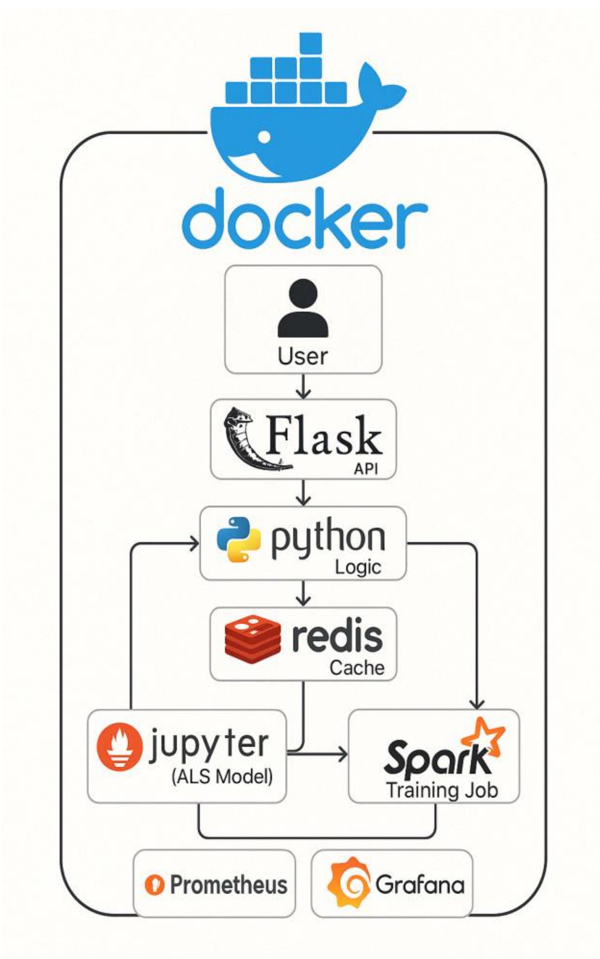
Netflix- Redis-Cache-Recommendation Engine

A full-stack, end-to-end ML pipeline simulating a real-world recommendation system for a streaming service. This project includes data ingestion, model training with Spark, REST API serving via Flask, Redis caching, Prometheus + Grafana monitoring, and containerized orchestration using Docker Compose.

□ Technologies Used

- **Docker + Docker Compose**
- **Apache Spark (PySpark)**
- **Redis**
- **Flask**
- **Prometheus & Grafana**
- **Jupiter Notebook (for exploration)**

□ System Architecture



□ Project Structure

```
.
├── docker-compose.yml
├── prometheus.yml
├── flask-api/
│   ├── app.py
│   ├── Dockerfile
│   └── requirements.txt
├── jupyter/
│   └── train_model.py
├── data/
│   └── synthetic_streaming_data.csv
└── grafana/ (provisioning dashboards)
```

□ Docker Compose Setup

```
docker-compose up --build
```

Access:

- Flask API: `http://localhost:5000`
- Prometheus: `http://localhost:9090`
- Grafana: `http://localhost:3000`
- Jupyter Notebook: `http://localhost:8888`

□ Prometheus Configuration

```
global:
  scrape_interval: 15s
  evaluation_interval: 15s
  scrape_timeout: 10s

scrape_configs:
  - job_name: 'prometheus'
    static_configs:
      - targets: ['prometheus:9090']

  - job_name: 'node-exporter'
    static_configs:
      - targets: ['metrics-server:9100']

  - job_name: 'flask-api'
    static_configs:
      - targets: ['flask-api:5000']

  - job_name: 'jupyter-notebook'
    static_configs:
      - targets: ['host.docker.internal:8001']
```

□ Flask API Endpoints

- `GET /health` - Health check
- `POST /watched` - Simulates a user watching a film

```
{
  "user_id": "U1001",
  "content_id": "C1010"
}
```

- `GET /recommend/<user_id>` - Returns recommendation
- `GET /metrics` - Prometheus metrics

☐ Monitoring

- Prometheus scrapes metrics from Flask and Jupyter
- Grafana dashboards show:
  - Cache hits & misses
  - Fallback usage
  - Model training runtime

☐ ML Training Pipeline

Location: `train_model.py`

- Loads streaming data
- Encodes `user_id` and `content_id`
- Trains ALS (collaborative filtering) model
- Caches top recommendation for each user into Redis

