Fundamentals of Distributed Systems
Assignment– 1
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GITHUB Link:
https://github.com/pallavis24-cmd/smart_grid

Q2. Dynamic Load Balancing for a Smart Grid

Title: Smart Grid EV Charging System
Subtitle: Load Balancing Using Python, Docker, Prometheus & Grafana

This project demonstrates how to dynamically route electric vehicle charging requests across substations to prevent overloading using modern cloud-native technologies.

The Problem:

• EV adoption is growing
• Substation overload can disrupt service
• Need for dynamic load balancing

Project Objective:
• Prevent overloads on charging stations
• Dynamically route requests based on real-time load
• Visualize system metrics and performance

Key Components:

• charge_request_service: Accepts incoming requests
• load_balancer: Routes based on load
• substation_service: Simulates charging & exposes metrics

Observability Stack:

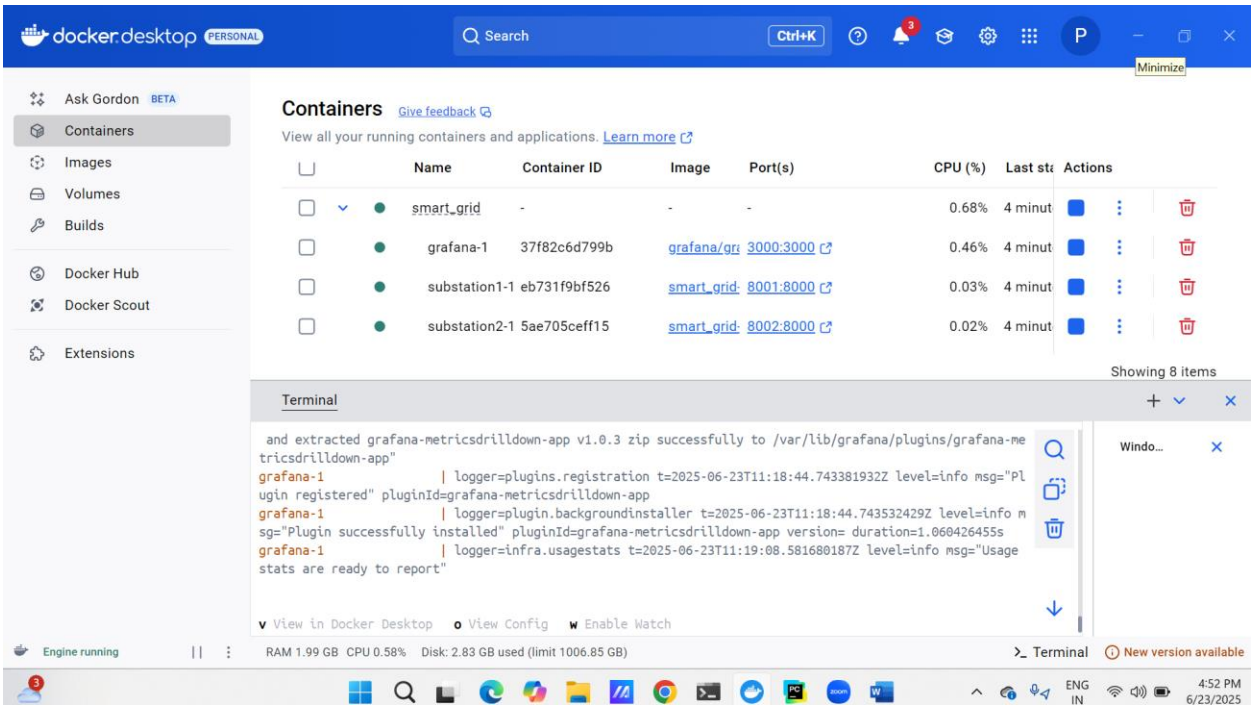
• Prometheus scrapes metrics every 5s
• Metric: substation_active_sessions
• Grafana dashboard for visualization

