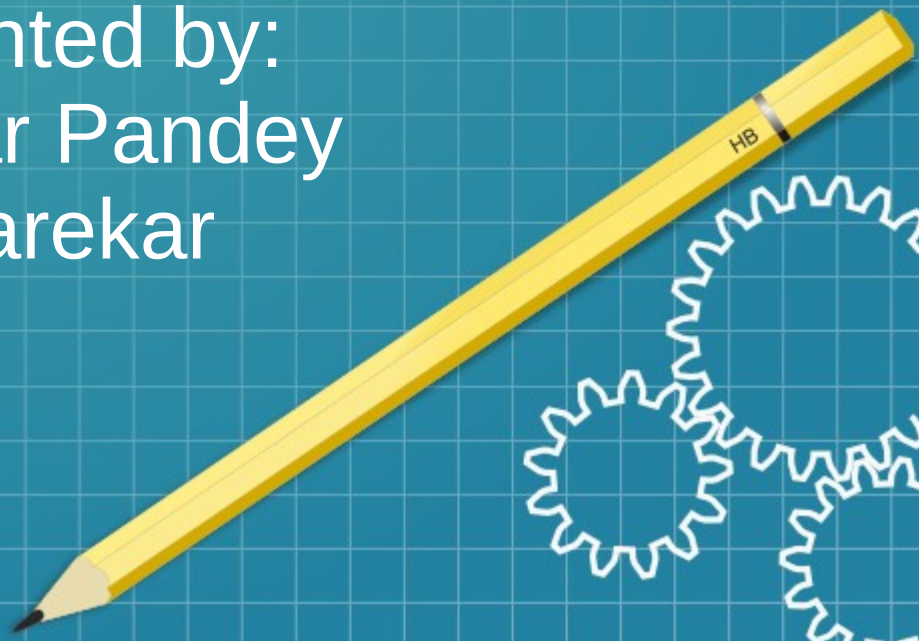
TCUP Hackathon 2023

Solution presented by:
Mr. Manishkumar Pandey
Mr. Atharv Darekar

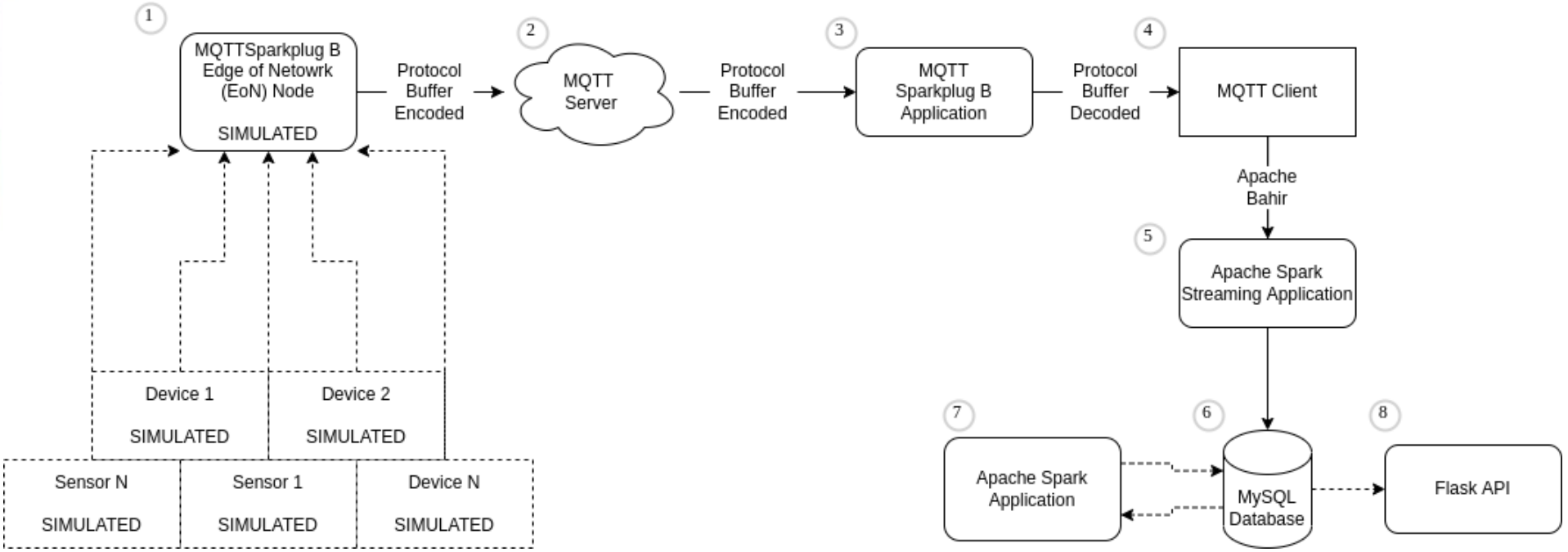


Use Case: Ice Plant

- This solution provides a working model of real time event processor for IoT devices in an ice plant.

- The solution provided is generic in nature and can be easily extended to any IoT application use case.

Architecture



1. MQTT Sparkplug B Edge of Netowrk (EoN) Node

- It simulates the data generated by various sensors and devices present in the monitoring system of the plant.
- It is developed using the mqtt-spb-wrapper version 1.0.16
- The generated data is compliant with the Sparkplug B schema and is encoded using Protocol Buffer.
- The program is configurable.

2. MQTT Server

- The system uses Mosquitto MQTT broker version 1.6.9-1.
- It receives the data generated by the simulator.

3. MQTT Sparkplug B Application

- This is the standard component of the Sparkplug B infrastructure responsible for subscribing to the various topics to receive the data published by the edge nodes.
- The data received from the MQTT topic is decoded and sent to the MQTT client for ingestion into Apache Spark Streaming application.

4. MQTT Client

- It is a simple program to feed the message received from the topic to the Apache Spark Streaming application.
- It is developed using paho-mqtt version 1.6.1.

5. Apache Spark Streaming application

- Developed using Apache Spark version 2.4.0, it ingest the data into MySQL server, version 8.0.32-0ubuntu0.20.04.2 by imposing a proper schema on the raw data received from the client.
- Apache Spark uses Apache Bahir version 2.11 to connect to the MQTT client

6. MySQL Database

- MySQL database is ideal for online transaction processing (OLTP) system and can easily handle the data write operations done by Apache Spark.

7. Apache Spark application

- This is a batch processing application configurable to process the streaming data as per the users requirement.
- It consumes the data stored in the MySQL database, processes it and writes back to MySQL database for report generation and future use.

8. Flask API

- The database is exposed for further activities like monitoring, analysis, visualization and reporting using the API.

Features

- The system is modular and scalable in nature, each component can be replaced with suitable tool as per the use case, for example
  - MQTT client can be replaced by Apache Kafka
  - Apache Spark can be replaced by Apache Flink
  - MySQL database can be replaced by Apache Hive
- The pipeline is developed using a layered approach which helps isolate and fix issues in case of failures.

Technology Used

- Flask 2.2.3
- Flask-SQLAlchemy 3.0.3
- Java 2:1.11-72
- Mosquitto 1.6.9-1
- MySQL Connector j-8.0.32
- MySQL Server 8.0.32-0ubuntu0.20.04.2
- PySpark 2.4.0
- Python 3.7
- Ubuntu 20.04
- mqtt-spb-wrapper 1.0.16
- mysql-connector-python 8.0.32
- paho-mqtt 1.6.1

