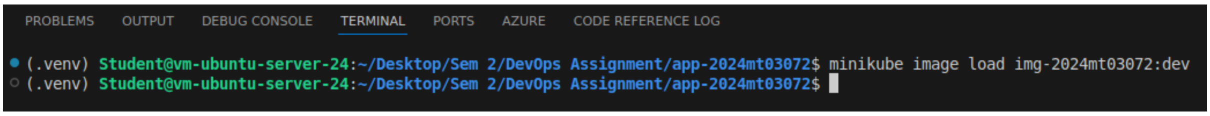
```
● (.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube start
  😄  minikube v1.35.0 on Ubuntu 24.04
  ▯   Using the docker driver based on existing profile
  ▯   Starting "minikube" primary control-plane node in "minikube" cluster
  ▯   Pulling base image v0.0.46 ...
  ▯   Updating the running docker "minikube" container ...
  ▯   Preparing Kubernetes v1.32.0 on Docker 27.4.1 ...
        ▪ kubelet.read-only-port=10255
  ▯   Verifying Kubernetes components...
        ▪ Using image gcr.io/k8s-minikube/storage-provisioner:v5
  ▯   Enabled addons: storage-provisioner, default-storageclass
  ▯   kubectl not found. If you need it, try: 'minikube kubectl -- get pods -A'
  ▯   Done! kubectl is now configured to use "minikube" cluster and "default" namespace by default
● (.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube status
  minikube
  type: Control Plane
  host: Running
  kubelet: Running
  apiserver: Running
  kubeconfig: Configured

○ (.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ █
```

2. Loading Docker Image into Minikube

a. Loading the image img-2024mt03072 into Minikube cluster.

```bash
minikube image load img-2024mt03072:dev
```

2.1. Screenshot



```
● (.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube image load img-2024mt03072:dev
○ (.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ █
```

3. Kubernetes Namespace Creation

a. Creating Kubernetes Namespace **ns-fastapi-2024mt03072** using the Namespace configuration file **fastapi-namespace-2024mt03072.yaml**. File → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/blob/main/app-2024mt03072/fastapi-namespace-2024mt03072.yaml.

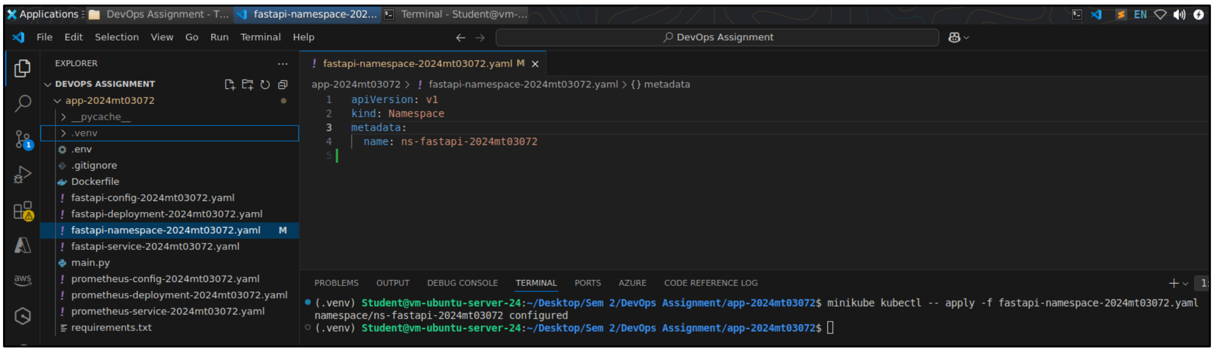
b. Applying the Kubernetes Namespace.

```bash
minikube kubectl -- apply -f fastapi-namespace-2024mt03072.yaml
```

c. Verifying the creation of the Kubernetes Namespace ns-fastapi-2024mt03072.

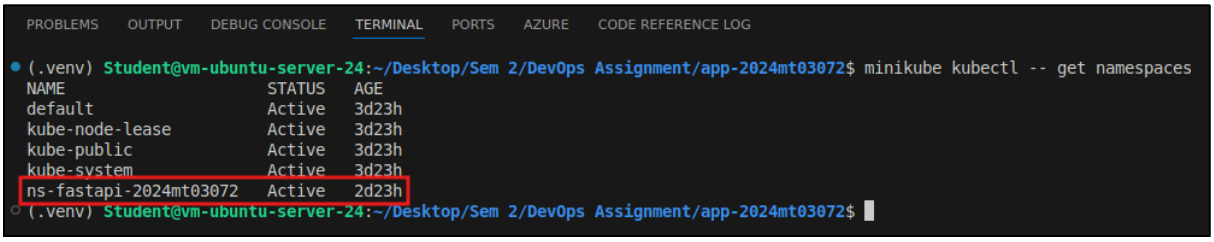
```bash
minikube kubectl -- get namespaces
```

3.1. Screenshot


Applications
DevOps Assignment - T...
fastapi-namespace-202...
Terminal - Student@vm-...
File
Edit
Selection
View
Go
Run
Terminal
Help
DevOps Assignment
EXPLORER
DEVOPS ASSIGNMENT
app-2024mt03072
__pycache__
.venv
.env
.gitignore
Dockerfile
fastapi-config-2024mt03072.yaml
fastapi-deployment-2024mt03072.yaml
fastapi-namespace-2024mt03072.yaml M
fastapi-service-2024mt03072.yaml
main.py
prometheus-config-2024mt03072.yaml
prometheus-deployment-2024mt03072.yaml
prometheus-service-2024mt03072.yaml
requirements.txt
fastapi-namespace-2024mt03072.yaml M
app-2024mt03072 > fastapi-namespace-2024mt03072.yaml > {} metadata
PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
PORTS
AZURE
CODE REFERENCE LOG

```yaml
apiVersion: v1
kind: Namespace
metadata:
  name: ns-fastapi-2024mt03072
```

```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- apply -f fastapi-namespace-2024mt03072.yaml
namespace/ns-fastapi-2024mt03072 configured
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```



```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- get namespaces
NAME                     STATUS   AGE
default                  Active   3d23h
kube-node-lease          Active   3d23h
kube-public              Active   3d23h
kube-system              Active   3d23h
ns-fastapi-2024mt03072   Active   2d23h
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```

4. Kubernetes ConfigMap Creation

a. Creating Kubernetes ConfigMap **config-2024mt03072** using the ConfigMap configuration file **fastapi-config-2024mt03072.yaml**.

File → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/blob/main/app-2024mt03072/fastapi-config-2024mt03072.yaml.

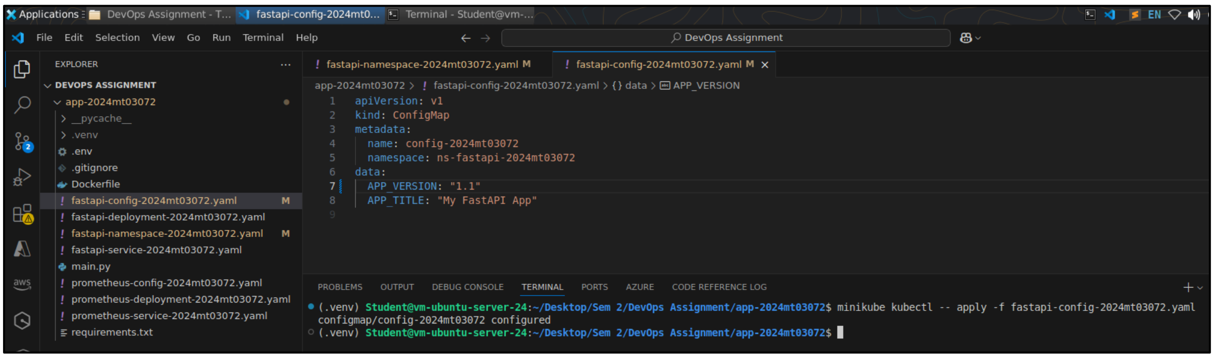
b. Applying the Kubernetes ConfigMap.

```bash
minikube kubectl -- apply -f fastapi-config-2024mt03072.yaml
```

c. Verifying the creation of the Kubernetes ConfigMap config-2024mt03072.

