ASSIGNMENT 7 – FINAL PROJECT

REAL TIME ANALYTICS

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Project Report: Real-Time Weather Monitoring and Visualization System

Introduction

The Real-Time Weather Monitoring and Visualization System is designed to provide live updates on weather conditions using an end-to-end pipeline. The project fetches weather data from a public API, processes it using Apache Kafka, stores it in a PostgreSQL database, and visualizes the data using Apache Superset. This system facilitates monitoring, analyzing, and presenting weather metrics, enabling stakeholders to make informed decisions.

Project Plan

Objectives:

1. Build a pipeline to fetch live weather data.
2. Process and stream data using Apache Kafka.
3. Store the transformed data in PostgreSQL.
4. Design a real-time, auto-refreshing dashboard using Apache Superset.
5. Enable seamless data consumption and visualization.

Steps:

1. **Data Collection** : Fetch weather data from the OpenWeatherMap API.
2. **Data Processing** : Stream data via Kafka Producer and Consumer.
3. **Data Storage** : Load data into PostgreSQL for persistence.
4. **Visualization** : Create an interactive dashboard to present the data.
5. **System Validation** : Test for accuracy, latency, and usability.

System Architecture Diagram :

```
[ Weather API ]
     |
     v
[ Kafka Producer ] --> [ Kafka Topic ] --> [ Kafka Consumer ]
     |
     v
[ PostgreSQL Database ]
     |
     v
[ Apache Superset Dashboard ]
```

Metrics Used in Weather Monitoring

1. **Temperature :**
   - Unit: Degrees Celsius (or Fahrenheit).
   - Metric: Real-time temperature of a city.
2. **Humidity :**
   - Unit: Percentage (%).
   - Metric: Represents atmospheric moisture content.
3. **Weather Condition :**
   - Descriptions: Clear, Cloudy, Rainy, etc.
   - Metric: Categorical classification of weather.
4. **Timestamp :**
   - Unit: Date-Time.
   - Metric: Represents the exact time of data capture.

Building the End-to-End System

1. Data Collection

- Fetched data from the OpenWeatherMap API using an API key.

- Query parameters: City, API key, and units.

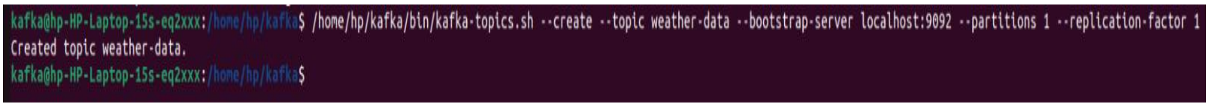
2. Data Transformation

- **Kafka Producer** :

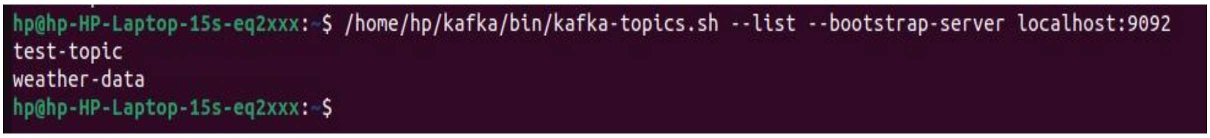
- Fetches and sends JSON data to a Kafka Topic.

- Example payload:

```
json
{
  "city": "London",
  "temperature": 12.5,
  "humidity": 80,
  "weather_description": "Clear",
  "timestamp": "2025-01-16T10:00:00Z"
}
```