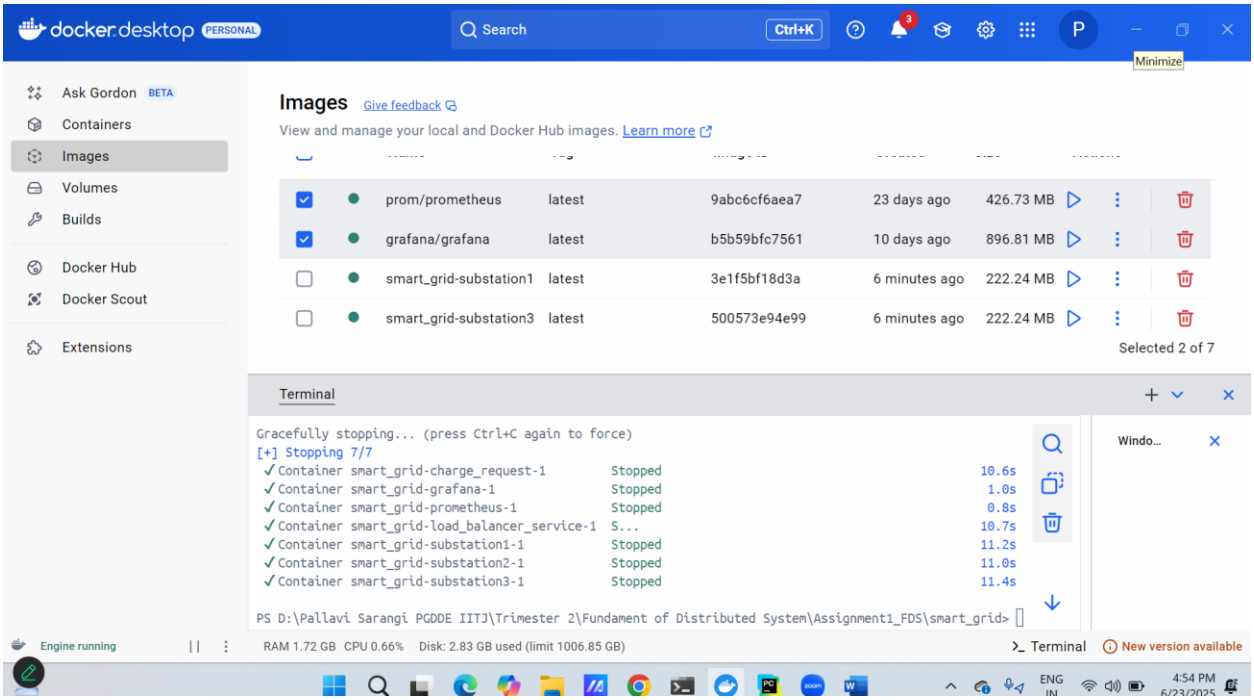
Results & Observations:

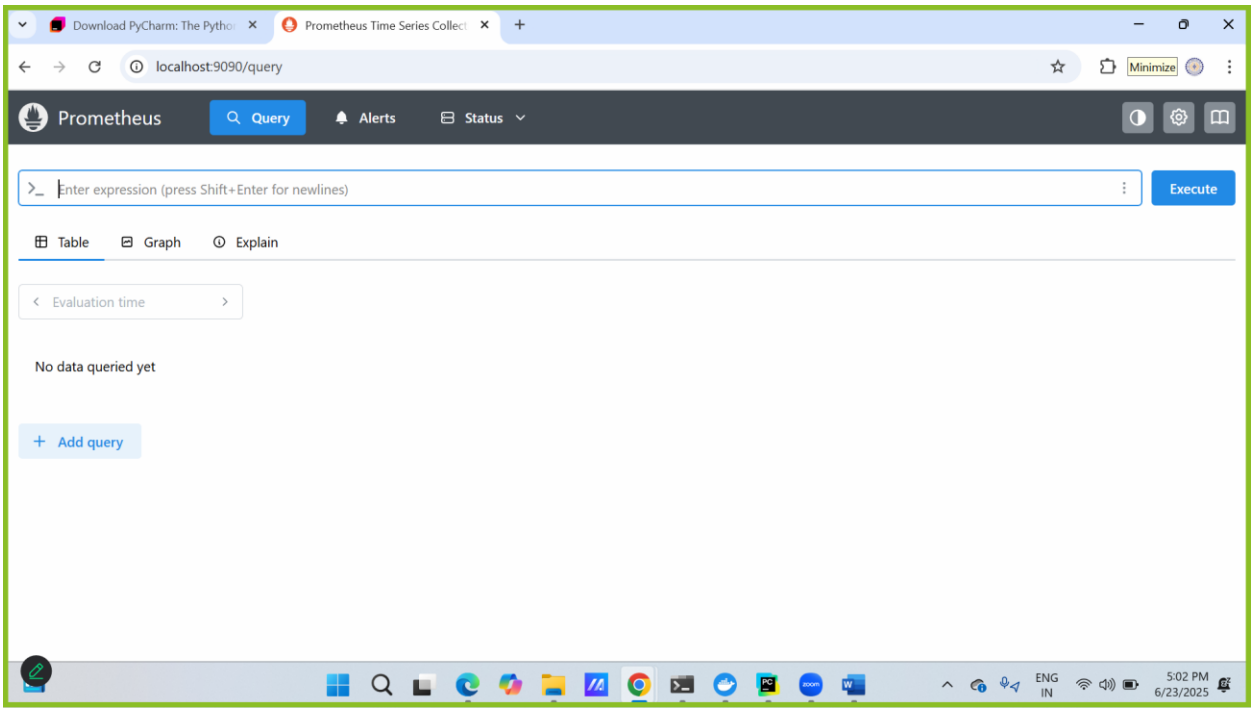
- Even distribution across substations
- No overloads observed
- System behaves as expected