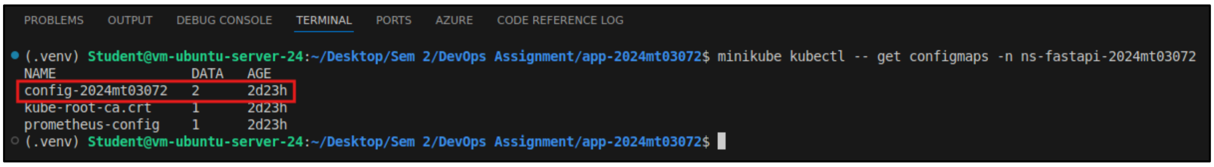
```bash
minikube kubectl -- get configmaps -n ns-fastapi-2024mt03072
```

4.1. Screenshot



```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: config-2024mt03072
  namespace: ns-fastapi-2024mt03072
data:
  APP_VERSION: "1.1"
  APP_TITLE: "My FastAPI App"
```

```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- apply -f fastapi-config-2024mt03072.yaml
configmap/config-2024mt03072 configured
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```



```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- get configmaps -n ns-fastapi-2024mt03072
NAME                 DATA   AGE
config-2024mt03072   2      2d23h
kube-root-ca.crt     1      2d23h
prometheus-config    1      2d23h
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```

5. Kubernetes Deployment Creation

a. Creating Kubernetes Deployment **fastapi-deployment** using the Deployment configuration file **fastapi-deployment-2024mt03072.yaml**.
   File → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/blob/main/app-2024mt03072/fastapi-deployment-2024mt03072.yaml.

b. It creates 2 replicas of the FastAPI application.

c. It reads the APP_VERSION and APP_TITLE values from Kubernetes ConfigMap named fastapi-config-2024mt03072.yaml.

d. Applying the Kubernetes Deployment.

```bash
minikube kubectl -- apply -f fastapi-deployment-2024mt03072.yaml
```

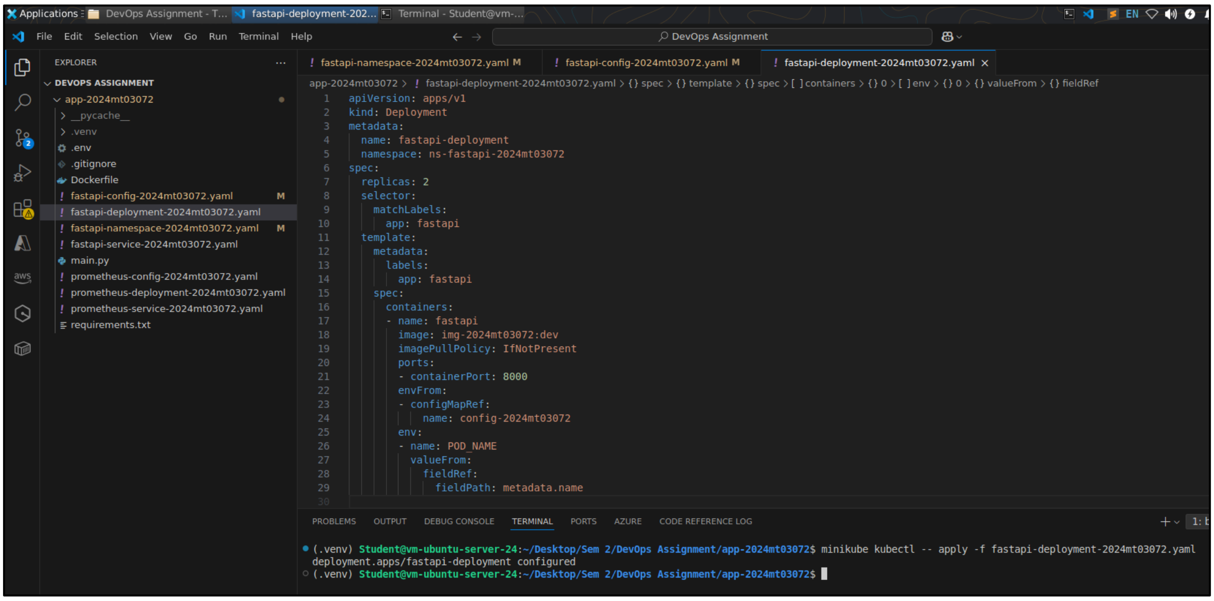
e. Verifying the creation of the Kubernetes Deployment fastapi-deployment.

```bash
minikube kubectl -- get deployments -n ns-fastapi-2024mt03072
```

f. Listing all pods running inside Kubernetes Namespace ns-fastapi-2024mt03072.

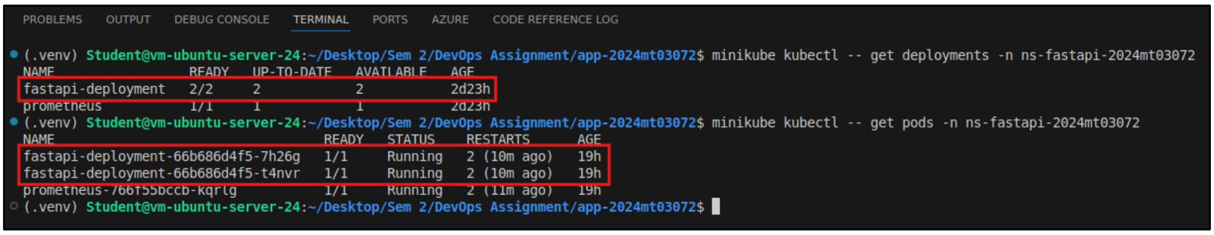
```bash
minikube kubectl -- get pods -n ns-fastapi-2024mt03072
```

5.1. Screenshot


DevOps Assignment
EXPLORER
DEVOPS ASSIGNMENT
app-2024mt03072
__pycache__
.venv
.env
.gitignore
Dockerfile
fastapi-config-2024mt03072.yaml
fastapi-deployment-2024mt03072.yaml
fastapi-namespace-2024mt03072.yaml
fastapi-service-2024mt03072.yaml
main.py
prometheus-config-2024mt03072.yaml
prometheus-deployment-2024mt03072.yaml
prometheus-service-2024mt03072.yaml
requirements.txt
app-2024mt03072 > fastapi-deployment-2024mt03072.yaml > {} spec > {} template > {} spec > [ ] containers > {} 0 > [ ] env > {} 0 > {} valueFrom > {} fieldRef
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS AZURE CODE REFERENCE LOG

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: fastapi-deployment
  namespace: ns-fastapi-2024mt03072
spec:
  replicas: 2
  selector:
    matchLabels:
      app: fastapi
  template:
    metadata:
      labels:
        app: fastapi
    spec:
      containers:
      - name: fastapi
        image: img-2024mt03072:dev
        imagePullPolicy: IfNotPresent
        ports:
        - containerPort: 8000
        envFrom:
        - configMapRef:
            name: config-2024mt03072
        env:
        - name: POD_NAME
          valueFrom:
            fieldRef:
              fieldPath: metadata.name
```

```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- apply -f fastapi-deployment-2024mt03072.yaml
deployment.apps/fastapi-deployment configured
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```


PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS AZURE CODE REFERENCE LOG

```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- get deployments -n ns-fastapi-2024mt03072
NAME                 READY   UP-TO-DATE   AVAILABLE   AGE
fastapi-deployment   2/2     2            2           2d23h
prometheus           1/1     1            1           2d23h
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- get pods -n ns-fastapi-2024mt03072
NAME                                  READY   STATUS    RESTARTS      AGE
fastapi-deployment-66b686d4f5-7h26g   1/1     Running   2 (10m ago)   19h
fastapi-deployment-66b686d4f5-t4nvr   1/1     Running   2 (10m ago)   19h
prometheus-766f55bccb-kqrlg           1/1     Running   2 (11m ago)   19h
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```

6. Challenges Faced

a. Pods not reflecting the latest implementation:

- Setting **imagePullPolicy** to **IfNotPresent** in fastapi-namespace-2024mt03072.yaml resolved the issue.

b. Adding new image tag each time while building the image and updating the same in fastapi-namespace-2024mt03072.yaml:

- Using fixed image tag “dev” during image build and adding it to the image name in fastapi-namespace-2024mt03072.yaml only once resolved the issue.

Task 5: Configure Networking with Load Balancer in Kubernetes Cluster

1. Kubernetes Service Creation

a. Creating Kubernetes Service **fastapi-service** using the Service configuration file **fastapi-service-2024mt03072.yaml**.

File → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/blob/main/app-2024mt03072/fastapi-service-2024mt03072.yaml.

b. It creates a Load Balancer to balance requests across both replicas.

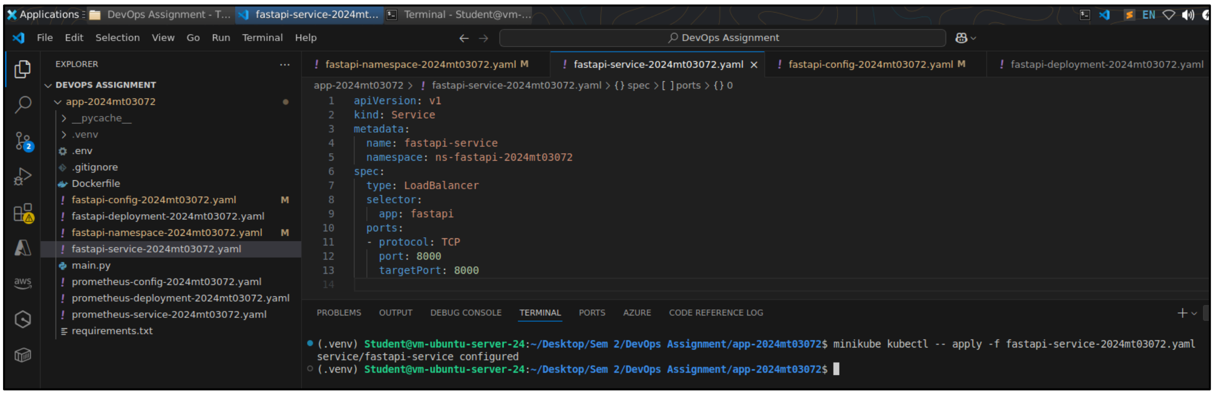
c. Applying the Kubernetes Service.