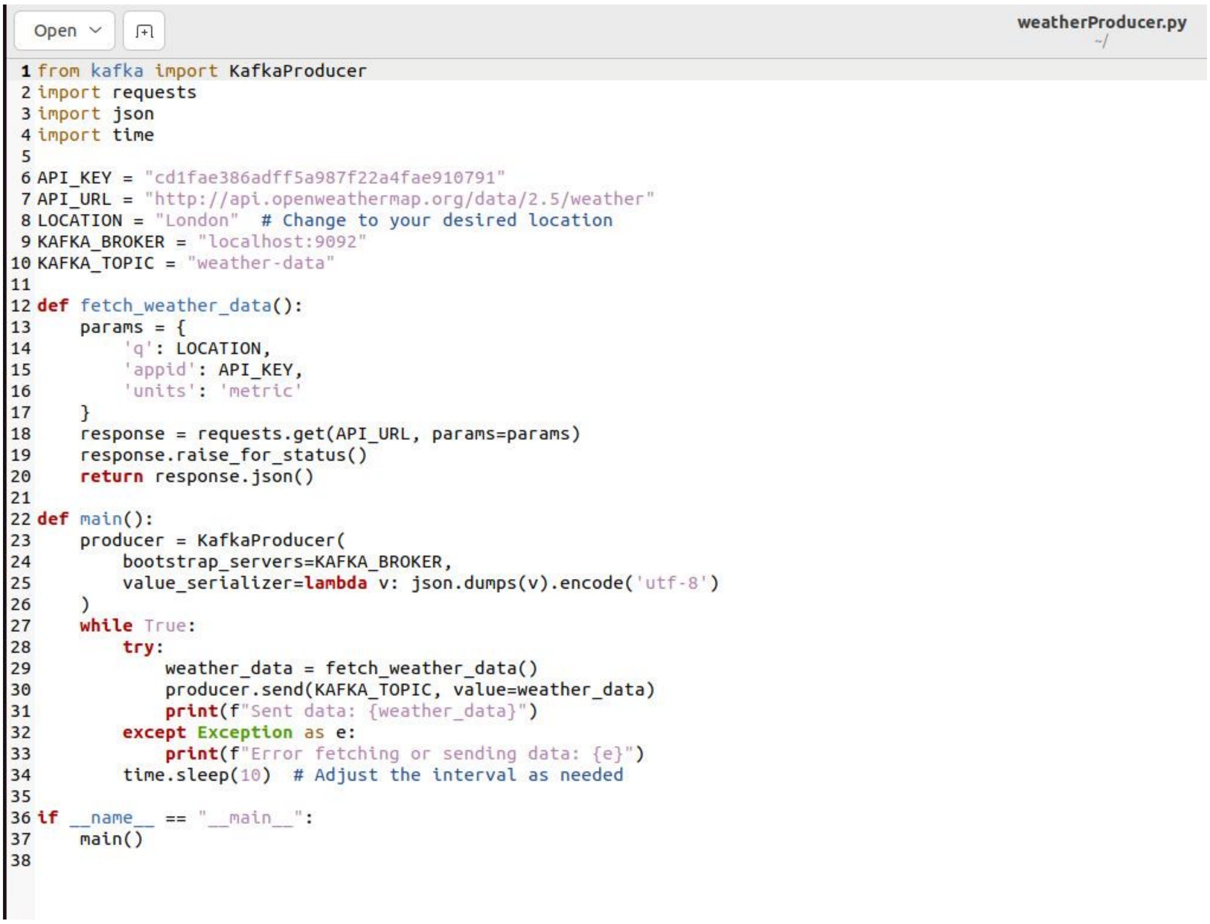


```
kafka@hp-HP-Laptop-15s-eq2xxx:/home/hp/kafka$ /home/hp/kafka/bin/kafka-topics.sh --create --topic weather-data --bootstrap-server localhost:9092 --partitions 1 --replication-factor 1
Created topic weather-data.
kafka@hp-HP-Laptop-15s-eq2xxx:/home/hp/kafka$
```



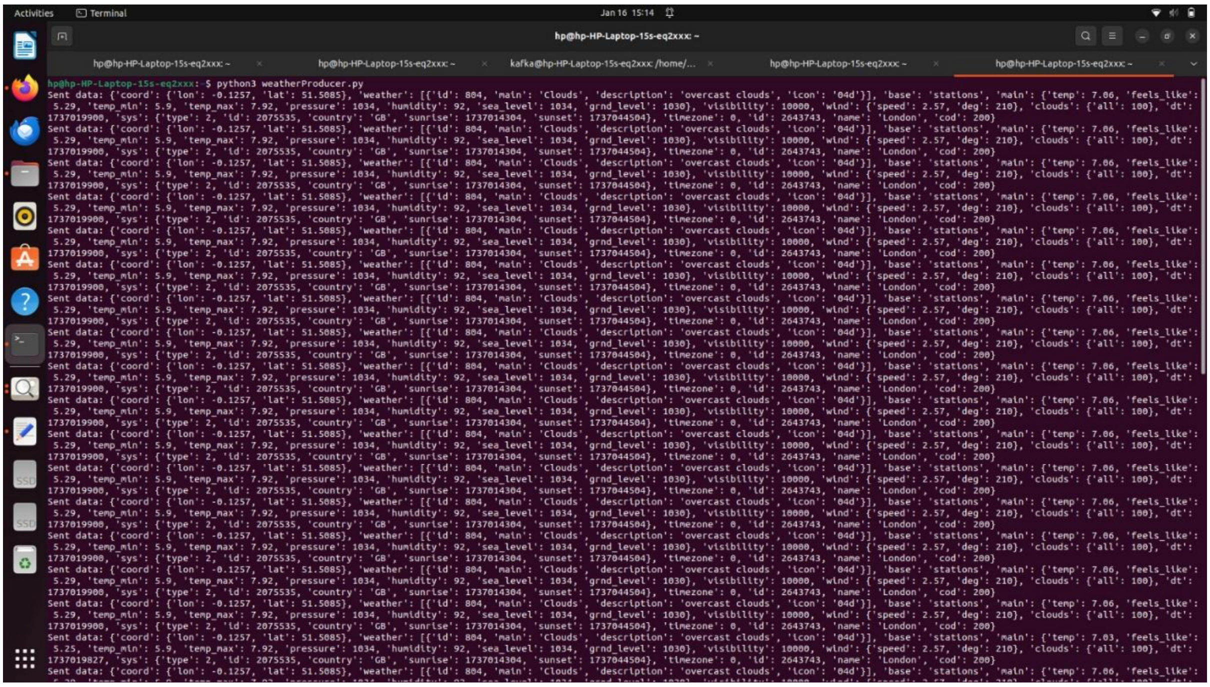
```
hp@hp-HP-Laptop-15s-eq2xxx:~$ /home/hp/kafka/bin/kafka-topics.sh --list --bootstrap-server localhost:9092
test-topic
weather-data
hp@hp-HP-Laptop-15s-eq2xxx:~$
```