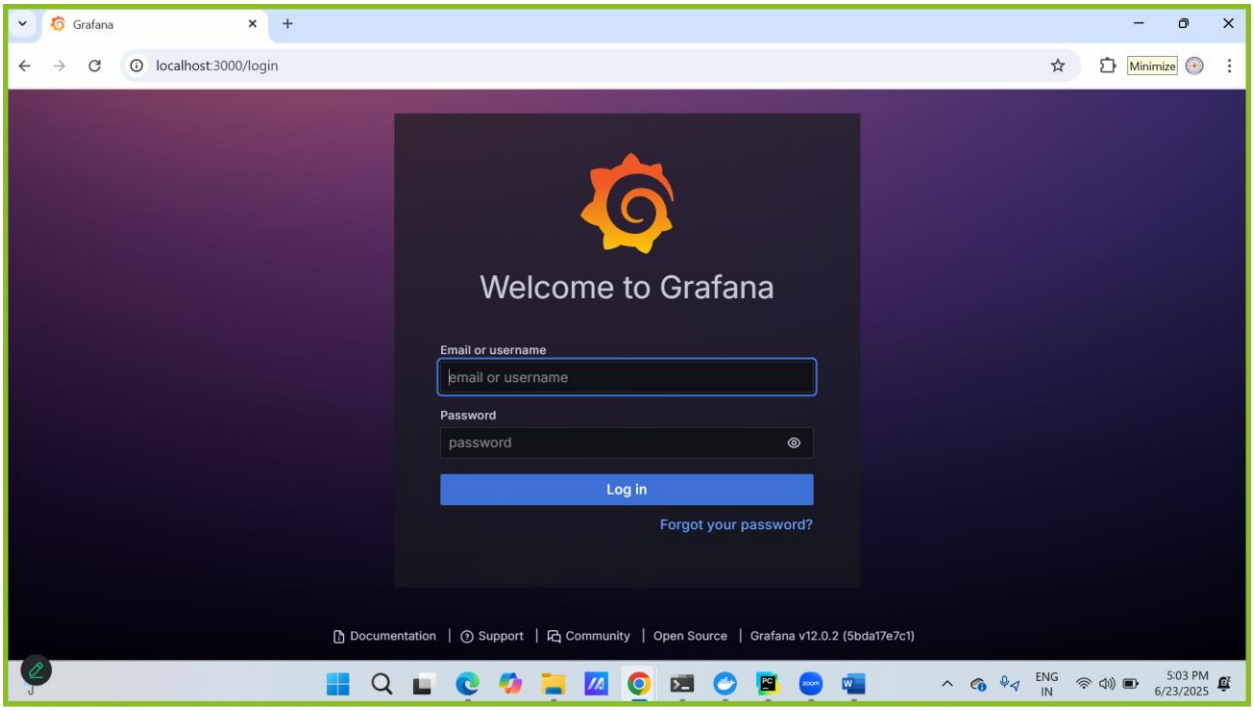
Conclusion & Future Work:

- Fully containerized and observable system
- Future: AI-based prediction, authentication, autoscaling




docker desktop PERSONAL
Search Ctrl+K
Minimize
Ask Gordon BETA
Containers
Images
Volumes
Builds
Docker Hub
Docker Scout
Extensions
Images
Give feedback
View and manage your local and Docker Hub images. Learn more
prom/prometheus latest 9abc6cf6aea7 23 days ago 426.73 MB
grafana/grafana latest b5b59bfc7561 10 days ago 896.81 MB
smart_grid-substation1 latest 3e1f5bf18d3a 6 minutes ago 222.24 MB
smart_grid-substation3 latest 500573e94e99 6 minutes ago 222.24 MB
Selected 2 of 7
Terminal
Gracefully stopping... (press Ctrl+C again to force)
[+] Stopping 7/7
✓ Container smart_grid-charge_request-1 Stopped 10.6s
✓ Container smart_grid-grafana-1 Stopped 1.0s
✓ Container smart_grid-prometheus-1 Stopped 0.8s
✓ Container smart_grid-load_balancer_service-1 S... 10.7s
✓ Container smart_grid-substation1-1 Stopped 11.2s
✓ Container smart_grid-substation2-1 Stopped 11.0s
✓ Container smart_grid-substation3-1 Stopped 11.4s
PS D:\Pallavi Sarangi PGDDE IITJ\Trimester 2\Fundament of Distributed System\Assignment1_FDS\smart_grid>
Windo...
Engine running
RAM 1.72 GB CPU 0.66% Disk: 2.83 GB used (limit 1006.85 GB)
Terminal
New version available
ENG
IN
4:54 PM
6/23/2025