```bash
minikube kubectl -- apply -f fastapi-service-2024mt03072.yaml
```

d. Verifying the creation of the Kubernetes Service fastapi-service.

```bash
minikube kubectl -- get services -n ns-fastapi-2024mt03072
```

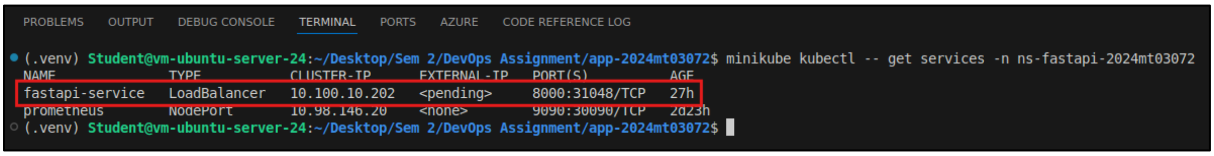
1.1. Screenshot



Applications
DevOps Assignment - T...
fastapi-service-2024mt...
Terminal - Student@vm-...
File Edit Selection View Go Run Terminal Help
DevOps Assignment
EXPLORER
DEVOPS ASSIGNMENT
app-2024mt03072
__pycache__
.venv
.env
.gitignore
Dockerfile
fastapi-config-2024mt03072.yaml M
fastapi-deployment-2024mt03072.yaml
fastapi-namespace-2024mt03072.yaml M
fastapi-service-2024mt03072.yaml
main.py
prometheus-config-2024mt03072.yaml
prometheus-deployment-2024mt03072.yaml
prometheus-service-2024mt03072.yaml
requirements.txt
fastapi-namespace-2024mt03072.yaml M
fastapi-service-2024mt03072.yaml
fastapi-config-2024mt03072.yaml M
fastapi-deployment-2024mt03072.yaml
app-2024mt03072 > fastapi-service-2024mt03072.yaml > {} spec > [ ] ports > {} 0
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS AZURE CODE REFERENCE LOG

```yaml
apiVersion: v1
kind: Service
metadata:
  name: fastapi-service
  namespace: ns-fastapi-2024mt03072
spec:
  type: LoadBalancer
  selector:
    app: fastapi
  ports:
  - protocol: TCP
    port: 8000
    targetPort: 8000
```

```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- apply -f fastapi-service-2024mt03072.yaml
service/fastapi-service configured
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```



PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS AZURE CODE REFERENCE LOG

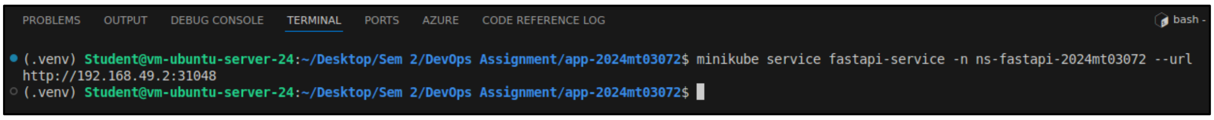
```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- get services -n ns-fastapi-2024mt03072
NAME              TYPE           CLUSTER-IP      EXTERNAL-IP   PORT(S)          AGE
fastapi-service   LoadBalancer   10.100.10.202   <pending>     8000:31048/TCP   27h
prometheus        NodePort       10.98.146.20    <none>        9090:30090/TCP   2d23h
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```

2. Obtaining Access URL

a. Retrieving the URL to access FastAPI application from browser.

```bash
minikube service fastapi-service -n ns-fastapi-2024mt03072 --url
```

2.1. Screenshot



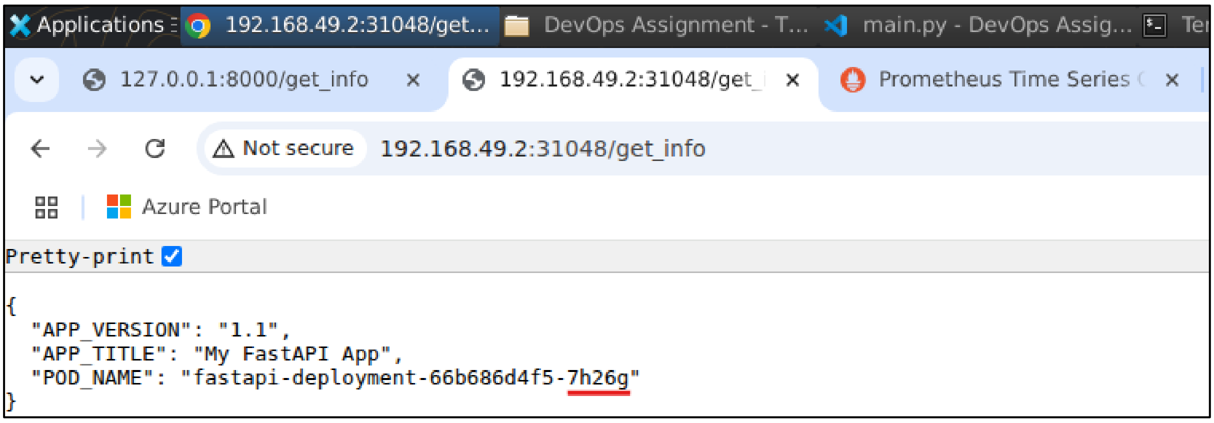
```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube service fastapi-service -n ns-fastapi-2024mt03072 --url
http://192.168.49.2:31048
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```

3. Accessing FastAPI Application

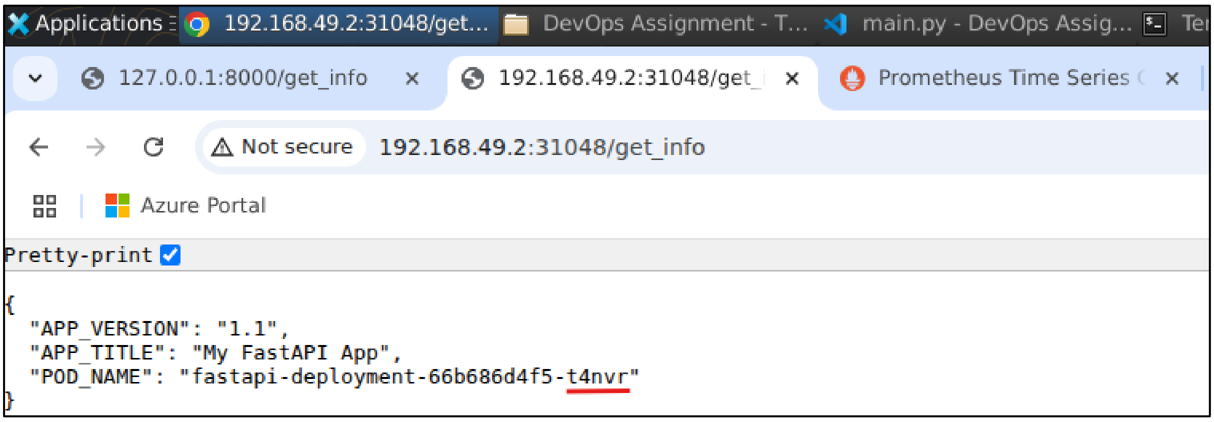
a. Accessing the application via http://192.168.49.2:31048/get_info on Google Chrome.

b. The fact that requests are getting routed to both the replicas is evident from the POD_NAME in the JSON object.