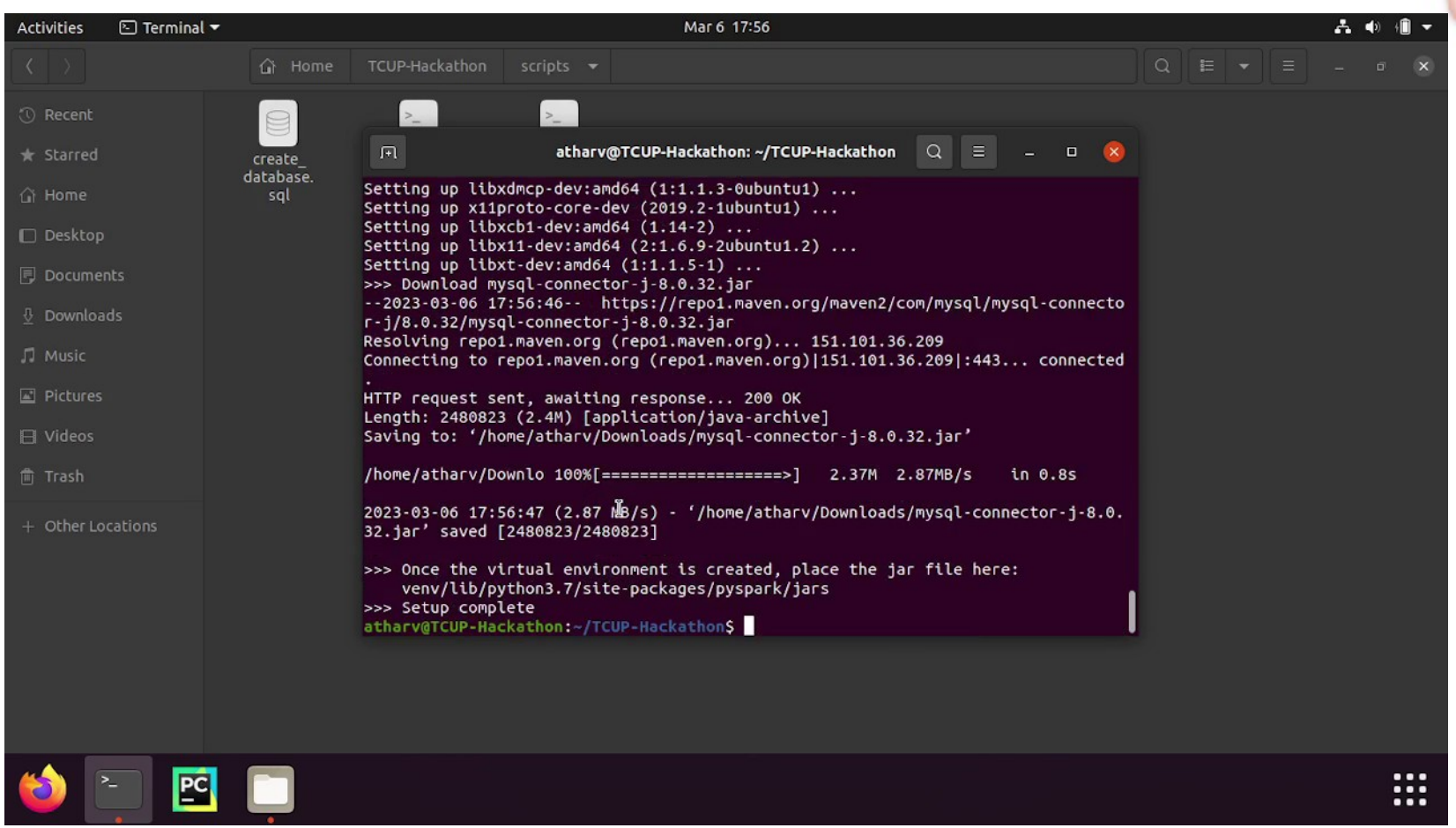
How to run the project?

1. Run setup file to install all the dependencies.
2. Setup virtual environment for the project.
3. Setup MySQL server:
   If using default project configurations:
   1. Set the root user to use the mysql_native_password plugin.
   2. Set a new password for the root user.
4. Edit configuration files of the project.
5. Run the run.py file in the environment.
6. Run the batch processing Apache Spark application.
7. Start the Flask server.
8. Test the API.

1. Run setup file to install all the dependencies.

- Run the ../scripts/setup.sh file to install all the dependencies from a non-root user with sudo rights.
- Command: “sh ../scripts/setup.sh”
- If the script fails due to network issue, re run the above command.

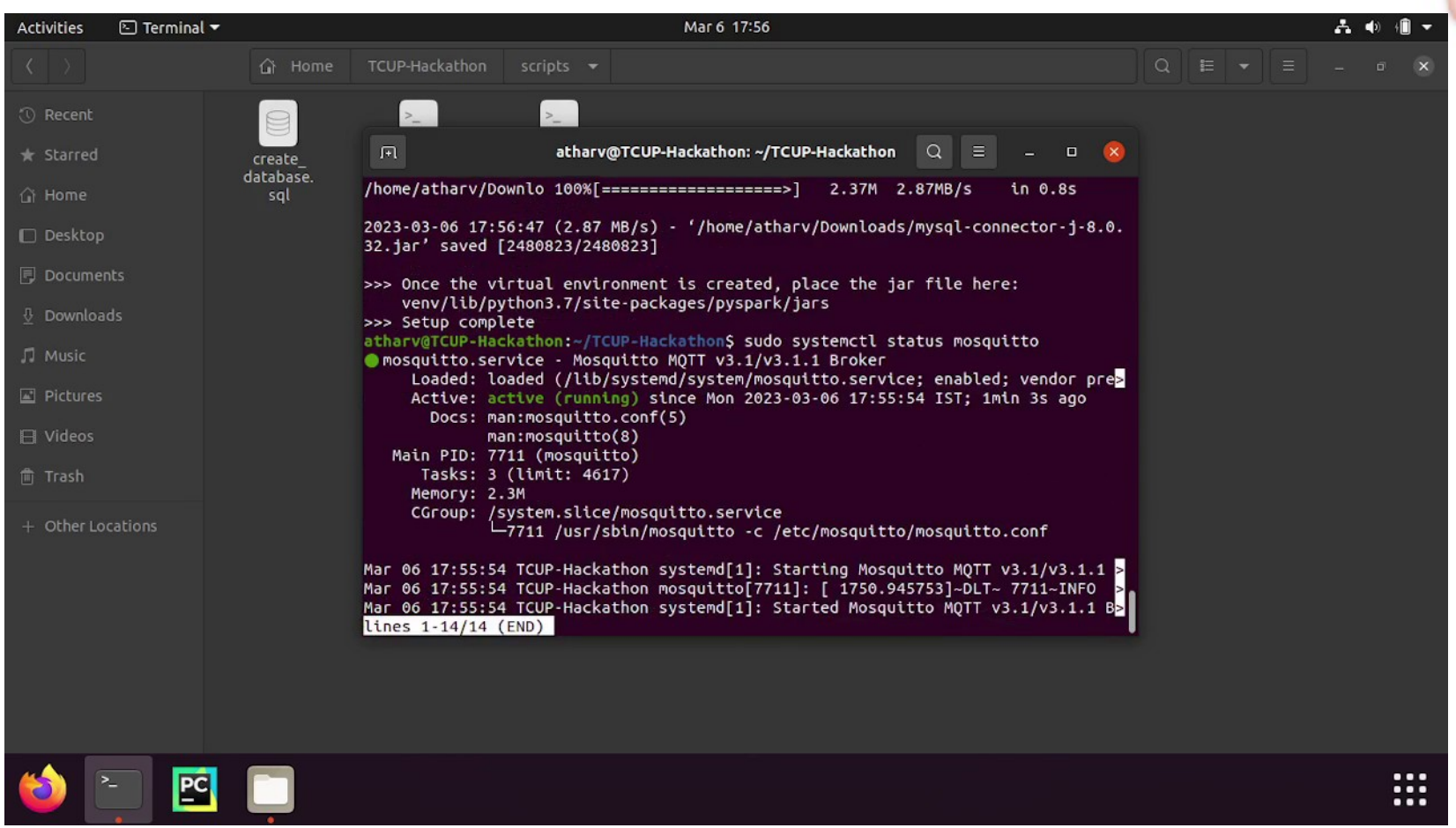
1. Run setup file to install all the dependencies.