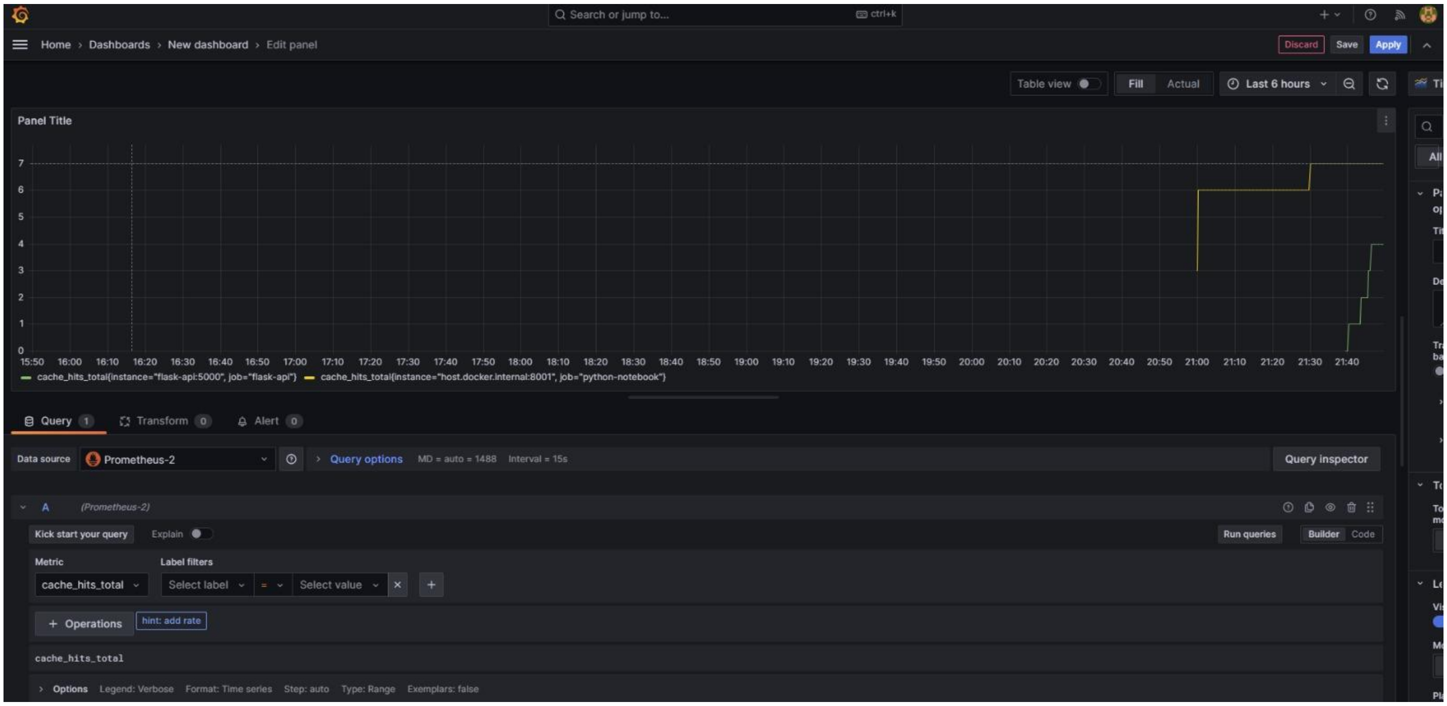
Sample Output:

```
✅ Cached for U1146: C384
✅ Cached for U1198: C892
...
```

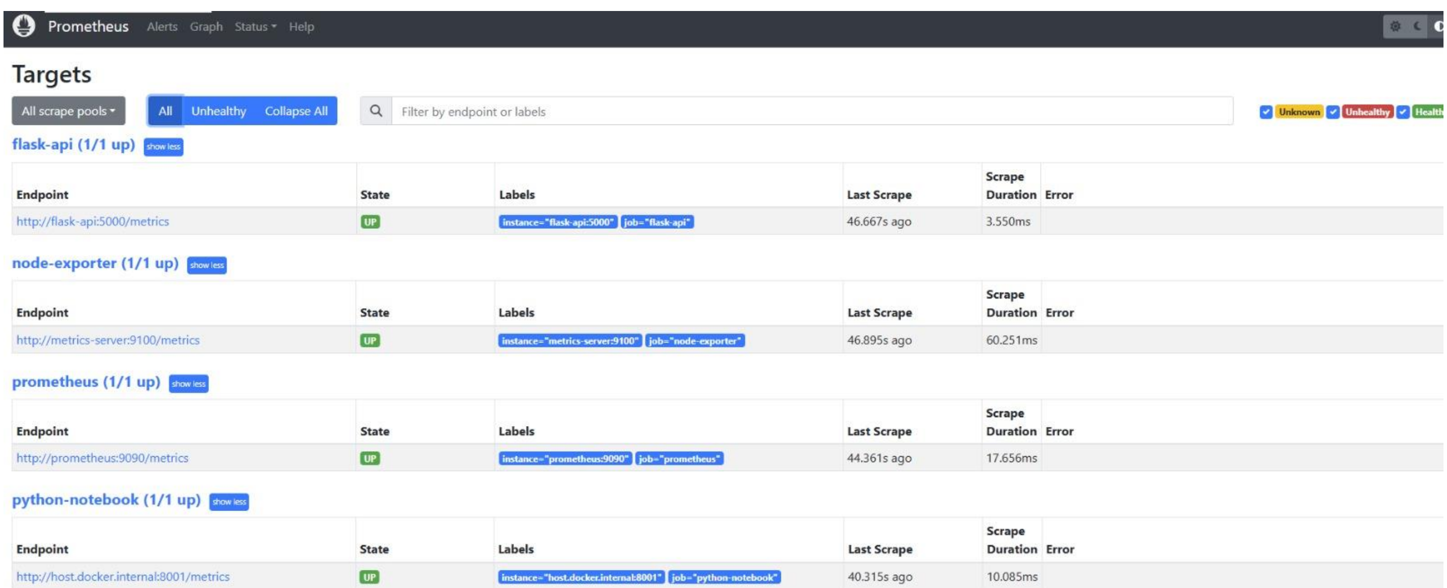
☐ Screenshots

☐ Recommendation Output:

□ Grafana Dashboard:



□ API with Prometheus Metrics:



✅TODO Next

- Add Kafka ingestion
- Replace fallback logic with real-time inference
- Federated learning for edge recommendations

□ Maintainer

Built by [Rahul Raj] - striving for ML-powered personalized streaming.

□ License

MIT License

□ Netflix-Style Recommendation System Demo

□ Overview

This project showcases a real-time, containerized recommendation pipeline using Docker Compose. It integrates services like Spark, Flask API, Redis, Prometheus, and Grafana to simulate a Netflix-style recommendation system.

✅Step 1: Show the System is Running

□ Narration:

"I've containerized and automated the entire Netflix-style recommendation pipeline using Docker Compose. Everything you see here is real-time and monitored."

□ Command:

```
bash
CopyEdit
docker ps
```

□ **Expected Output:**

```
bash
CopyEdit
CONTAINER ID   IMAGE          COMMAND                  STATUS          PORTS
abc123         spark          "/bin/bash"              Up 5 minutes    ...
def456         jupyter        "start-notebook.sh"      Up 5 minutes    ...
ghi789         flask-api      "python app.py"          Up 5 minutes    5000/tcp
jkl012         redis          "docker-entrypoint.sh"   Up 5 minutes    6379/tcp
mno345         prometheus     "/bin/prometheus"        Up 5 minutes    9090/tcp
pqr678         grafana        "/run.sh"                Up 5 minutes    3000/tcp
```

□ **Screenshot Placeholder:**

Insert a screenshot of the terminal displaying the `docker ps` output.

✅Step 2: Simulate a User Watching a Movie

□ **Narration:**

"Let's say user U999 watches C1010, which is, say, Stranger Things. The system automatically predicts and caches the next likely show."

□ **Command:**

```
bash
CopyEdit
curl -X POST http://localhost:5000/watched \
  -H "Content-Type: application/json" \
  -d '{"user_id": "U999", "content_id": "C1010"}'
```

□ **Expected Response:**

```
json
CopyEdit
{
  "user_id": "U999",
  "watched": "C1010",
  "predicted_next": "C1045"
}
```

□ **Screenshot Placeholder:**

Insert a screenshot of the terminal displaying the curl response.

✅Step 3: Retrieve Cached Recommendation

□ **Narration:**

“Now, the user comes back to the app and asks: what should I watch next? We instantly return the prediction from Redis.”

□ **Command:**

```
bash
CopyEdit
curl http://localhost:5000/recommend/U999
```

□ **Expected Response:**

```
json
CopyEdit
{
  "user_id": "U999",
  "recommendation": "C1045",
  "cache_hit": true
}
```

□ **Screenshot Placeholder:**

Insert a screenshot of the terminal displaying the curl response.

✅Step 4: Handle New User Scenario

□ **Narration:**

“If the user is new and we don’t have predictions yet, the system handles it gracefully with a fallback.”

□ **Command:**

```
bash
CopyEdit
curl http://localhost:5000/recommend/U1234
```

□ **Expected Response:**

```
json
CopyEdit
{
  "user_id": "U1234",
  "recommendation": "C000",
  "cache_hit": false,
  "fallback_used": true
}
```

□ **Screenshot Placeholder:**

Insert a screenshot of the terminal displaying the curl response.

✅Step 5: Monitor System Metrics with Prometheus

□ **Narration:**

"We also expose Prometheus metrics for system health and activity."

□ **Access:**

Navigate to http://localhost:9090 in your browser.

□ **Metrics to Observe:**

- `cache_hits`
- `cache_misses`
- `fallbacks_used`

□ **Screenshot Placeholder:**

Insert a screenshot of the Prometheus dashboard displaying the relevant metrics.

✅Step 6: Visualize Data with Grafana

□ **Narration:**

"Here's the Grafana dashboard tracking live recommendations, cache efficiency, fallback trends, and more."

□ **Access:**

Navigate to http://localhost:3000 in your browser.

□ **Login Credentials:**

- **Username:** `admin`
- **Password:** `admin`Reddit+2Netflix TechBlog+2Medium+2Medium+12doc.ic.ac.uk+12Learn R, Python & Data Science Online+12

□ **Screenshot Placeholder:**

Insert a screenshot of the Grafana dashboard displaying the relevant panels.

□ Bonus Features

- Develop a simple HTML/JS frontend or CLI to simulate the watch and recommend flow.
- Display Spark job logs within JupyterLab or via Docker logs.
- Highlight the pipeline's extensibility for federated learning, edge caching, or A/B testing.AWS in Plain English