3.1. Screenshot



```
{
  "APP_VERSION": "1.1",
  "APP_TITLE": "My FastAPI App",
  "POD_NAME": "fastapi-deployment-66b686d4f5-7h26g"
}
```



```
{
  "APP_VERSION": "1.1",
  "APP_TITLE": "My FastAPI App",
  "POD_NAME": "fastapi-deployment-66b686d4f5-t4nvr"
}
```

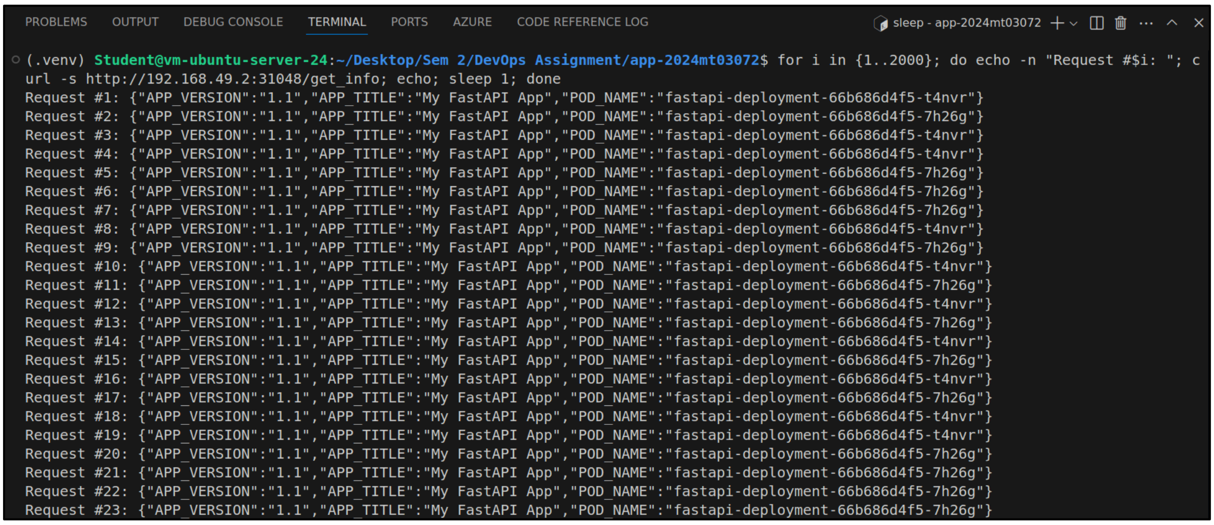
4. Load Balancer Testing

a. Using cURL to make several requests to /get_info endpoint.

b. The output clearly shows that requests are getting routed to both the replicas.

```bash
for i in {1..2000}; do echo -n "Request #$i: "; curl -s
http://192.168.49.2:31048/get_info; echo; sleep 1; done
```

4.1. Screenshot



```
○ (.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ for i in {1..2000}; do echo -n "Request #$i: "; c
url -s http://192.168.49.2:31048/get_info; echo; sleep 1; done
Request #1: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-t4nvr"}
Request #2: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-7h26g"}
Request #3: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-t4nvr"}
Request #4: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-t4nvr"}
Request #5: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-7h26g"}
Request #6: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-7h26g"}
Request #7: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-7h26g"}
Request #8: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-t4nvr"}
Request #9: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-7h26g"}
Request #10: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-t4nvr"}
Request #11: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-7h26g"}
Request #12: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-t4nvr"}
Request #13: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-7h26g"}
Request #14: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-t4nvr"}
Request #15: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-7h26g"}
Request #16: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-t4nvr"}
Request #17: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-7h26g"}
Request #18: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-t4nvr"}
Request #19: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-t4nvr"}
Request #20: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-7h26g"}
Request #21: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-7h26g"}
Request #22: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-7h26g"}
Request #23: {"APP_VERSION":"1.1","APP_TITLE":"My FastAPI App","POD_NAME":"fastapi-deployment-66b686d4f5-7h26g"}
```

5. Challenges Faced

a. No challenges faced while running the dockerized backend application over Google Chrome.

Task 6: Configure Prometheus for Metrics Collection

1. Prometheus Setup

a. Adding the package **prometheus_client** to requirements.txt file.

File link → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/blob/main/app-2024mt03072/requirements.txt

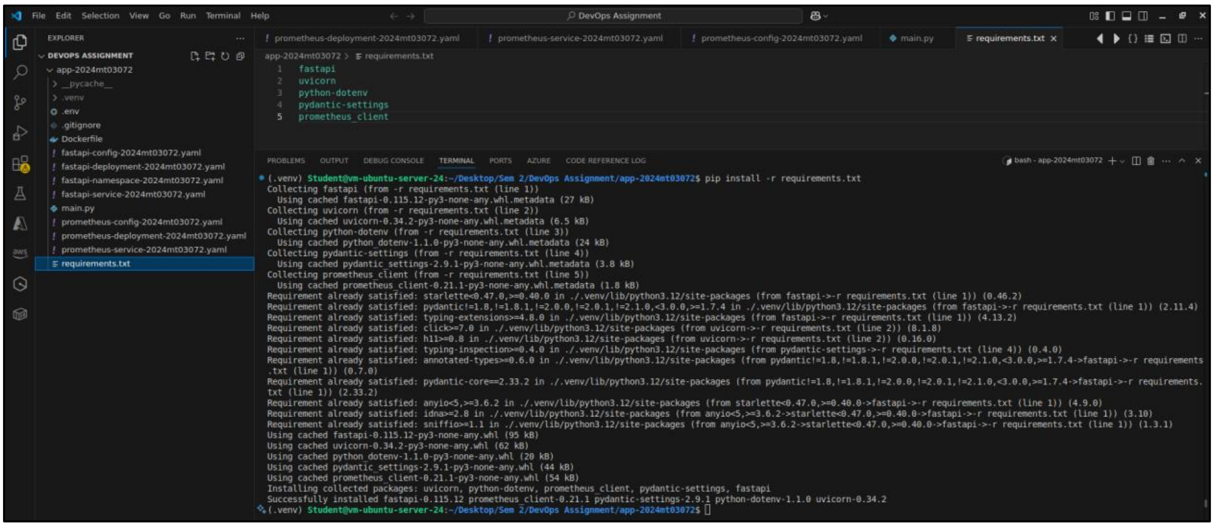
b. Installing prometheus_client by executing requirements.txt using pip install.

```bash
pip install -r requirements.txt
```

Note:

- **prometheus_client**: A Python client for exposing metrics in a format Prometheus can scrape for monitoring and alerting.

1.1. Screenshot


File Edit Selection View Go Run Terminal Help
DevOps Assignment
EXPLORER
DEVOPS ASSIGNMENT
app-2024mt03072
__pycache__
.venv
.env
.gitignore
Dockerfile
fastapi-config-2024mt03072.yaml
fastapi-deployment-2024mt03072.yaml
fastapi-namespace-2024mt03072.yaml
fastapi-service-2024mt03072.yaml
main.py
prometheus-config-2024mt03072.yaml
prometheus-deployment-2024mt03072.yaml
prometheus-service-2024mt03072.yaml
requirements.txt
prometheus-deployment-2024mt03072.yaml
prometheus-service-2024mt03072.yaml
prometheus-config-2024mt03072.yaml
main.py
requirements.txt
app-2024mt03072 > requirements.txt
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS AZURE CODE REFERENCE LOG
bash - app-2024mt03072

```
fastapi
uvicorn
python-dotenv
pydantic-settings
prometheus_client
```

```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ pip install -r requirements.txt
Collecting fastapi (from -r requirements.txt (line 1))
  Using cached fastapi-0.115.12-py3-none-any.whl.metadata (27 kB)
Collecting uvicorn (from -r requirements.txt (line 2))
  Using cached uvicorn-0.34.2-py3-none-any.whl.metadata (6.5 kB)
Collecting python-dotenv (from -r requirements.txt (line 3))
  Using cached python_dotenv-1.1.0-py3-none-any.whl.metadata (24 kB)
Collecting pydantic-settings (from -r requirements.txt (line 4))
  Using cached pydantic_settings-2.9.1-py3-none-any.whl.metadata (3.8 kB)
Collecting prometheus_client (from -r requirements.txt (line 5))
  Using cached prometheus_client-0.21.1-py3-none-any.whl.metadata (1.8 kB)
Requirement already satisfied: starlette<0.47.0,>=0.40.0 in ./.venv/lib/python3.12/site-packages (from fastapi->-r requirements.txt (line 1)) (0.46.2)
Requirement already satisfied: pydantic!=1.8,!=1.8.1,!=2.0.0,!=2.0.1,!=2.1.0,<3.0.0,>=1.7.4 in ./.venv/lib/python3.12/site-packages (from fastapi->-r requirements.txt (line 1)) (2.11.4)
Requirement already satisfied: typing-extensions>=4.8.0 in ./.venv/lib/python3.12/site-packages (from fastapi->-r requirements.txt (line 1)) (4.13.2)
Requirement already satisfied: click>=7.0 in ./.venv/lib/python3.12/site-packages (from uvicorn->-r requirements.txt (line 2)) (8.1.8)
Requirement already satisfied: h11>=0.8 in ./.venv/lib/python3.12/site-packages (from uvicorn->-r requirements.txt (line 2)) (0.16.0)
Requirement already satisfied: typing-inspection>=0.4.0 in ./.venv/lib/python3.12/site-packages (from pydantic-settings->-r requirements.txt (line 4)) (0.4.0)
Requirement already satisfied: annotated-types>=0.6.0 in ./.venv/lib/python3.12/site-packages (from pydantic!=1.8,!=1.8.1,!=2.0.0,!=2.0.1,!=2.1.0,<3.0.0,>=1.7.4->fastapi->-r requirements
.txt (line 1)) (0.7.0)
Requirement already satisfied: pydantic-core==2.33.2 in ./.venv/lib/python3.12/site-packages (from pydantic!=1.8,!=1.8.1,!=2.0.0,!=2.0.1,!=2.1.0,<3.0.0,>=1.7.4->fastapi->-r requirements.
txt (line 1)) (2.33.2)
Requirement already satisfied: anyio<5,>=3.6.2 in ./.venv/lib/python3.12/site-packages (from starlette<0.47.0,>=0.40.0->fastapi->-r requirements.txt (line 1)) (4.9.0)
Requirement already satisfied: idna>=2.8 in ./.venv/lib/python3.12/site-packages (from anyio<5,>=3.6.2->starlette<0.47.0,>=0.40.0->fastapi->-r requirements.txt (line 1)) (3.10)
Requirement already satisfied: sniffio>=1.1 in ./.venv/lib/python3.12/site-packages (from anyio<5,>=3.6.2->starlette<0.47.0,>=0.40.0->fastapi->-r requirements.txt (line 1)) (1.3.1)
Using cached fastapi-0.115.12-py3-none-any.whl (95 kB)
Using cached uvicorn-0.34.2-py3-none-any.whl (62 kB)
Using cached python_dotenv-1.1.0-py3-none-any.whl (20 kB)
Using cached pydantic_settings-2.9.1-py3-none-any.whl (44 kB)
Using cached prometheus_client-0.21.1-py3-none-any.whl (54 kB)
Installing collected packages: uvicorn, python-dotenv, prometheus_client, pydantic-settings, fastapi
Successfully installed fastapi-0.115.12 prometheus_client-0.21.1 pydantic-settings-2.9.1 python-dotenv-1.1.0 uvicorn-0.34.2
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ 
```