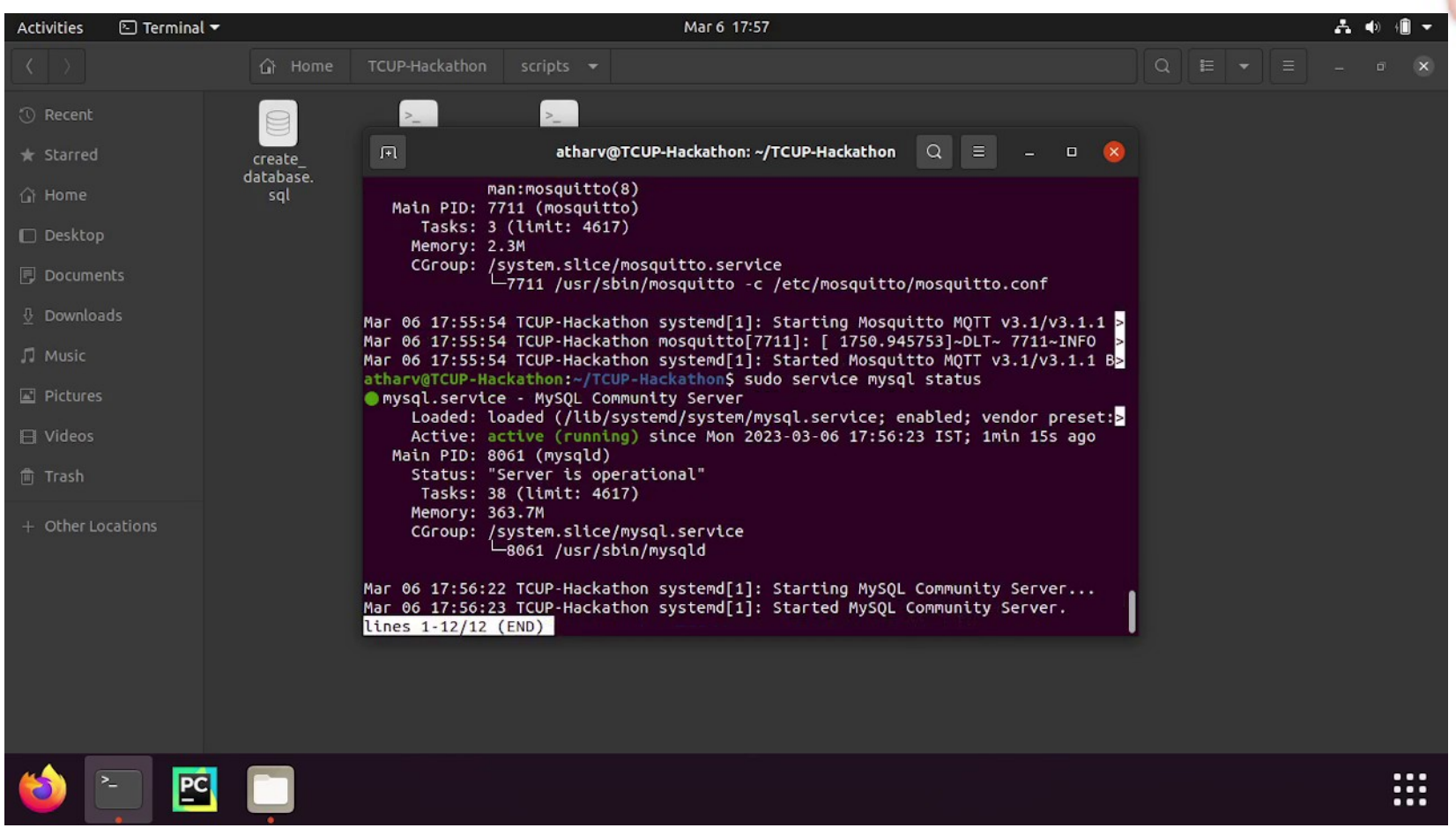
1. Run setup file to install all the dependencies.

- Ensure the status of the following services is up and running:
  - Mosquitto MQTT Broker
    - Command: sudo systemctl status moquitto
  - MySQL server
    - Command: sudo service mysql status

1. Run setup file to install all the dependencies.



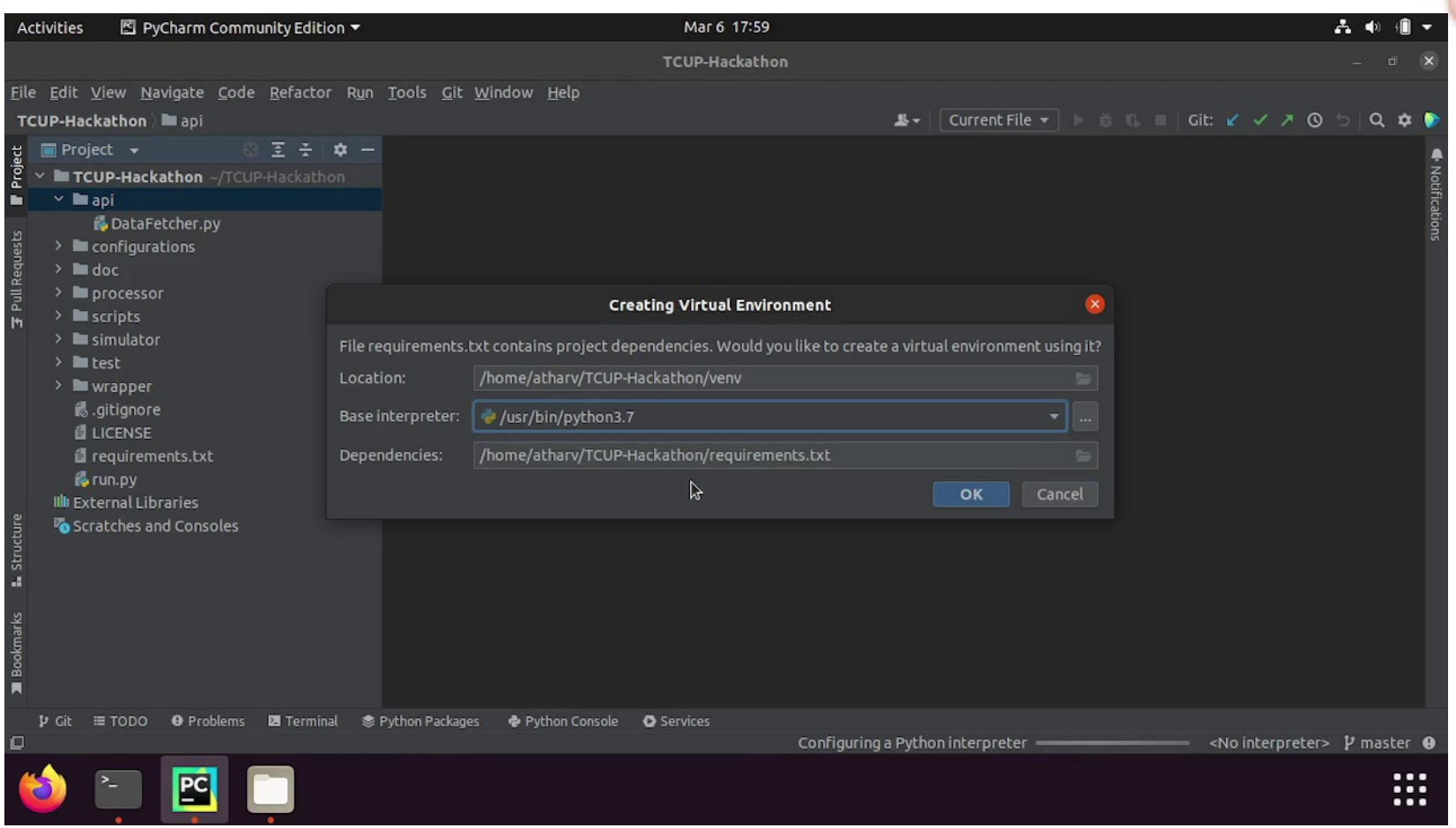
1. Run setup file to install all the dependencies.



2. Setup virtual environment for the project.

- You can use PyCharm 2022.3.2 (Community Edition) for easy setup.
- Open the project.
- Ensure to use Python version 3.7 and dependencies from the requirements.txt file.
- The IDE will auto install the dependencies.
- To complete the setup, place the “mysql-connector-j-8.0.32.jar” file in the path “../venv/lib/python3.7/site-packages/pyspark/jars”