Prometheus Time Series Collect
localhost:9090/query
Minimize
Prometheus
Query
Alerts
Status
Enter expression (press Shift+Enter for newlines)
Execute
Table
Graph
Explain
Evaluation time
No data queried yet
Add query
ENG
IN
5:02 PM
6/23/2025


Grafana
localhost:3000/login
Minimize
Welcome to Grafana
Email or username
email or username
Password
password
Log in
Forgot your password?
Documentation
Support
Community
Open Source
Grafana v12.0.2 (5bda17e7c1)
ENG
IN
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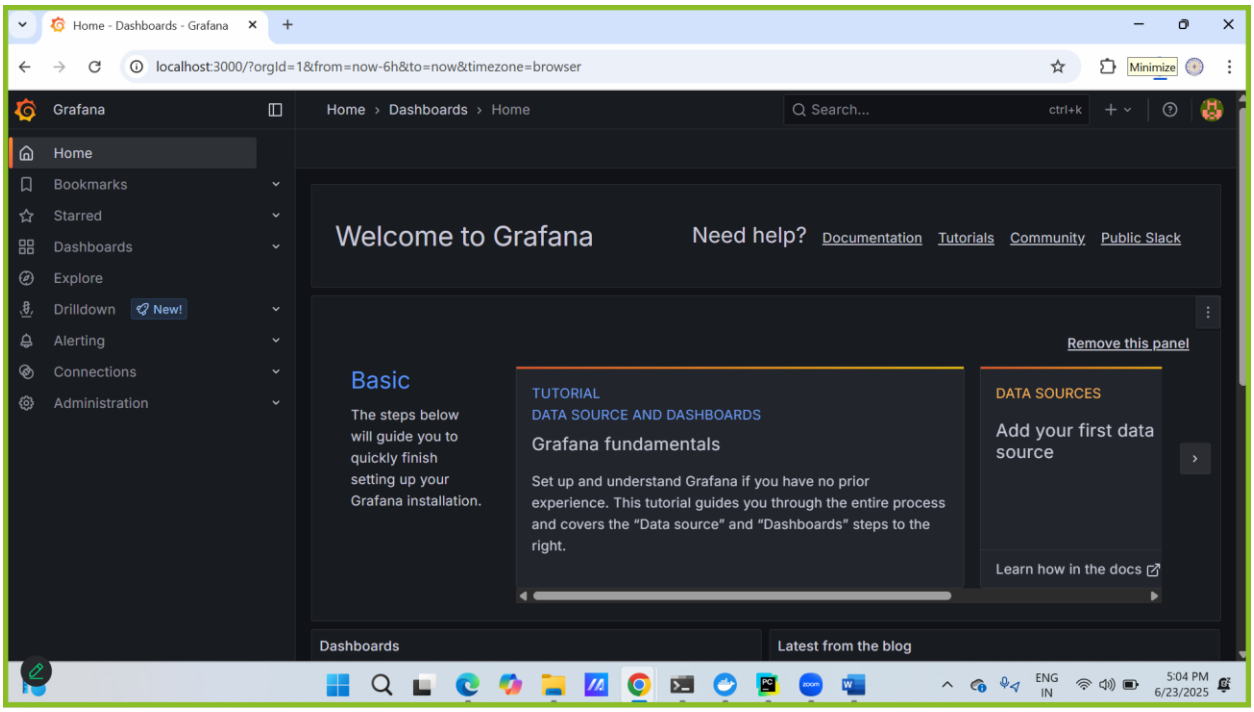
6/23/2025