2. Integrating Prometheus in FastAPI Application

a. Integrating Prometheus in the FastAPI application to collect metrics by importing Prometheus client in main.py file.

File link → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/blob/main/app-2024mt03072/main.py

3. Prometheus ConfigMap Creation

a. Creating Prometheus ConfigMap **prometheus-config** using the ConfigMap configuration file **prometheus-config-2024mt03072.yaml**.

File → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/blob/main/app-2024mt03072/prometheus-config-2024mt03072.yaml.

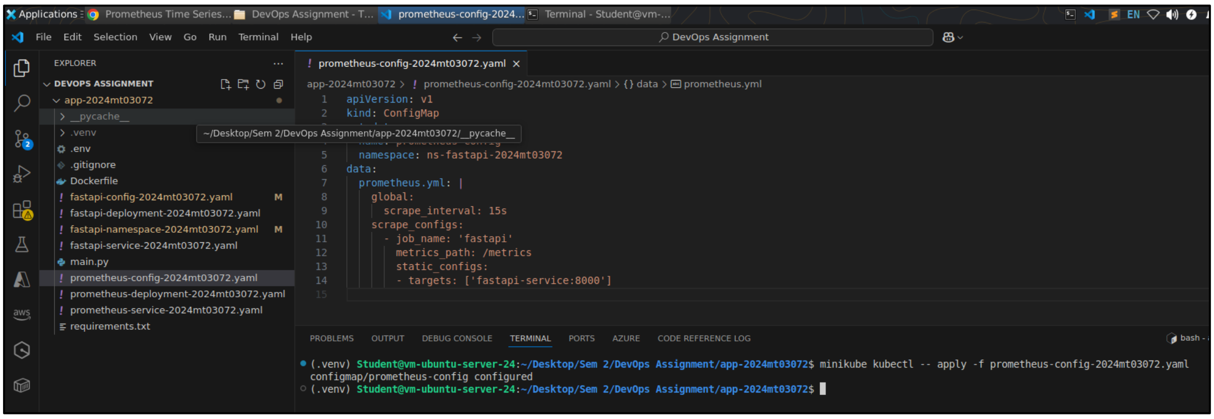
b. Applying the Prometheus ConfigMap.

```bash
minikube kubectl -- apply -f prometheus-config-2024mt03072.yaml
```

c. Verifying the creation of the Prometheus ConfigMap prometheus-config.

```bash
minikube kubectl -- get configmaps -n ns-fastapi-2024mt03072
```

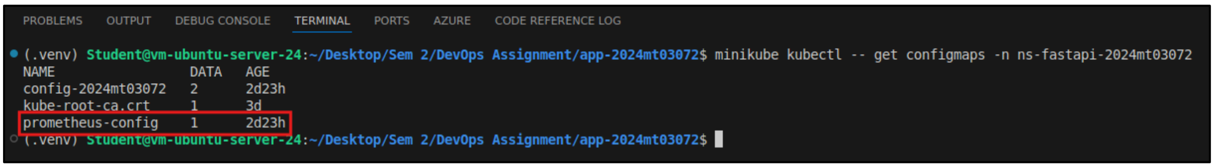
3.1. Screenshot



Applications
Prometheus Time Series...
DevOps Assignment - T...
prometheus-config-2024...
Terminal - Student@vm-...
File Edit Selection View Go Run Terminal Help
DevOps Assignment
EXPLORER
DEVOPS ASSIGNMENT
app-2024mt03072
__pycache__
.venv
~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072/__pycache__
.env
.gitignore
Dockerfile
fastapi-config-2024mt03072.yaml M
fastapi-deployment-2024mt03072.yaml
fastapi-namespace-2024mt03072.yaml M
fastapi-service-2024mt03072.yaml
main.py
prometheus-config-2024mt03072.yaml
prometheus-deployment-2024mt03072.yaml
prometheus-service-2024mt03072.yaml
requirements.txt
prometheus-config-2024mt03072.yaml
app-2024mt03072 > prometheus-config-2024mt03072.yaml > {} data > prometheus.yml
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS AZURE CODE REFERENCE LOG
bash

```yaml
apiVersion: v1
kind: ConfigMap
metadata:
  name: prometheus-config
  namespace: ns-fastapi-2024mt03072
data:
  prometheus.yml: |
    global:
      scrape_interval: 15s
    scrape_configs:
      - job_name: 'fastapi'
        metrics_path: /metrics
        static_configs:
        - targets: ['fastapi-service:8000']
```

```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- apply -f prometheus-config-2024mt03072.yaml
configmap/prometheus-config configured
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```



PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS AZURE CODE REFERENCE LOG

```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- get configmaps -n ns-fastapi-2024mt03072
NAME                   DATA   AGE
config-2024mt03072     2      2d23h
kube-root-ca.crt       1      3d
prometheus-config      1      2d23h
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```

4. Prometheus Deployment Creation

a. Creating Prometheus Deployment **prometheus** using the Deployment configuration file **prometheus-deployment-2024mt03072.yaml**.

File → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/blob/main/app-2024mt03072/prometheus-deployment-2024mt03072.yaml.

b. Applying the Prometheus Deployment.

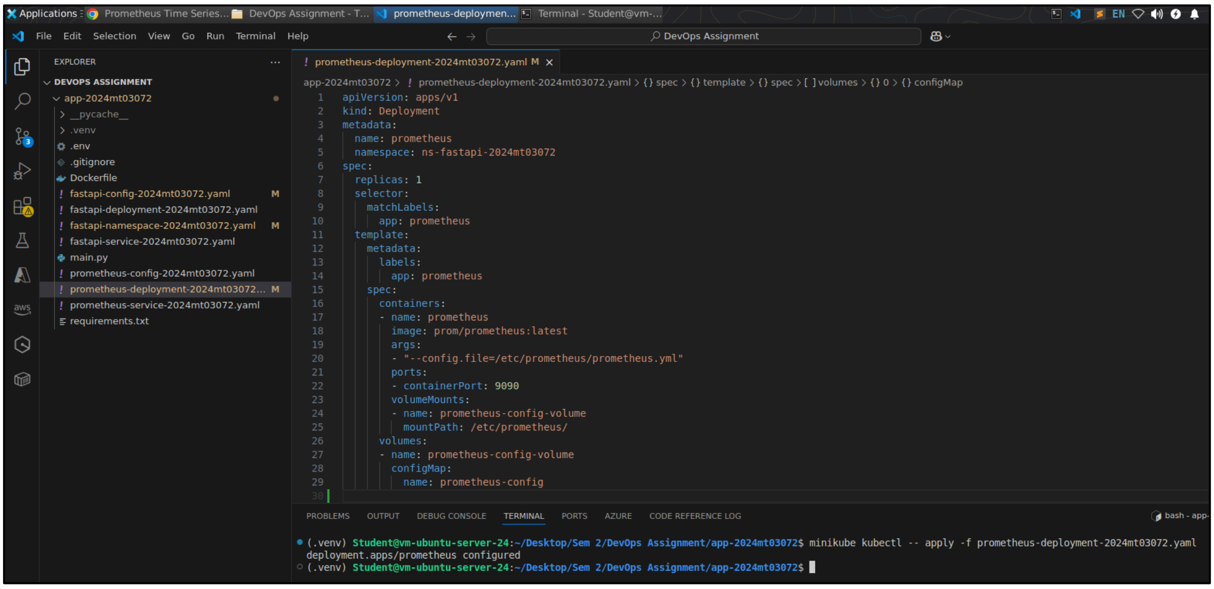
```bash
minikube kubectl -- apply -f prometheus-deployment-2024mt03072.yaml
```