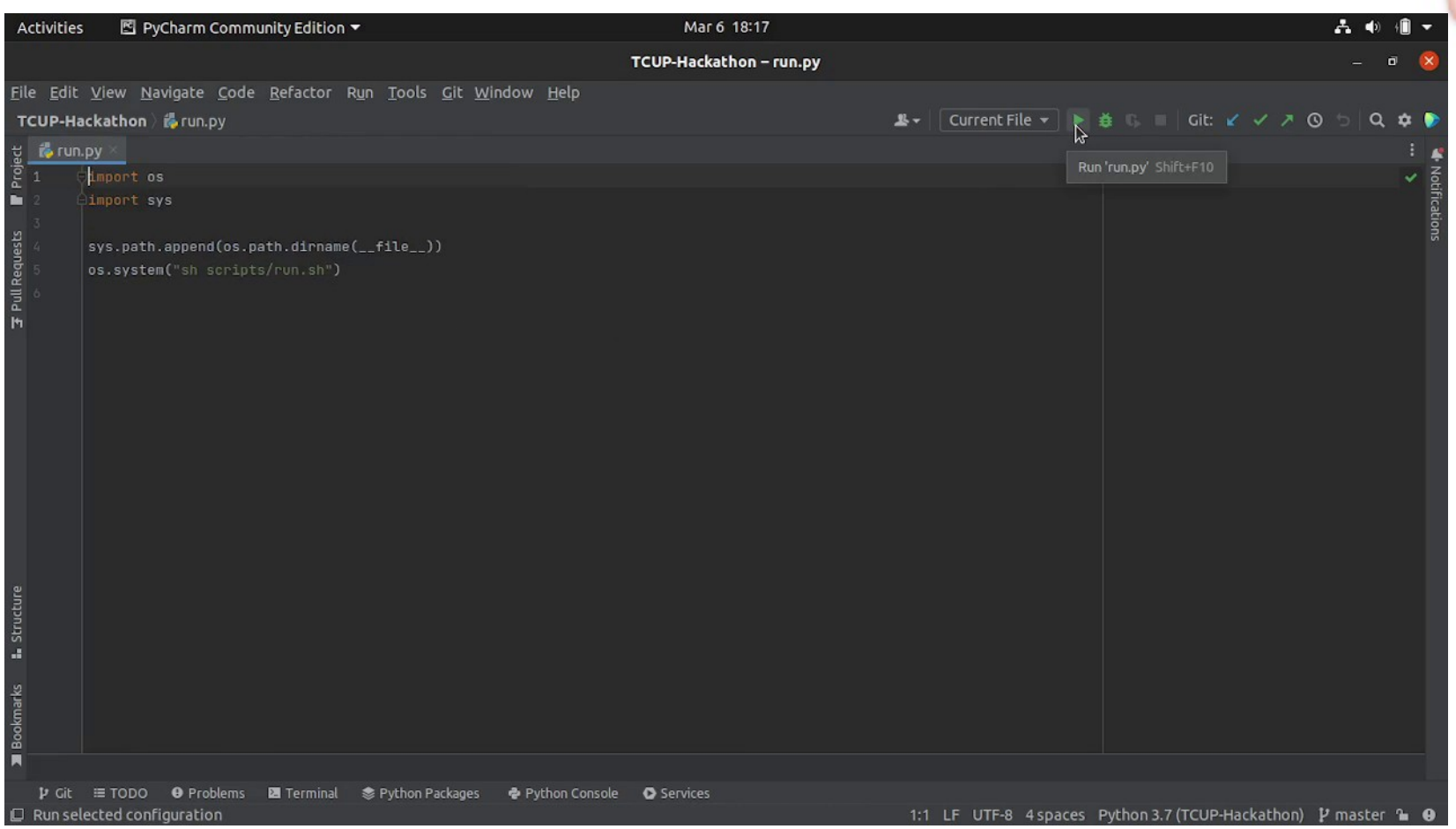
2. Setup virtual environment for the project.



3. Setup MySQL server.

- If using default project configurations:
  - Set the root user to use the mysql_native_password plugin.
    - Command: Run in the MySQL terminal.
      - “UPDATE user SET plugin=’mysql_native_password’ WHERE User=’root’;”
      - “FLUSH PRIVILEGES;”
  - Set a new password for the root user.
    - Command: Run in the MySQL terminal.
      - “ALTER USER ‘root’@’localhost’ IDENTIFIED BY *‘password’*;”

5. Run the run.py file in the environment.



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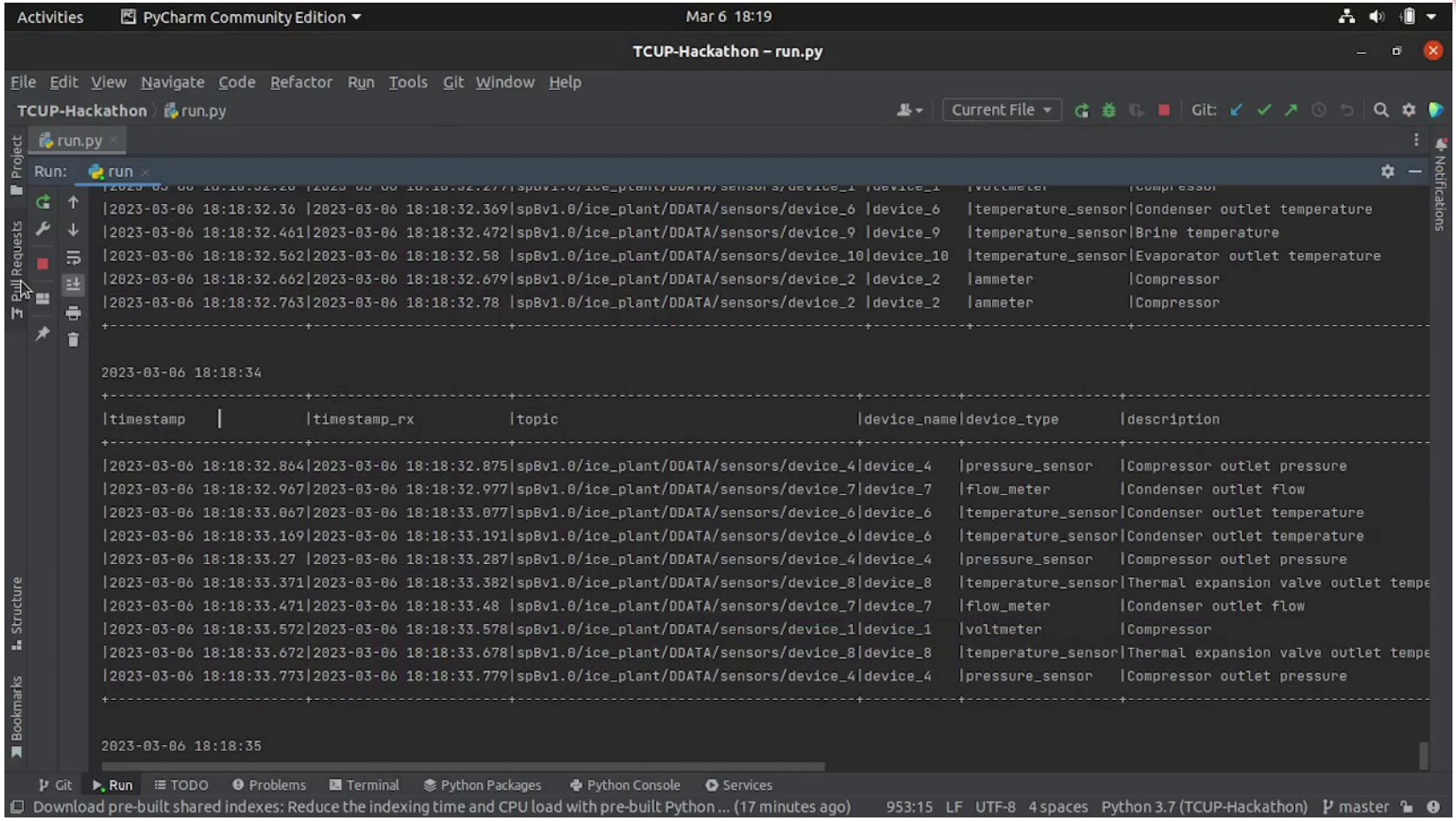

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- The dummy data generated is ingested into MySQL database.
- You can verify it from the MySQL console.