Python code for producer:



```python
from kafka import KafkaProducer
import requests
import json
import time

API_KEY = "cd1fae386adff5a987f22a4fae910791"
API_URL = "http://api.openweathermap.org/data/2.5/weather"
LOCATION = "London"  # Change to your desired location
KAFKA_BROKER = "localhost:9092"
KAFKA_TOPIC = "weather-data"

def fetch_weather_data():
    params = {
        'q': LOCATION,
        'appid': API_KEY,
        'units': 'metric'
    }
    response = requests.get(API_URL, params=params)
    response.raise_for_status()
    return response.json()

def main():
    producer = KafkaProducer(
        bootstrap_servers=KAFKA_BROKER,
        value_serializer=lambda v: json.dumps(v).encode('utf-8')
    )
    while True:
        try:
            weather_data = fetch_weather_data()
            producer.send(KAFKA_TOPIC, value=weather_data)
            print(f"Sent data: {weather_data}")
        except Exception as e:
            print(f"Error fetching or sending data: {e}")
        time.sleep(10)  # Adjust the interval as needed

if __name__ == "__main__":
    main()

```

Running the code :


Activities
Terminal
Jan 16 15:14
hp@hp-HP-Laptop-15s-eq2xxx: ~
hp@hp-HP-Laptop-15s-eq2xxx: ~
hp@hp-HP-Laptop-15s-eq2xxx: ~
kafka@hp-HP-Laptop-15s-eq2xxx: /home/...
hp@hp-HP-Laptop-15s-eq2xxx: ~
hp@hp-HP-Laptop-15s-eq2xxx: ~

```
hp@hp-HP-Laptop-15s-eq2xxx:~$ python3 weatherProducer.py
Sent data: {'coord': {'lon': -0.1257, 'lat': 51.5085}, 'weather': [{'id': 804, 'main': 'Clouds', 'description': 'overcast clouds', 'icon': '04d'}], 'base': 'stations', 'main': {'temp': 7.06, 'feels_like':
 5.29, 'temp_min': 5.9, 'temp_max': 7.92, 'pressure': 1034, 'humidity': 92, 'sea_level': 1034, 'grnd_level': 1030}, 'visibility': 10000, 'wind': {'speed': 2.57, 'deg': 210}, 'clouds': {'all': 100}, 'dt':
1737019900, 'sys': {'type': 2, 'id': 2075535, 'country': 'GB', 'sunrise': 1737014304, 'sunset': 1737044504}, 'timezone': 0, 'id': 2643743, 'name': 'London', 'cod': 200}
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Sent data: {'coord': {'lon': -0.1257, 'lat': 51.5085}, 'weather': [{'id': 804, 'main': 'Clouds', 'description': 'overcast clouds', 'icon': '04d'}], 'base': 'stations', 'main': {'temp': 7.06, 'feels_like':
```
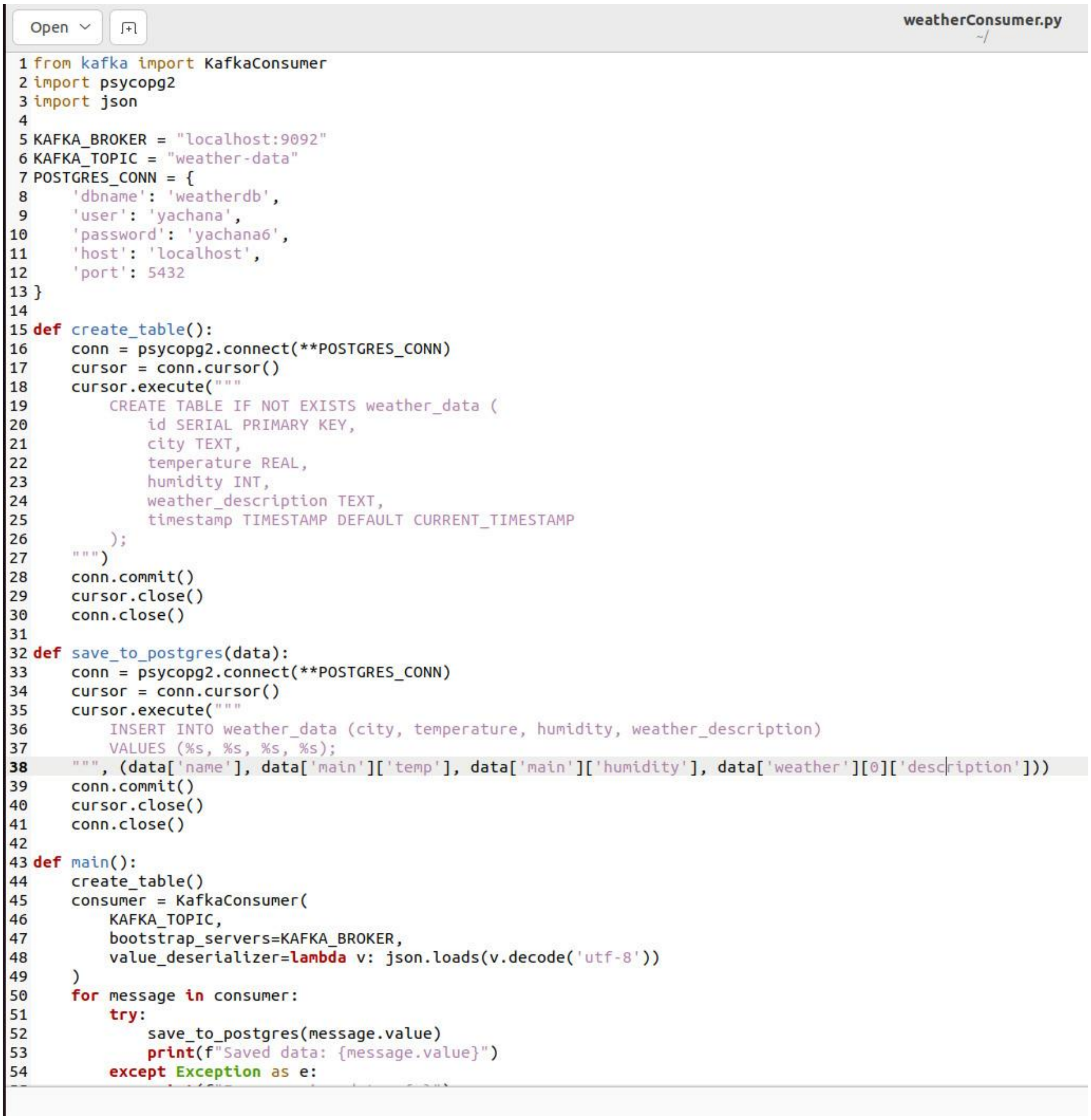