c. Verifying the creation of the Prometheus Deployment prometheus.

```bash
minikube kubectl -- get deployments -n ns-fastapi-2024mt03072
```

d. Listing all pods running inside Kubernetes Namespace ns-fastapi-2024mt03072.

```bash
minikube kubectl -- get pods -n ns-fastapi-2024mt03072
```

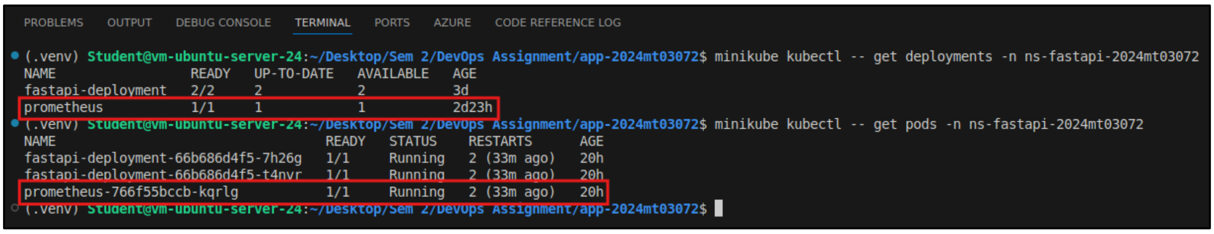


app-2024mt03072 > prometheus-deployment-2024mt03072.yaml > {} spec > {} template > {} spec > [ ] volumes > {} 0 > {} configMap

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: prometheus
  namespace: ns-fastapi-2024mt03072
spec:
  replicas: 1
  selector:
    matchLabels:
      app: prometheus
  template:
    metadata:
      labels:
        app: prometheus
    spec:
      containers:
      - name: prometheus
        image: prom/prometheus:latest
        args:
        - "--config.file=/etc/prometheus/prometheus.yml"
        ports:
        - containerPort: 9090
        volumeMounts:
        - name: prometheus-config-volume
          mountPath: /etc/prometheus/
      volumes:
      - name: prometheus-config-volume
        configMap:
          name: prometheus-config
```

```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- apply -f prometheus-deployment-2024mt03072.yaml
deployment.apps/prometheus configured
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```

Applications
Prometheus Time Series...
DevOps Assignment - T...
prometheus-deploymen...
Terminal - Student@vm-...
File
Edit
Selection
View
Go
Run
Terminal
Help
DevOps Assignment
EXPLORER
DEVOPS ASSIGNMENT
app-2024mt03072
__pycache__
.venv
.env
.gitignore
Dockerfile
fastapi-config-2024mt03072.yaml
fastapi-deployment-2024mt03072.yaml
fastapi-namespace-2024mt03072.yaml
fastapi-service-2024mt03072.yaml
main.py
prometheus-config-2024mt03072.yaml
prometheus-deployment-2024mt03072...
prometheus-service-2024mt03072.yaml
requirements.txt
prometheus-deployment-2024mt03072.yaml
PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
PORTS
AZURE
CODE REFERENCE LOG
bash - app-



```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- get deployments -n ns-fastapi-2024mt03072
NAME                 READY   UP-TO-DATE   AVAILABLE   AGE
fastapi-deployment   2/2     2            2           3d
prometheus           1/1     1            1           2d23h
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- get pods -n ns-fastapi-2024mt03072
NAME                                  READY   STATUS    RESTARTS      AGE
fastapi-deployment-66b686d4f5-7h26g   1/1     Running   2 (33m ago)   20h
fastapi-deployment-66b686d4f5-t4nvr   1/1     Running   2 (33m ago)   20h
prometheus-766f55bccb-kqrlg           1/1     Running   2 (33m ago)   20h
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$
```

5. Prometheus Service Creation

a. Creating Prometheus Service **prometheus** using the Service configuration file **prometheus-service-2024mt03072.yaml**.

File → https://github.com/kaushikpaul90/bits-pilani-sem2-devops-app-2024mt03072/blob/main/app-2024mt03072/prometheus-service-2024mt03072.yaml.

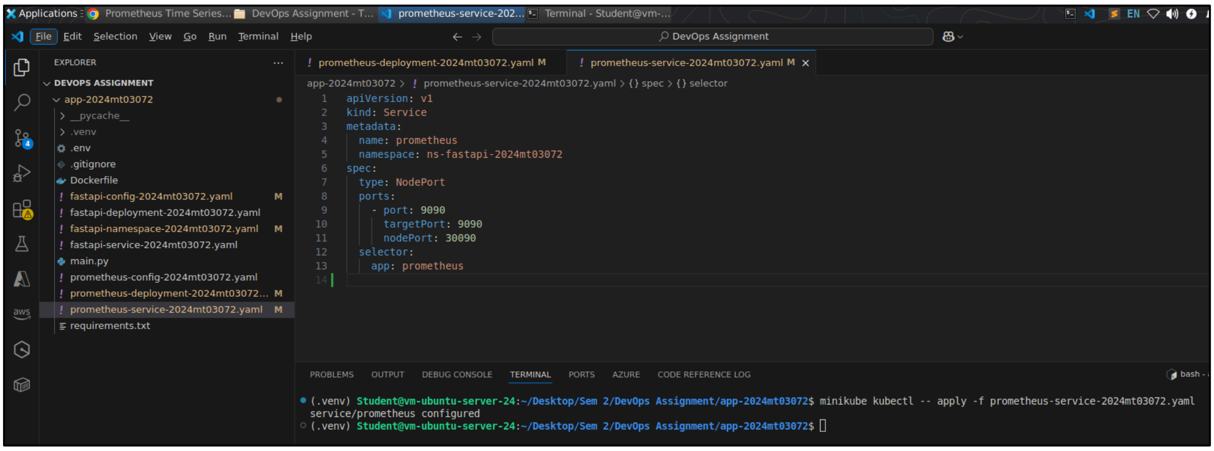
b. Applying the Kubernetes Service.

```bash
minikube kubectl -- apply -f prometheus-service-2024mt03072.yaml
```

c. Verifying the creation of the Kubernetes Service prometheus.

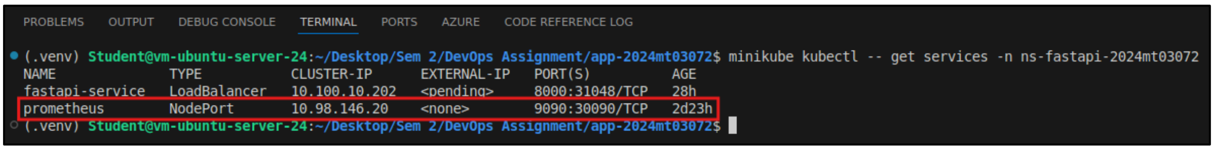
```bash
minikube kubectl -- get services -n ns-fastapi-2024mt03072
```

5.1. Screenshot



```yaml
apiVersion: v1
kind: Service
metadata:
  name: prometheus
  namespace: ns-fastapi-2024mt03072
spec:
  type: NodePort
  ports:
    - port: 9090
      targetPort: 9090
      nodePort: 30090
  selector:
    app: prometheus
```

```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- apply -f prometheus-service-2024mt03072.yaml
service/prometheus configured
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ 
```



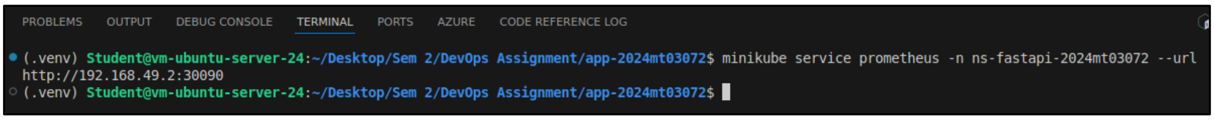
```
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube kubectl -- get services -n ns-fastapi-2024mt03072
NAME              TYPE           CLUSTER-IP      EXTERNAL-IP   PORT(S)          AGE
fastapi-service   LoadBalancer   10.100.10.202   <pending>     8000:31048/TCP   28h
prometheus        NodePort       10.98.146.20    <none>        9090:30090/TCP   2d23h
(.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ 
```