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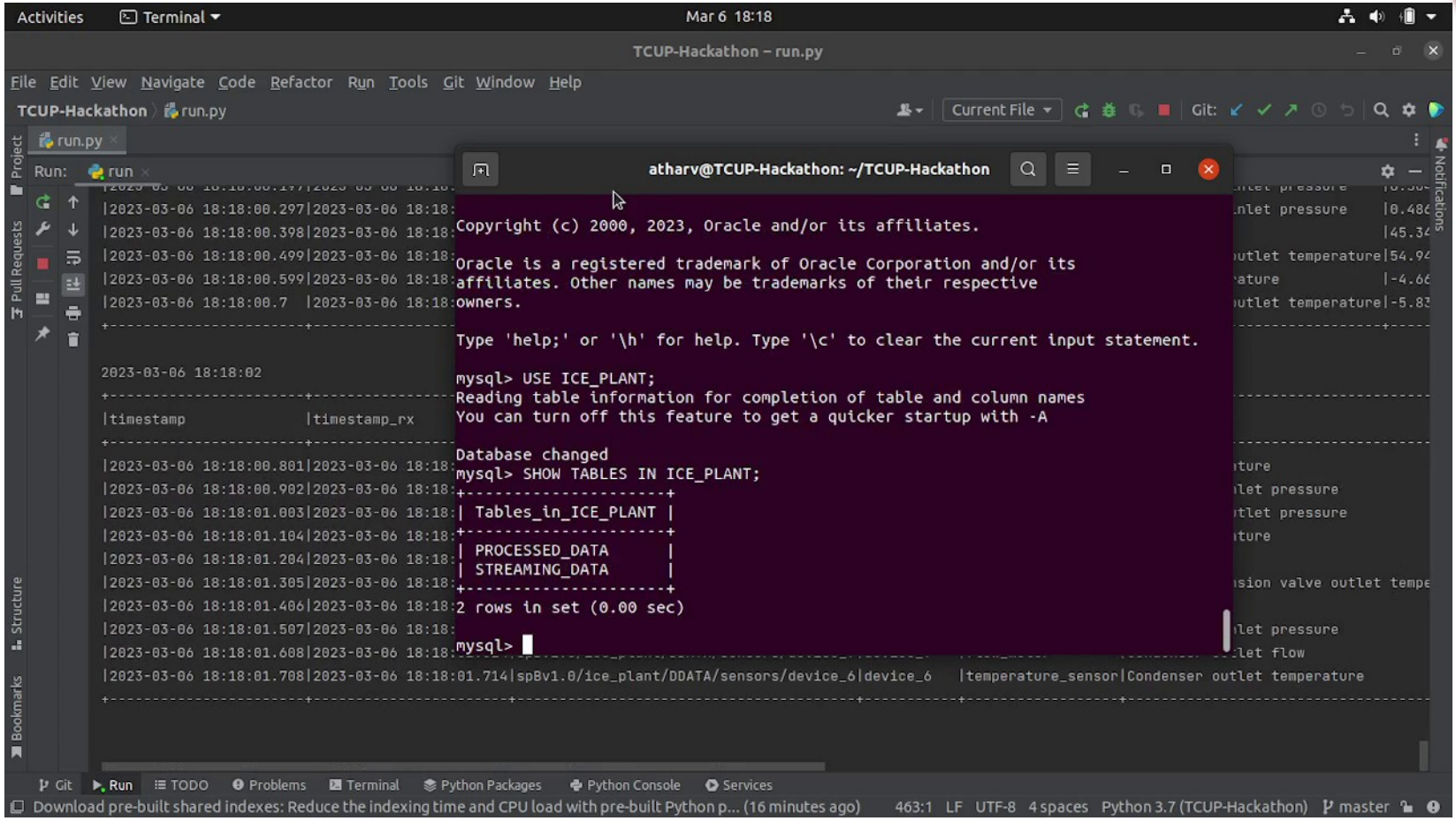

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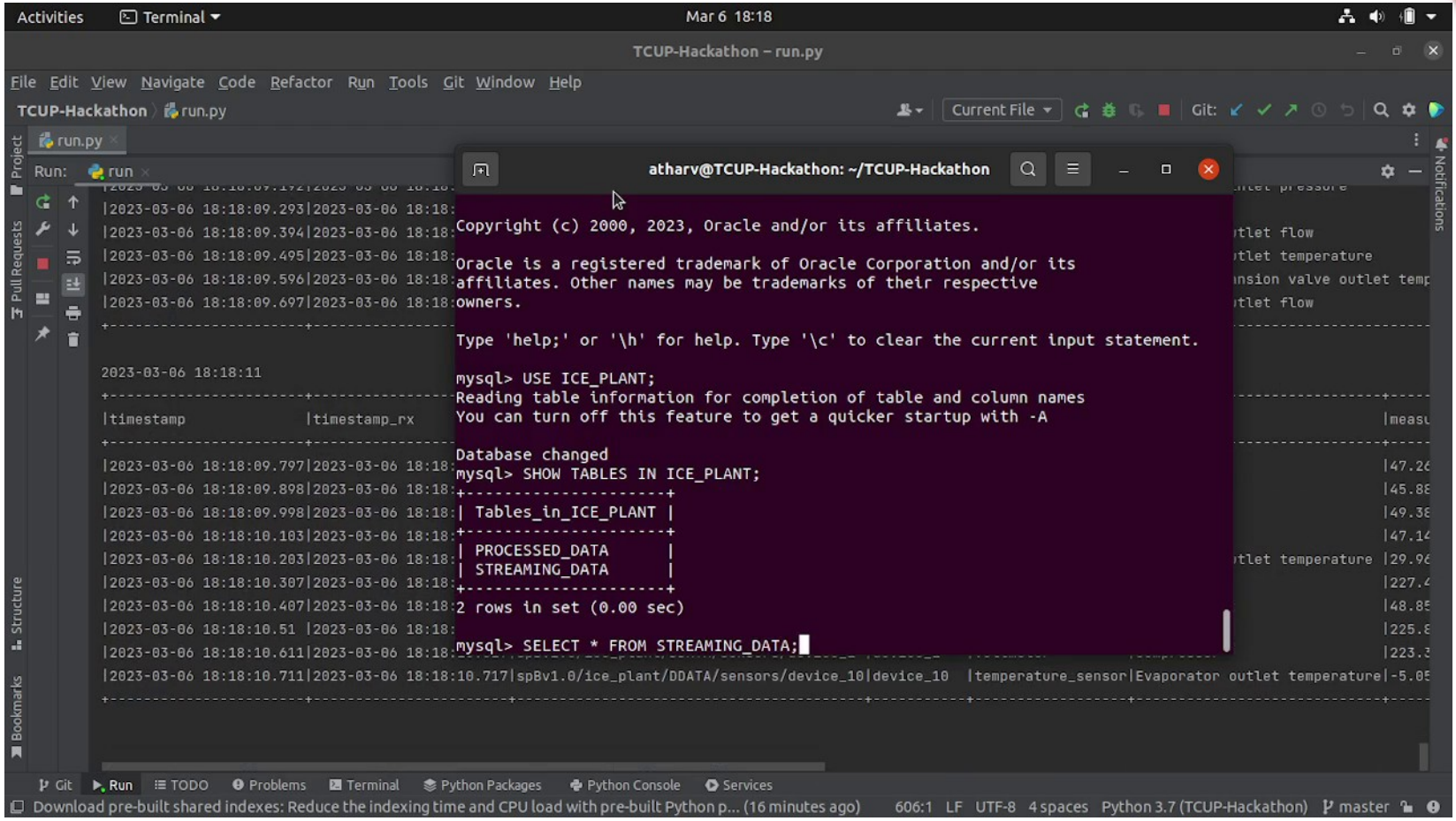