- **Kafka Consumer :**

- Consumes data from the Kafka Topic.

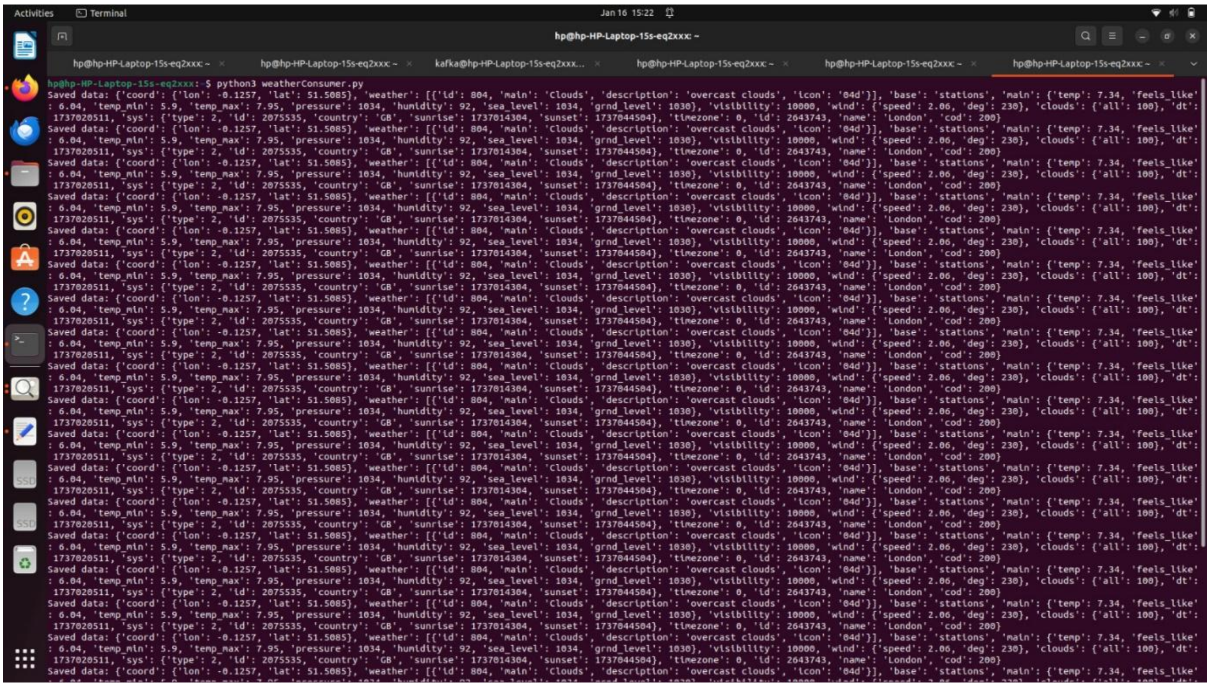
- Transforms data into a format compatible with PostgreSQL.