Home - Dashboards - Grafana
localhost:3000/?orgId=1&from=now-6h&to=now&timezone=browser
Grafana
Home
Bookmarks
Starred
Dashboards
Explore
Drilldown
New!
Alerting
Connections
Administration
Home › Dashboards › Home
Search...
ctrl+k
Welcome to Grafana
Need help?
Documentation
Tutorials
Community
Public Slack
Remove this panel
Basic
The steps below will guide you to quickly finish setting up your Grafana installation.
TUTORIAL
DATA SOURCE AND DASHBOARDS
Grafana fundamentals
Set up and understand Grafana if you have no prior experience. This tutorial guides you through the entire process and covers the "Data source" and "Dashboards" steps to the right.
DATA SOURCES
Add your first data source
Learn how in the docs
Dashboards
Latest from the blog
ENG IN
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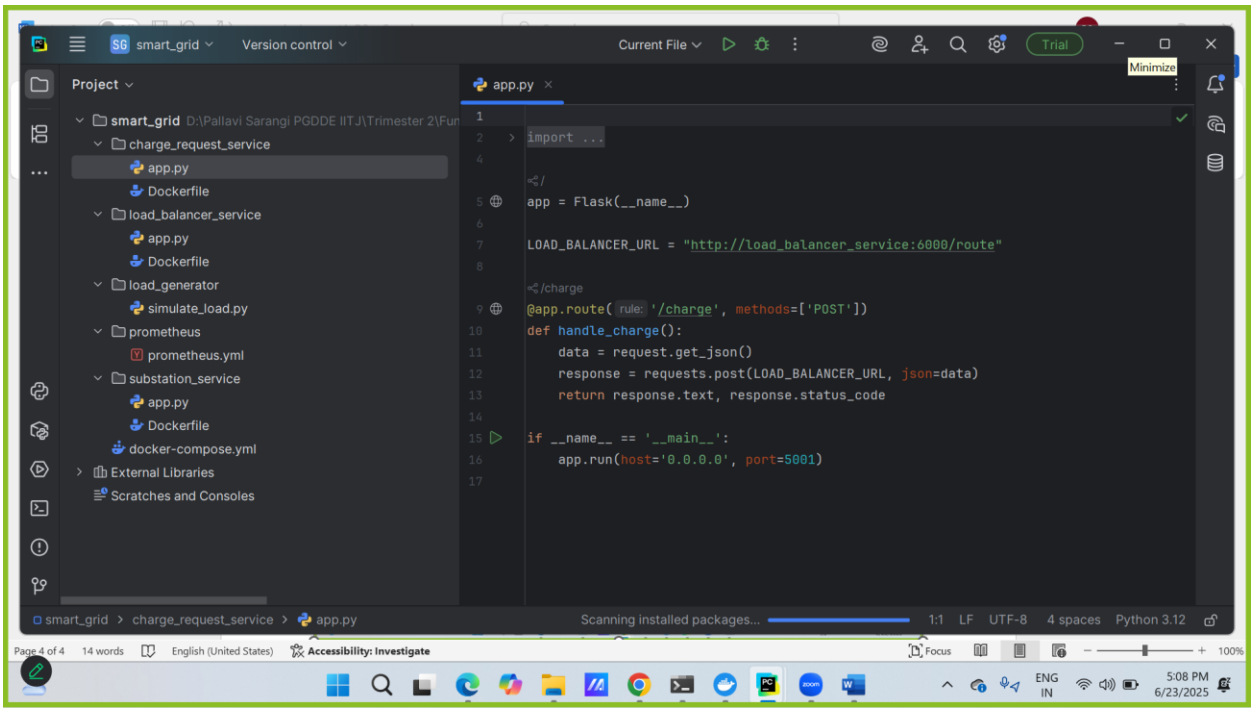
smart_grid
Version control
Current File
Trial
Minimize
Project
app.py
smart_grid D:\Pallavi Sarangi PGDDE IITJ\Trimester 2\Fun
charge_request_service
app.py
Dockerfile
load_balancer_service
app.py
Dockerfile
load_generator
simulate_load.py
prometheus
prometheus.yml
substation_service
app.py
Dockerfile
docker-compose.yml
External Libraries
Scratches and Consoles
import ...
app = Flask(__name__)
LOAD_BALANCER_URL = "http://load_balancer_service:6000/route"
/charge
@app.route(rule: '/charge', methods=['POST'])
def handle_charge():
data = request.get_json()
response = requests.post(LOAD_BALANCER_URL, json=data)
return response.text, response.status_code
if __name__ == '__main__':
app.run(host='0.0.0.0', port=5001)
smart_grid › charge_request_service › app.py
Scanning installed packages...
1:1 LF UTF-8 4 spaces Python 3.12
Page 4 of 4 14 words English (United States)
Accessibility: Investigate
Focus
100%
ENG IN
5:08 PM 6/23/2025