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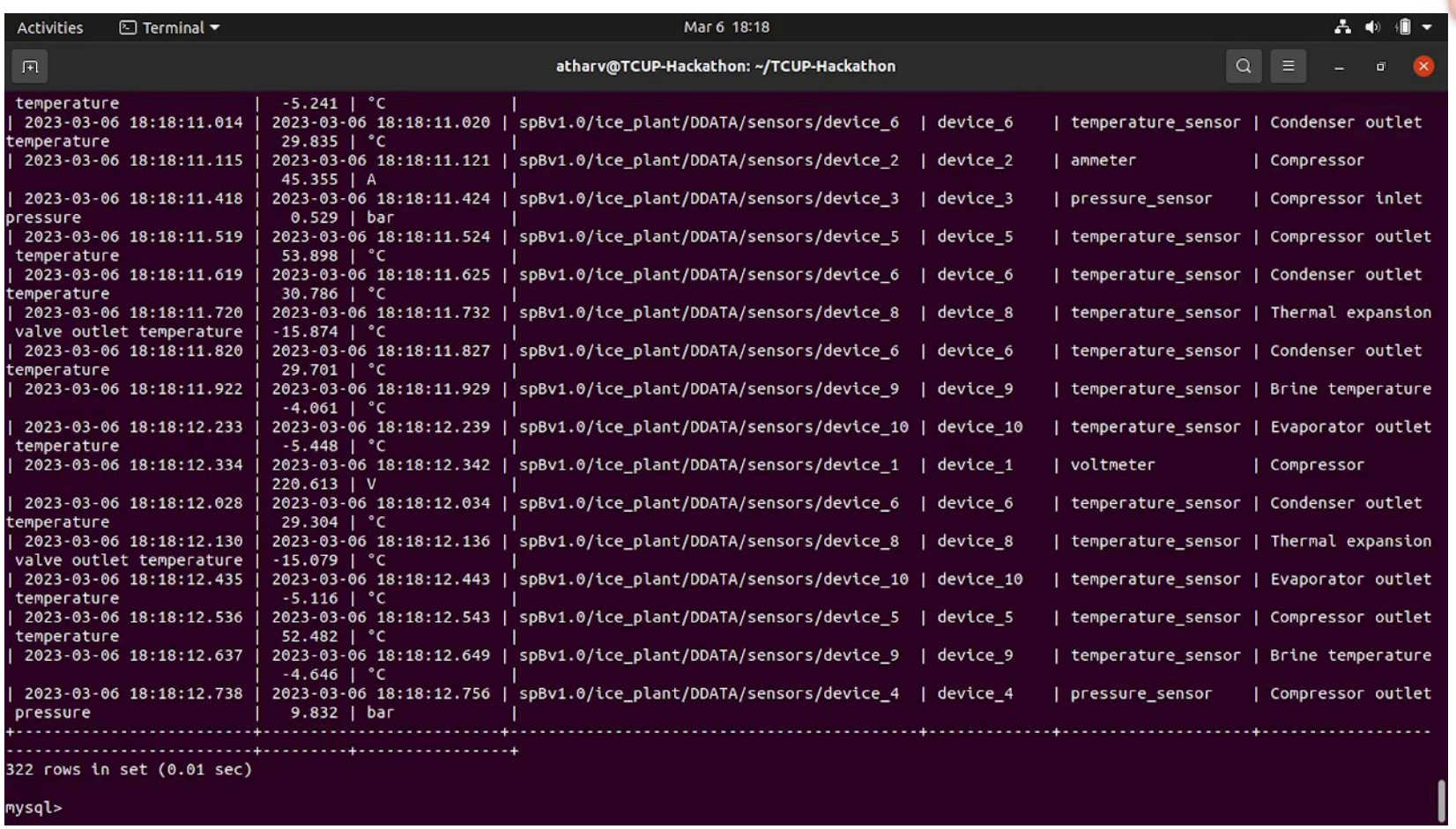
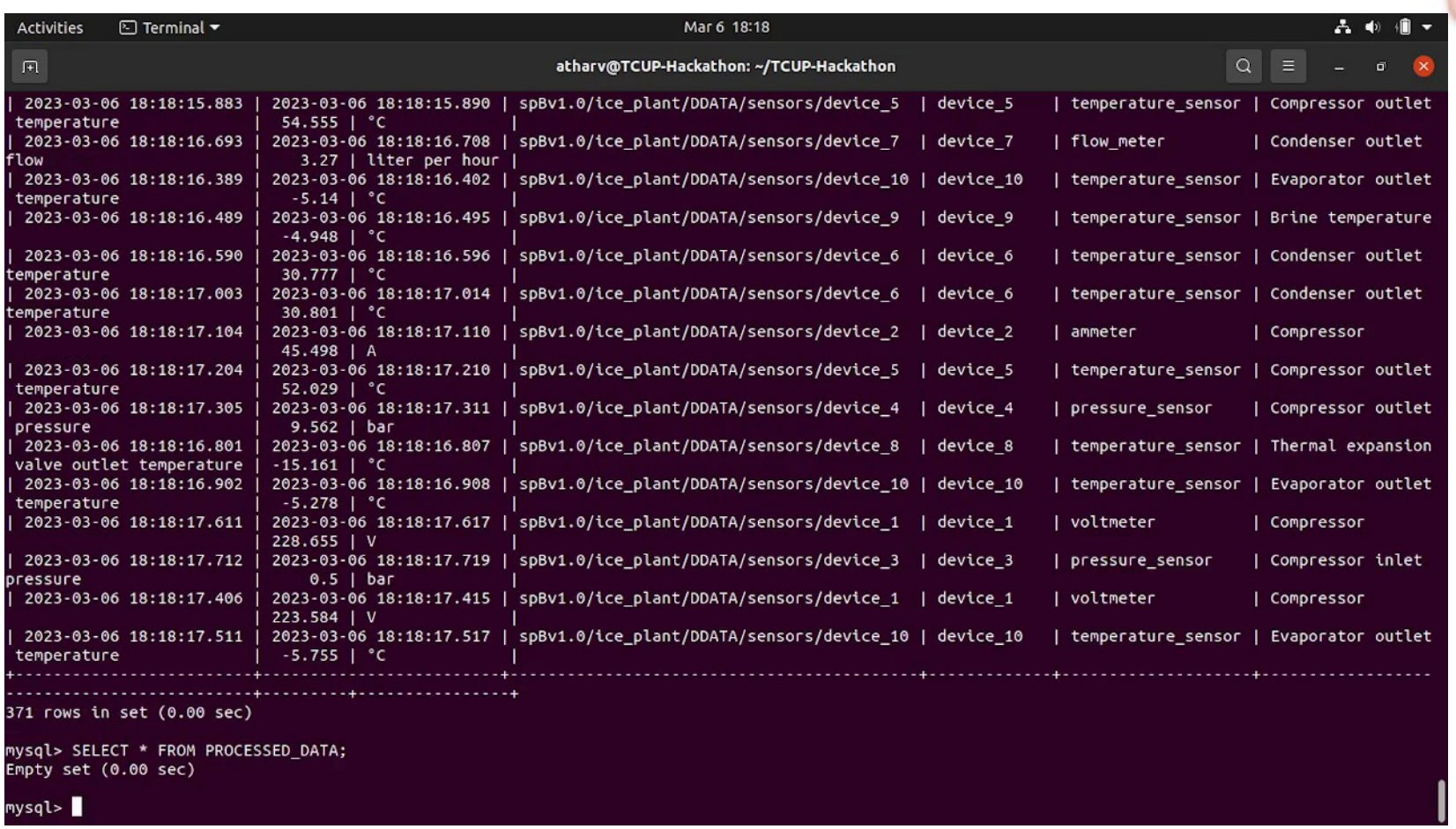



```
 temperature              |  -5.241 | °C            |
| 2023-03-06 18:18:11.014 | 2023-03-06 18:18:11.020 | spBv1.0/ice_plant/DDATA/sensors/device_6  | device_6    | temperature_sensor | Condenser outlet
temperature              |  29.835 | °C            |
| 2023-03-06 18:18:11.115 | 2023-03-06 18:18:11.121 | spBv1.0/ice_plant/DDATA/sensors/device_2  | device_2    | ammeter            | Compressor
                         |  45.355 | A             |
| 2023-03-06 18:18:11.418 | 2023-03-06 18:18:11.424 | spBv1.0/ice_plant/DDATA/sensors/device_3  | device_3    | pressure_sensor    | Compressor inlet
pressure                 |   0.529 | bar           |
| 2023-03-06 18:18:11.519 | 2023-03-06 18:18:11.524 | spBv1.0/ice_plant/DDATA/sensors/device_5  | device_5    | temperature_sensor | Compressor outlet
 temperature             |  53.898 | °C            |
| 2023-03-06 18:18:11.619 | 2023-03-06 18:18:11.625 | spBv1.0/ice_plant/DDATA/sensors/device_6  | device_6    | temperature_sensor | Condenser outlet
temperature              |  30.786 | °C            |
| 2023-03-06 18:18:11.720 | 2023-03-06 18:18:11.732 | spBv1.0/ice_plant/DDATA/sensors/device_8  | device_8    | temperature_sensor | Thermal expansion
 valve outlet temperature | -15.874 | °C            |
| 2023-03-06 18:18:11.820 | 2023-03-06 18:18:11.827 | spBv1.0/ice_plant/DDATA/sensors/device_6  | device_6    | temperature_sensor | Condenser outlet
temperature              |  29.701 | °C            |
| 2023-03-06 18:18:11.922 | 2023-03-06 18:18:11.929 | spBv1.0/ice_plant/DDATA/sensors/device_9  | device_9    | temperature_sensor | Brine temperature
                         |  -4.061 | °C            |
| 2023-03-06 18:18:12.233 | 2023-03-06 18:18:12.239 | spBv1.0/ice_plant/DDATA/sensors/device_10 | device_10   | temperature_sensor | Evaporator outlet
 temperature             |  -5.448 | °C            |
| 2023-03-06 18:18:12.334 | 2023-03-06 18:18:12.342 | spBv1.0/ice_plant/DDATA/sensors/device_1  | device_1    | voltmeter          | Compressor
                         | 220.613 | V             |
| 2023-03-06 18:18:12.028 | 2023-03-06 18:18:12.034 | spBv1.0/ice_plant/DDATA/sensors/device_6  | device_6    | temperature_sensor | Condenser outlet
temperature              |  29.304 | °C            |
| 2023-03-06 18:18:12.130 | 2023-03-06 18:18:12.136 | spBv1.0/ice_plant/DDATA/sensors/device_8  | device_8    | temperature_sensor | Thermal expansion
 valve outlet temperature | -15.079 | °C            |
| 2023-03-06 18:18:12.435 | 2023-03-06 18:18:12.443 | spBv1.0/ice_plant/DDATA/sensors/device_10 | device_10   | temperature_sensor | Evaporator outlet
 temperature             |  -5.116 | °C            |
| 2023-03-06 18:18:12.536 | 2023-03-06 18:18:12.543 | spBv1.0/ice_plant/DDATA/sensors/device_5  | device_5    | temperature_sensor | Compressor outlet
 temperature             |  52.482 | °C            |
| 2023-03-06 18:18:12.637 | 2023-03-06 18:18:12.649 | spBv1.0/ice_plant/DDATA/sensors/device_9  | device_9    | temperature_sensor | Brine temperature
                         |  -4.646 | °C            |
| 2023-03-06 18:18:12.738 | 2023-03-06 18:18:12.756 | spBv1.0/ice_plant/DDATA/sensors/device_4  | device_4    | pressure_sensor    | Compressor outlet
 pressure                |   9.832 | bar           |
+-------------------------+-------------------------+-------------------------------------------+-------------+--------------------+-----------------
-------------------------+---------+---------------+
322 rows in set (0.01 sec)

mysql>
```