6. Obtaining Prometheus Access URL

a. Retrieving the URL to access Prometheus UI from browser.

```bash
minikube service prometheus -n ns-fastapi-2024mt03072 --url
```

6.1. Screenshot

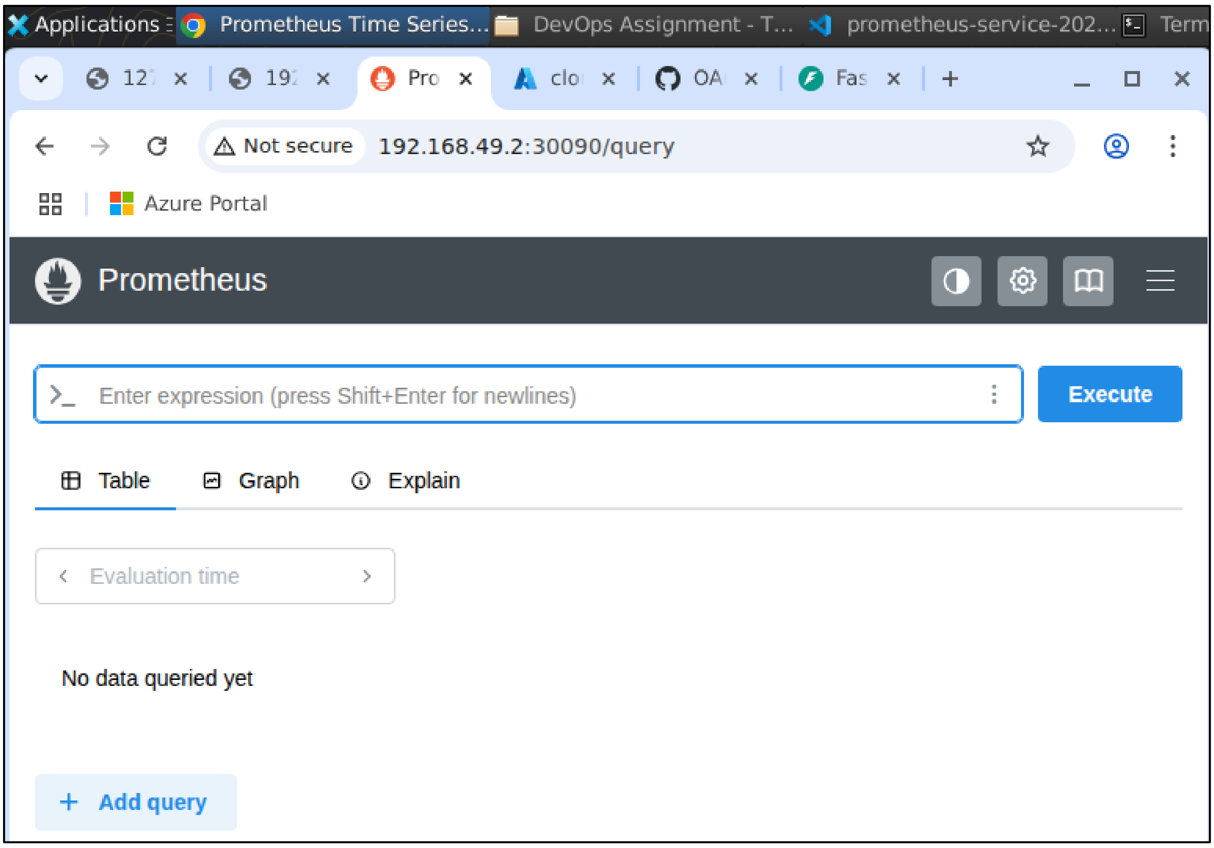


```
● (.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ minikube service prometheus -n ns-fastapi-2024mt03072 --url
  http://192.168.49.2:30090
○ (.venv) Student@vm-ubuntu-server-24:~/Desktop/Sem 2/DevOps Assignment/app-2024mt03072$ 
```

7. Accessing Prometheus UI

a. Accessing Prometheus UI via http://192.168.49.2:30090 on Google Chrome.

7.1. Screenshot



No data queried yet

8. Prometheus Metrics Collection

a. Querying the number of requests received by the /get_info endpoint using metrics **get_info_requests_total**.

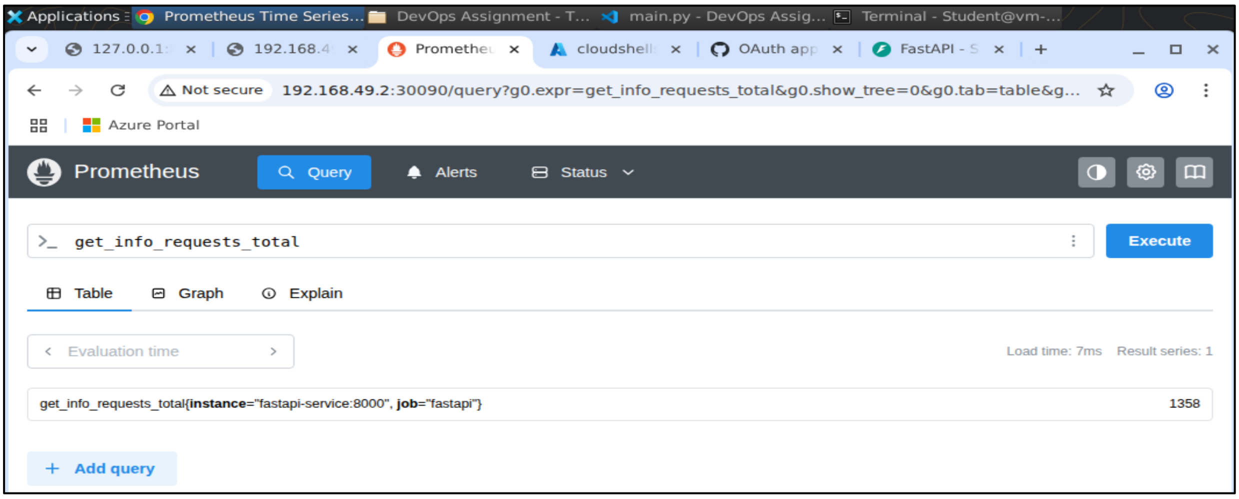
b. Querying CPU usage for each replica using metrics **container_cpu_usage_seconds_total**.

- **container_cpu_usage_seconds_total{namespace="ns-fastapi-2024mt03072"}** → This Prometheus query returns the total cumulative CPU time (in seconds) consumed by each pod replica in the Kubernetes namespace ns-fastapi-2024mt03072 on the Minikube cluster.

c. Querying memory usage for each replica using metrics **container_memory_usage_bytes**.

- **container_memory_usage_bytes{namespace="ns-fastapi-2024mt03072"} / (1024 * 1024)** → This Prometheus query returns the memory usage (in Mega Bytes) of each pod replica running in the Kubernetes namespace ns-fastapi-2024mt03072 on the Minikube cluster.