Python code for consumer :



```python
from kafka import KafkaConsumer
import psycopg2
import json

KAFKA_BROKER = "localhost:9092"
KAFKA_TOPIC = "weather-data"
POSTGRES_CONN = {
    'dbname': 'weatherdb',
    'user': 'yachana',
    'password': 'yachana6',
    'host': 'localhost',
    'port': 5432
}

def create_table():
    conn = psycopg2.connect(**POSTGRES_CONN)
    cursor = conn.cursor()
    cursor.execute("""
        CREATE TABLE IF NOT EXISTS weather_data (
            id SERIAL PRIMARY KEY,
            city TEXT,
            temperature REAL,
            humidity INT,
            weather_description TEXT,
            timestamp TIMESTAMP DEFAULT CURRENT_TIMESTAMP
        );
    """)
    conn.commit()
    cursor.close()
    conn.close()

def save_to_postgres(data):
    conn = psycopg2.connect(**POSTGRES_CONN)
    cursor = conn.cursor()
    cursor.execute("""
        INSERT INTO weather_data (city, temperature, humidity, weather_description)
        VALUES (%s, %s, %s, %s);
    """, (data['name'], data['main']['temp'], data['main']['humidity'], data['weather'][0]['description']))
    conn.commit()
    cursor.close()
    conn.close()

def main():
    create_table()
    consumer = KafkaConsumer(
        KAFKA_TOPIC,
        bootstrap_servers=KAFKA_BROKER,
        value_deserializer=lambda v: json.loads(v.decode('utf-8'))
    )
    for message in consumer:
        try:
            save_to_postgres(message.value)
            print(f"Saved data: {message.value}")
        except Exception as e:
```

Running the code :



Activities
Terminal
Jan 16 15:22
hp@hp-HP-Laptop-15s-eq2xxx: ~
hp@hp-HP-Laptop-15s-eq2xxx: ~
hp@hp-HP-Laptop-15s-eq2xxx: ~
kafka@hp-HP-Laptop-15s-eq2xxx...
hp@hp-HP-Laptop-15s-eq2xxx: ~
hp@hp-HP-Laptop-15s-eq2xxx: ~
hp@hp-HP-Laptop-15s-eq2xxx: ~

```
hp@hp-HP-Laptop-15s-eq2xxx:~$ python3 weatherConsumer.py
Saved data: {'coord': {'lon': -0.1257, 'lat': 51.5085}, 'weather': [{'id': 804, 'main': 'Clouds', 'description': 'overcast clouds', 'icon': '04d'}], 'base': 'stations', 'main': {'temp': 7.34, 'feels_like'
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```

3. **Data Storage**

- PostgreSQL :

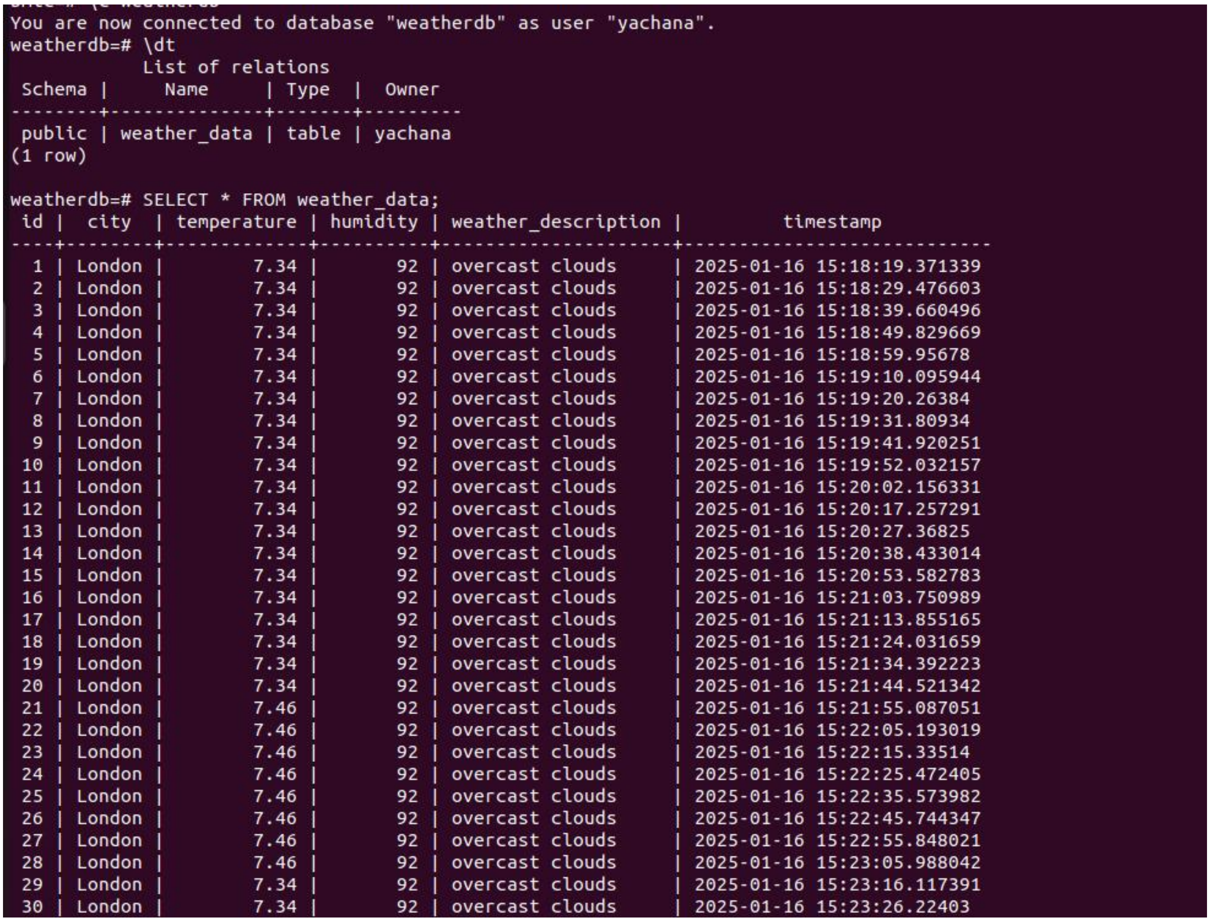
- Schema Design:

```
sql
CREATE TABLE weather_data (
    id SERIAL PRIMARY KEY,
    city TEXT,
    temperature REAL,
    humidity INT,
    weather_description TEXT,
    timestamp TIMESTAMP DEFAULT CURRENT_TIMESTAMP
);
```

- Insert transformed data into the database.

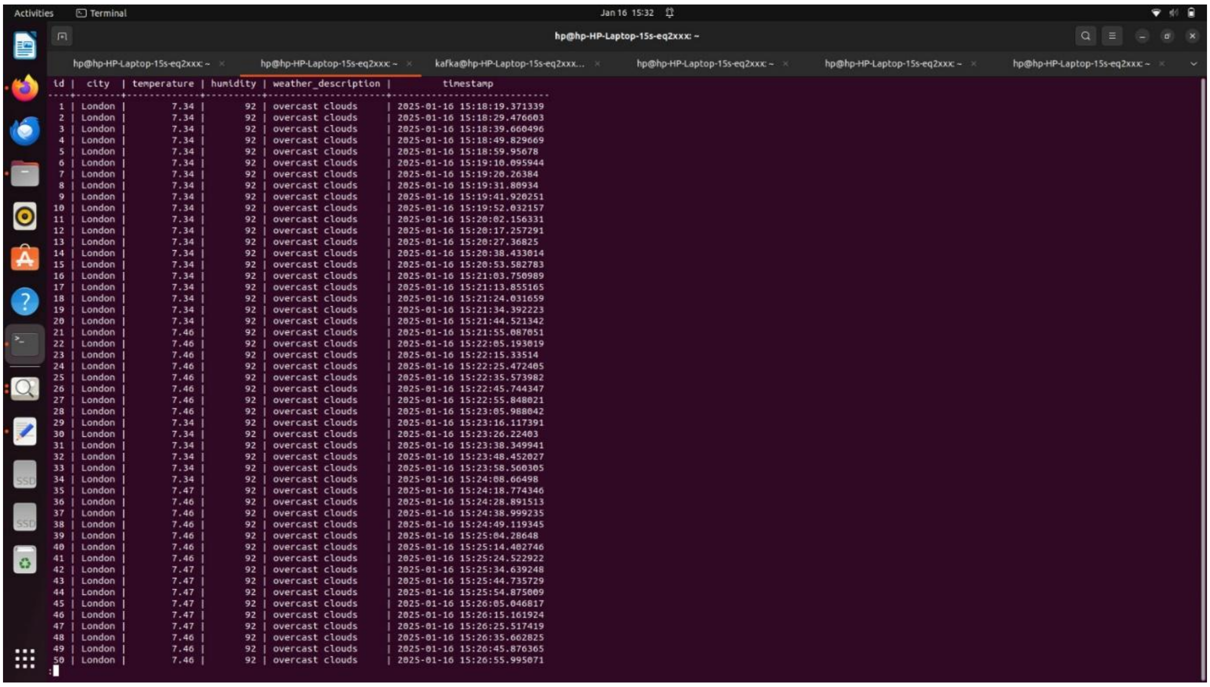
Created database “weatherdb” and table “weather_data” in it :

The data generated is inserted into the table :