5. Run the run.py file in the environment.



6. Run the batch processing Apache Spark application.

- Edit the configuration file to aggregate the data over various batches viz. year, day, hour, minute and second.
- Command:

  “spark-submit processor/DataProcessor.py configurations/data_processor_configuration.json”

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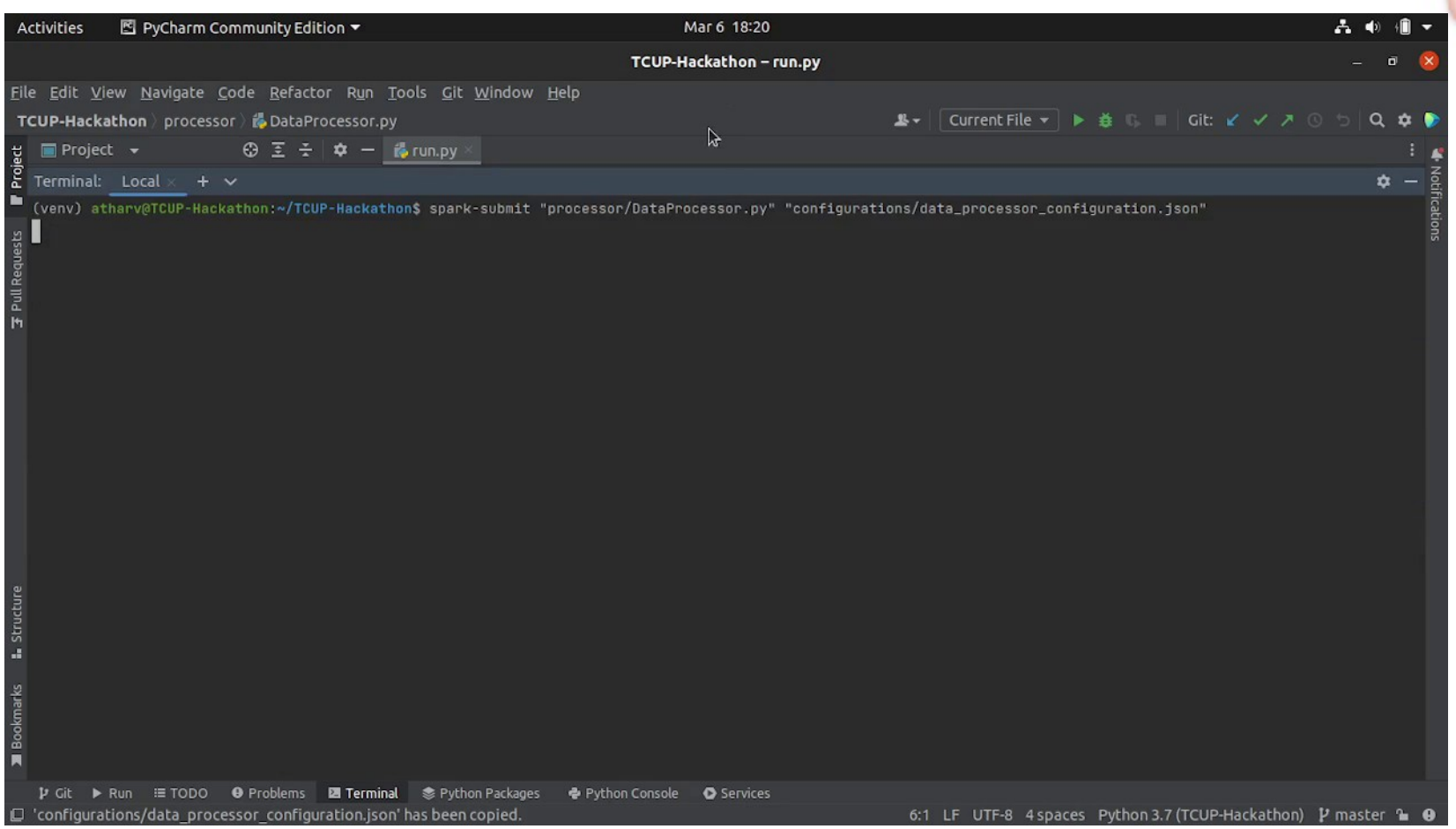
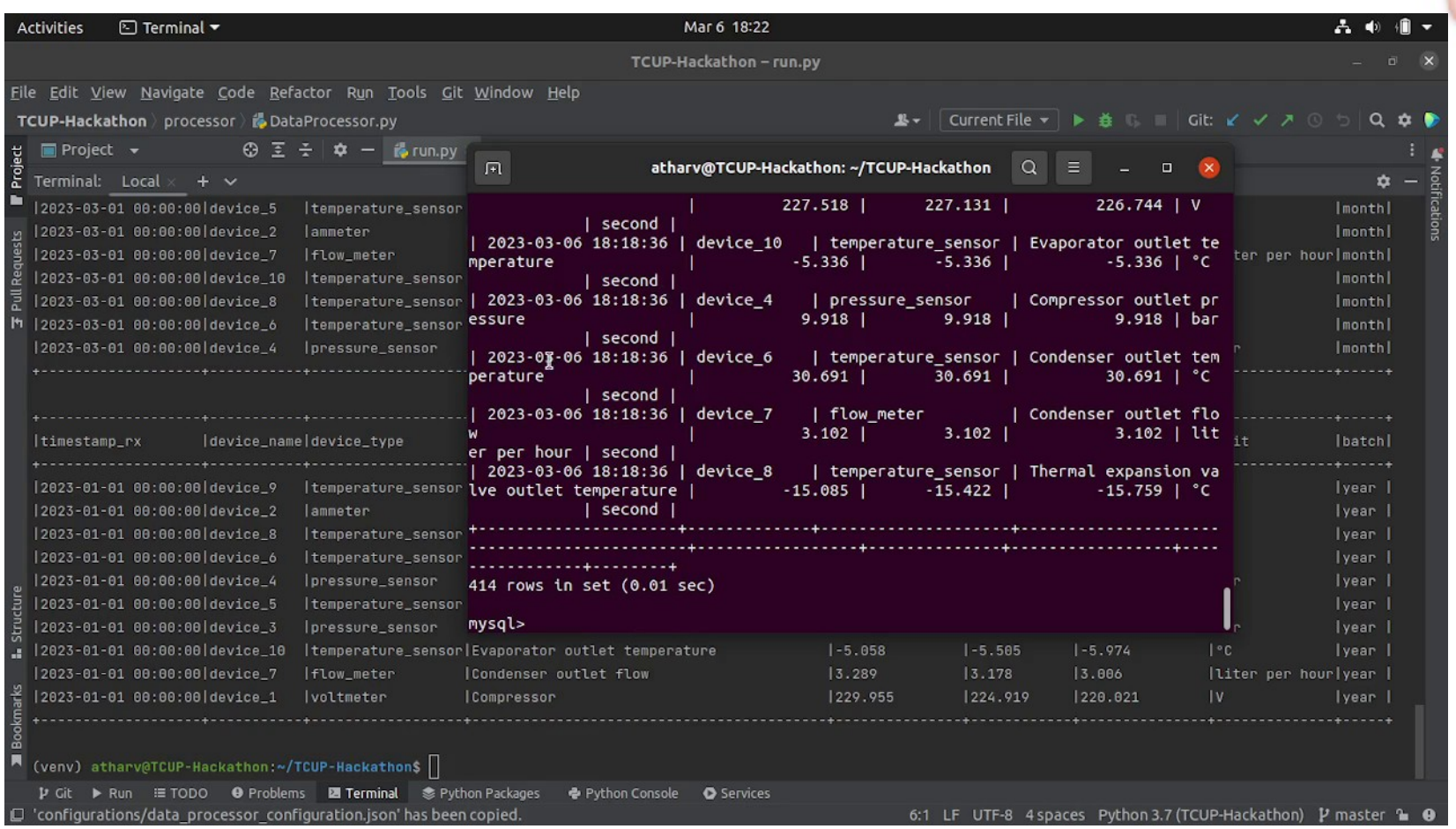


6. Run the batch processing Apache Spark application.



7. Start the Flask server.

- Modify the run configuration for the DataFetcher.py file.
- Add the configuration file as a parameter.
- Run the program to start the Flask server.