8.1. Screenshot

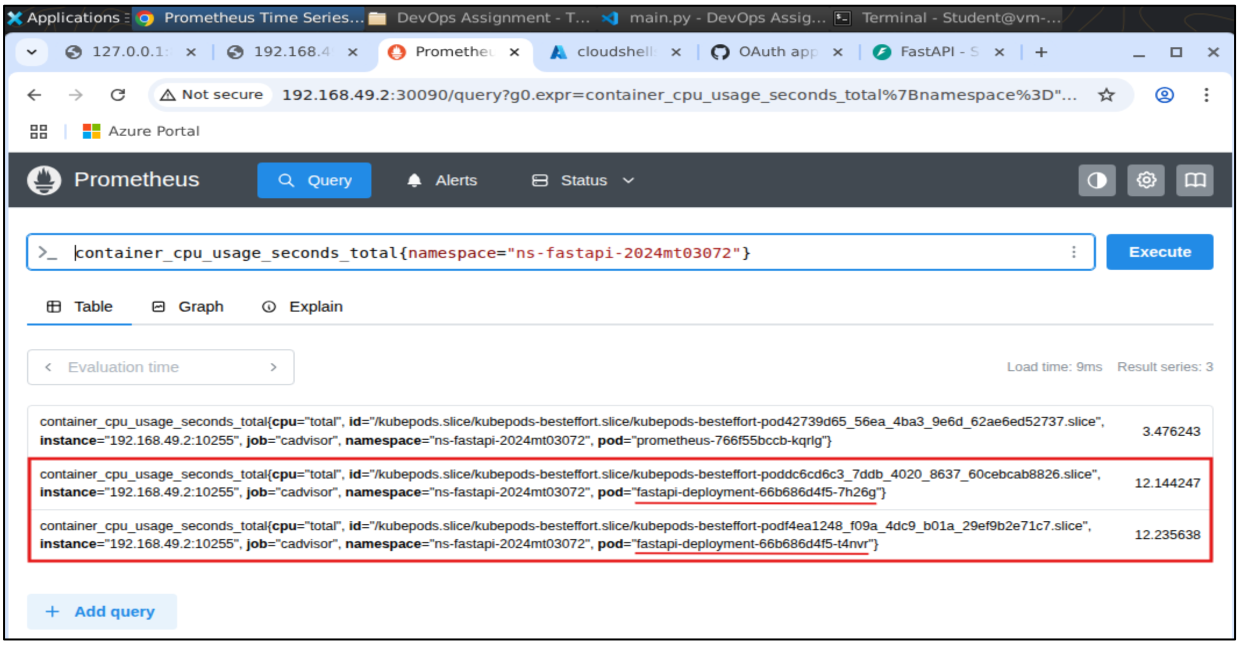


192.168.49.2:30090/query?g0.expr=get_info_requests_total&g0.show_tree=0&g0.tab=table&g...

```
get_info_requests_total
```

Load time: 7ms   Result series: 1

```
get_info_requests_total{instance="fastapi-service:8000", job="fastapi"}    1358
```

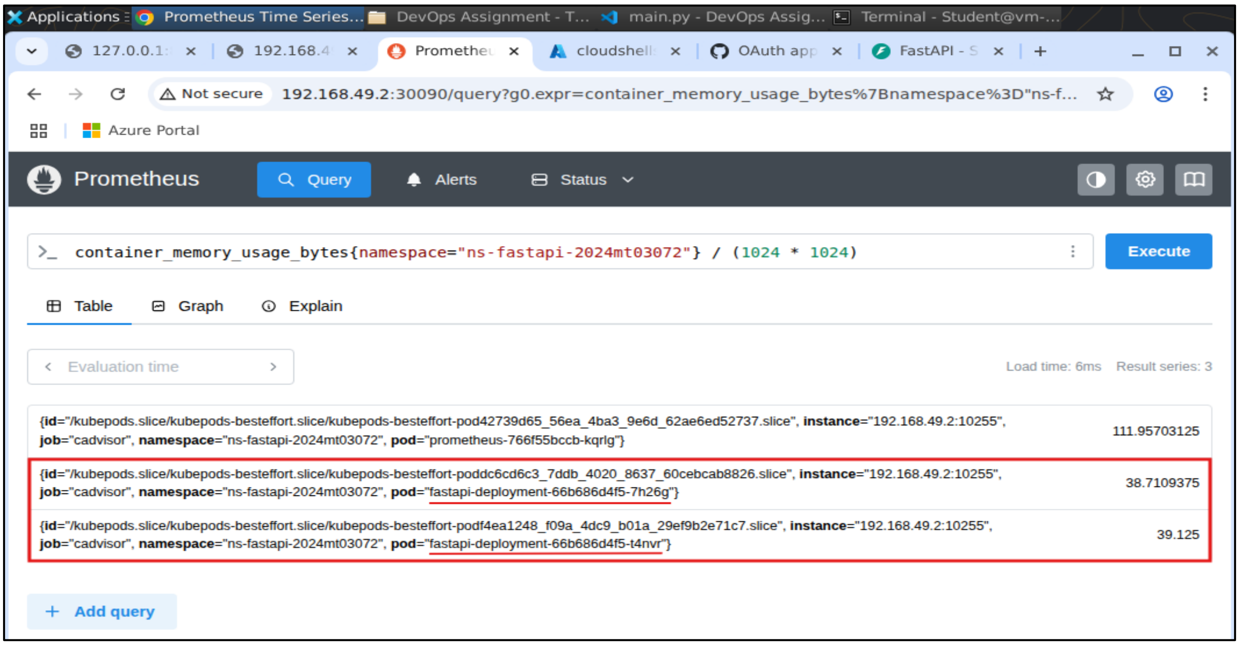


192.168.49.2:30090/query?g0.expr=container_cpu_usage_seconds_total%7Bnamespace%3D"...

```
container_cpu_usage_seconds_total{namespace="ns-fastapi-2024mt03072"}
```

Load time: 9ms   Result series: 3

```
container_cpu_usage_seconds_total{cpu="total", id="/kubepods.slice/kubepods-besteffort.slice/kubepods-besteffort-pod42739d65_56ea_4ba3_9e6d_62ae6ed52737.slice",
instance="192.168.49.2:10255", job="cadvisor", namespace="ns-fastapi-2024mt03072", pod="prometheus-766f55bccb-kqrlg"}    3.476243
container_cpu_usage_seconds_total{cpu="total", id="/kubepods.slice/kubepods-besteffort.slice/kubepods-besteffort-poddc6cd6c3_7ddb_4020_8637_60cebcab8826.slice",
instance="192.168.49.2:10255", job="cadvisor", namespace="ns-fastapi-2024mt03072", pod="fastapi-deployment-66b686d4f5-7h26g"}    12.144247
container_cpu_usage_seconds_total{cpu="total", id="/kubepods.slice/kubepods-besteffort.slice/kubepods-besteffort-podf4ea1248_f09a_4dc9_b01a_29ef9b2e71c7.slice",
instance="192.168.49.2:10255", job="cadvisor", namespace="ns-fastapi-2024mt03072", pod="fastapi-deployment-66b686d4f5-t4nvr"}    12.235638
```



```
192.168.49.2:30090/query?g0.expr=container_memory_usage_bytes%7Bnamespace%3D"ns-f...
```

```
container_memory_usage_bytes{namespace="ns-fastapi-2024mt03072"} / (1024 * 1024)
```

```
{id="/kubepods.slice/kubepods-besteffort.slice/kubepods-besteffort-pod42739d65_56ea_4ba3_9e6d_62ae6ed52737.slice", instance="192.168.49.2:10255",
job="cadvisor", namespace="ns-fastapi-2024mt03072", pod="prometheus-766f55bccb-kqrlg"}     111.95703125
{id="/kubepods.slice/kubepods-besteffort.slice/kubepods-besteffort-poddc6cd6c3_7ddb_4020_8637_60cebcab8826.slice", instance="192.168.49.2:10255",
job="cadvisor", namespace="ns-fastapi-2024mt03072", pod="fastapi-deployment-66b686d4f5-7h26g"}     38.7109375
{id="/kubepods.slice/kubepods-besteffort.slice/kubepods-besteffort-podf4ea1248_f09a_4dc9_b01a_29ef9b2e71c7.slice", instance="192.168.49.2:10255",
job="cadvisor", namespace="ns-fastapi-2024mt03072", pod="fastapi-deployment-66b686d4f5-t4nvr"}     39.125
```

9. Challenges Faced

a. Metric Discovery Complexity:

- Identifying the correct Prometheus metrics (container_cpu_usage_seconds_total, container_memory_usage_bytes) to monitor CPU/memory usage per pod.
- After lot of research and analysis, I came across the metrics container_cpu_usage_seconds_total and container_memory_usage_bytes to monitor CPU and memory usage per pod respectively.

b. Scraping Configuration:

- Even after identifying the metrics, Prometheus was not able to collect them without proper scraping configuration.
- Adding cAdvisor job to prometheus-config-2024mt03072.yaml exposed container-level metrics for Prometheus to scrape, finally resolving the issue.

Conclusion

This assignment provided a comprehensive, hands-on experience with the complete DevOps lifecycle for a cloud-native backend application. Starting from the development of a FastAPI-based microservice, the project covered containerization with Docker, orchestrated deployment using Kubernetes, and advanced monitoring with Prometheus.

Key learnings included:

- **Environment Management:** Leveraging environment variables and ConfigMaps for flexible configuration across local and cloud environments.
- **Containerization:** Building and running Docker images and containers, ensuring portability and consistency.
- **Kubernetes Orchestration:** Deploying scalable, highly available applications with replica management, namespace isolation, and service exposure for load balancing.
- **Monitoring and Observability:** Integrating Prometheus to collect and visualize application and infrastructure metrics and overcoming the challenge of identifying and scraping the correct metrics for resource usage and request tracking.
- **Troubleshooting:** Addressing common issues such as image update propagation, service exposure, and metric visibility, which are crucial skills for real-world DevOps scenarios.

Overall, this assignment not only solidified theoretical concepts but also enhanced practical skills in deploying, scaling, and monitoring modern cloud applications. The experience gained through iterative debugging and configuration will be invaluable for future projects in cloud-native DevOps and site reliability engineering.