```
You are now connected to database "weatherdb" as user "yachana".
weatherdb=# \dt
            List of relations
 Schema |     Name     | Type  |  Owner
--------+--------------+-------+---------
 public | weather_data | table | yachana
(1 row)

weatherdb=# SELECT * FROM weather_data;
 id |  city  | temperature | humidity | weather_description |         timestamp
----+--------+-------------+----------+---------------------+----------------------------
  1 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:18:19.371339
  2 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:18:29.476603
  3 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:18:39.660496
  4 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:18:49.829669
  5 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:18:59.95678
  6 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:19:10.095944
  7 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:19:20.26384
  8 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:19:31.80934
  9 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:19:41.920251
 10 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:19:52.032157
 11 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:20:02.156331
 12 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:20:17.257291
 13 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:20:27.36825
 14 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:20:38.433014
 15 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:20:53.582783
 16 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:21:03.750989
 17 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:21:13.855165
 18 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:21:24.031659
 19 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:21:34.392223
 20 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:21:44.521342
 21 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:21:55.087051
 22 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:22:05.193019
 23 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:22:15.33514
 24 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:22:25.472405
 25 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:22:35.573982
 26 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:22:45.744347
 27 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:22:55.848021
 28 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:23:05.988042
 29 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:23:16.117391
 30 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:23:26.22403
```


Activities
Terminal
Jan 16 15:32
hp@hp-HP-Laptop-15s-eq2xxx: ~
hp@hp-HP-Laptop-15s-eq2xxx: ~
hp@hp-HP-Laptop-15s-eq2xxx: ~
kafka@hp-HP-Laptop-15s-eq2xxx...
hp@hp-HP-Laptop-15s-eq2xxx: ~
hp@hp-HP-Laptop-15s-eq2xxx: ~
hp@hp-HP-Laptop-15s-eq2xxx: ~

```
 id |  city  | temperature | humidity | weather_description |         timestamp
----+--------+-------------+----------+---------------------+----------------------------
  1 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:18:19.371339
  2 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:18:29.476603
  3 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:18:39.660496
  4 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:18:49.829669
  5 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:18:59.95678
  6 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:19:10.095944
  7 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:19:20.26384
  8 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:19:31.80934
  9 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:19:41.920251
 10 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:19:52.032157
 11 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:20:02.156331
 12 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:20:17.257291
 13 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:20:27.36825
 14 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:20:38.433014
 15 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:20:53.582783
 16 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:21:03.750989
 17 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:21:13.855165
 18 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:21:24.031659
 19 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:21:34.392223
 20 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:21:44.521342
 21 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:21:55.087051
 22 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:22:05.193019
 23 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:22:15.33514
 24 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:22:25.472405
 25 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:22:35.573982
 26 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:22:45.744347
 27 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:22:55.848021
 28 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:23:05.988042
 29 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:23:16.117391
 30 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:23:26.22403
 31 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:23:38.349941
 32 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:23:48.452027
 33 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:23:58.560305
 34 | London |        7.34 |       92 | overcast clouds     | 2025-01-16 15:24:08.66498
 35 | London |        7.47 |       92 | overcast clouds     | 2025-01-16 15:24:18.774346
 36 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:24:28.891513
 37 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:24:38.999235
 38 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:24:49.119345
 39 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:25:04.28648
 40 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:25:14.402746
 41 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:25:24.522922
 42 | London |        7.47 |       92 | overcast clouds     | 2025-01-16 15:25:34.639248
 43 | London |        7.47 |       92 | overcast clouds     | 2025-01-16 15:25:44.735729
 44 | London |        7.47 |       92 | overcast clouds     | 2025-01-16 15:25:54.875009
 45 | London |        7.47 |       92 | overcast clouds     | 2025-01-16 15:26:05.046817
 46 | London |        7.47 |       92 | overcast clouds     | 2025-01-16 15:26:15.161924
 47 | London |        7.47 |       92 | overcast clouds     | 2025-01-16 15:26:25.517419
 48 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:26:35.662825
 49 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:26:45.876365
 50 | London |        7.46 |       92 | overcast clouds     | 2025-01-16 15:26:55.995071
:
```

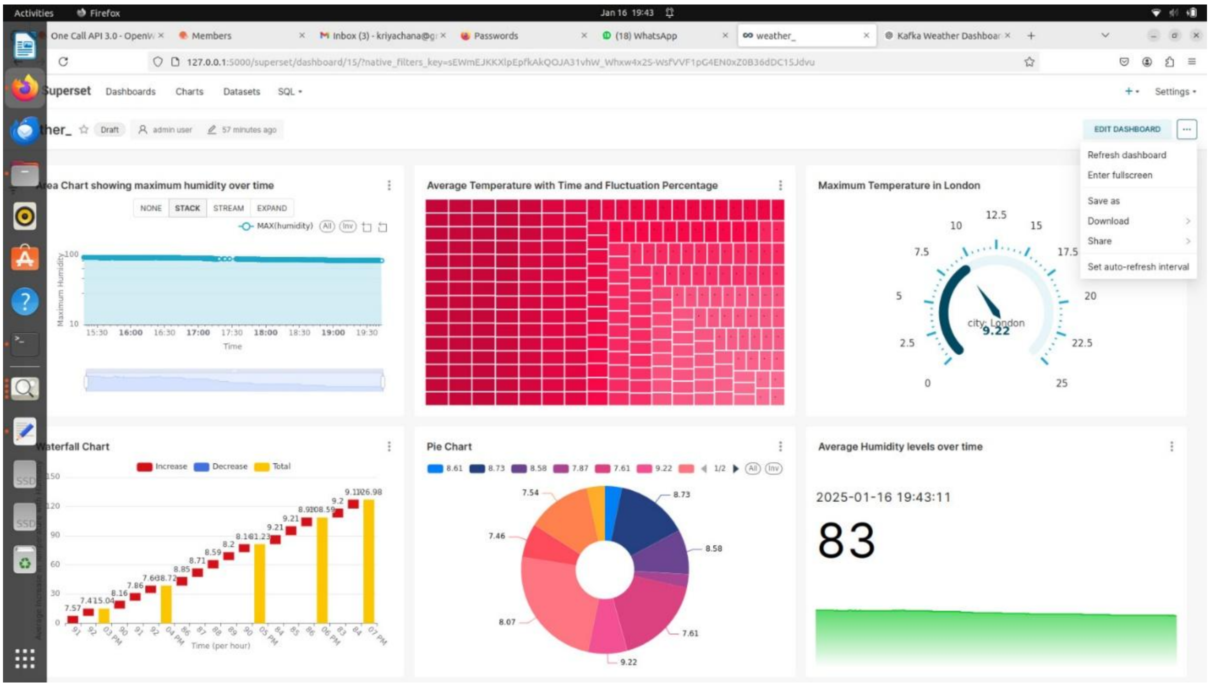
4. **Data Subscription :**

- Kafka enables real-time streaming, ensuring new weather updates are consistently pushed into PostgreSQL.

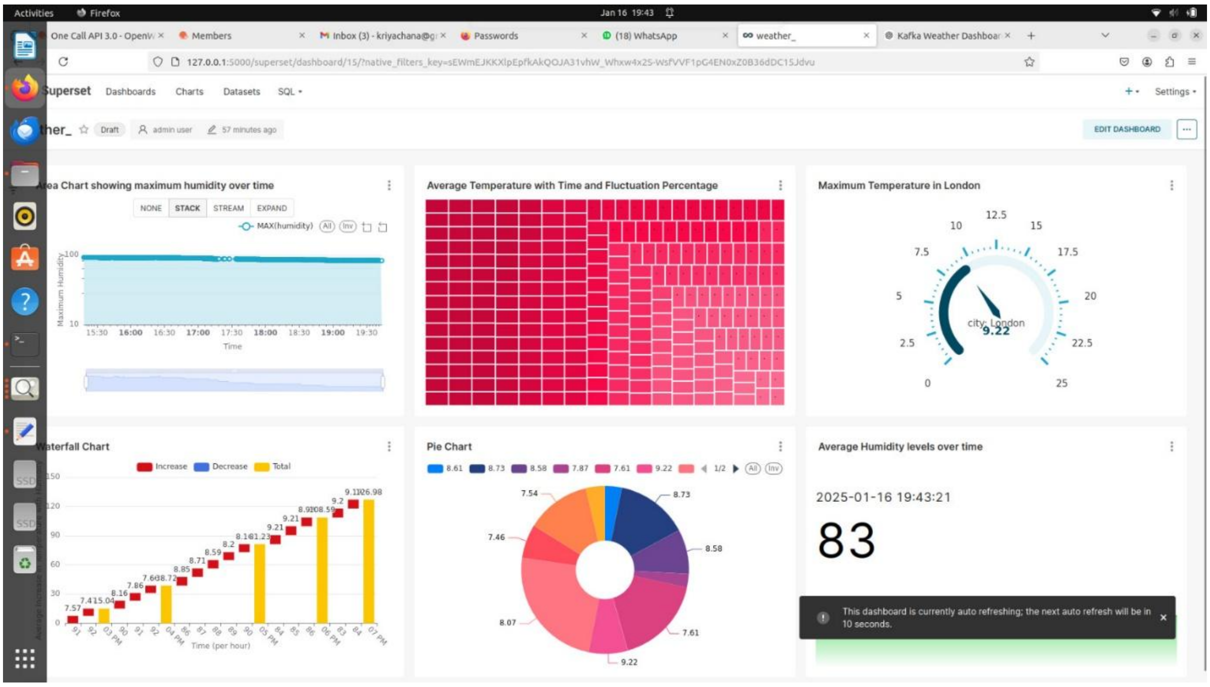
5. **Data Presentation** :-

-**Apache Superset** :

- Creating visualizations (e.g., time-series charts, heatmaps, and gauge charts).
- Configuring auto-refresh to update charts every 5-30 seconds.
- Example Dashboards:
  - Line chart showing temperature trends.
  - Heatmap visualizing humidity across cities.
  - Gauge chart displaying live temperature.



Auto refreshing the charts in 10 seconds :



This dashboard is currently auto refreshing; the next auto refresh will be in 10 seconds.

Benefits and Conclusion

This project provides an efficient system for real-time weather monitoring and visualization. By leveraging Kafka for streaming, PostgreSQL for persistence, and Superset for presentation, stakeholders can access up-to-date weather insights. The system is scalable, reliable, and user-friendly, making it an ideal solution for applications requiring live data analysis and decision-making.

If further enhancements or new metrics are needed, the modular design of this system allows for easy upgrades and scaling.