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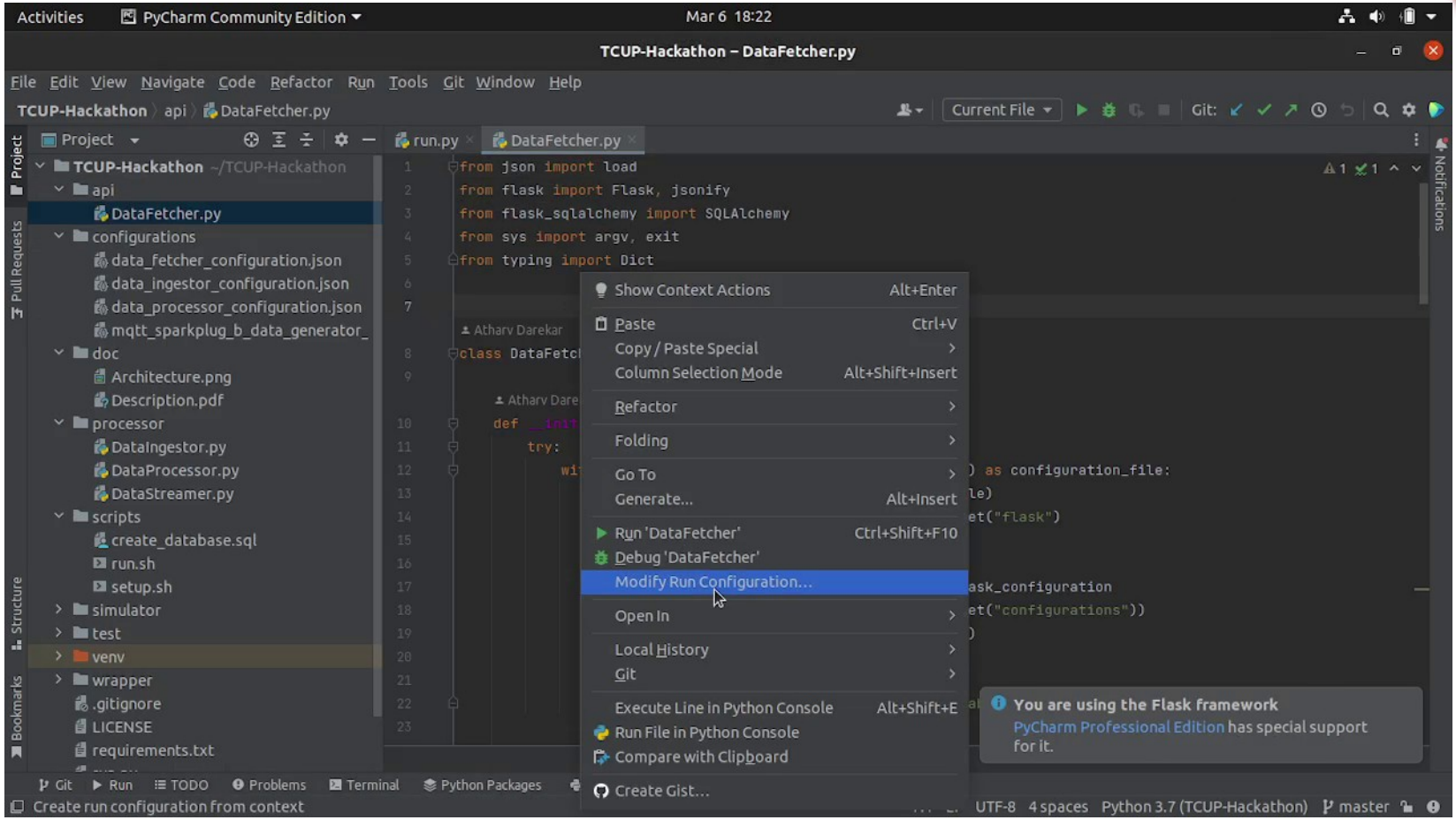

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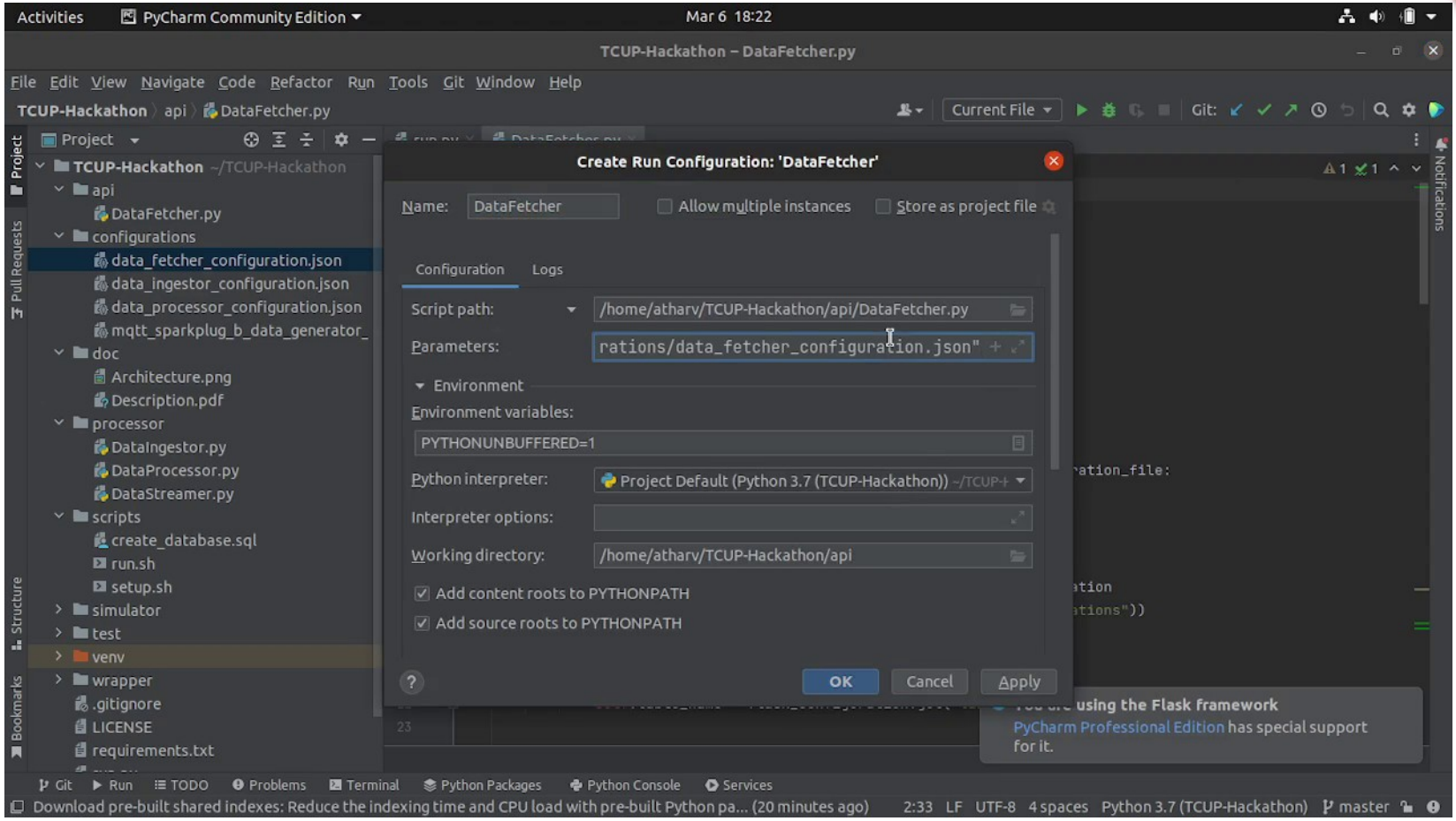

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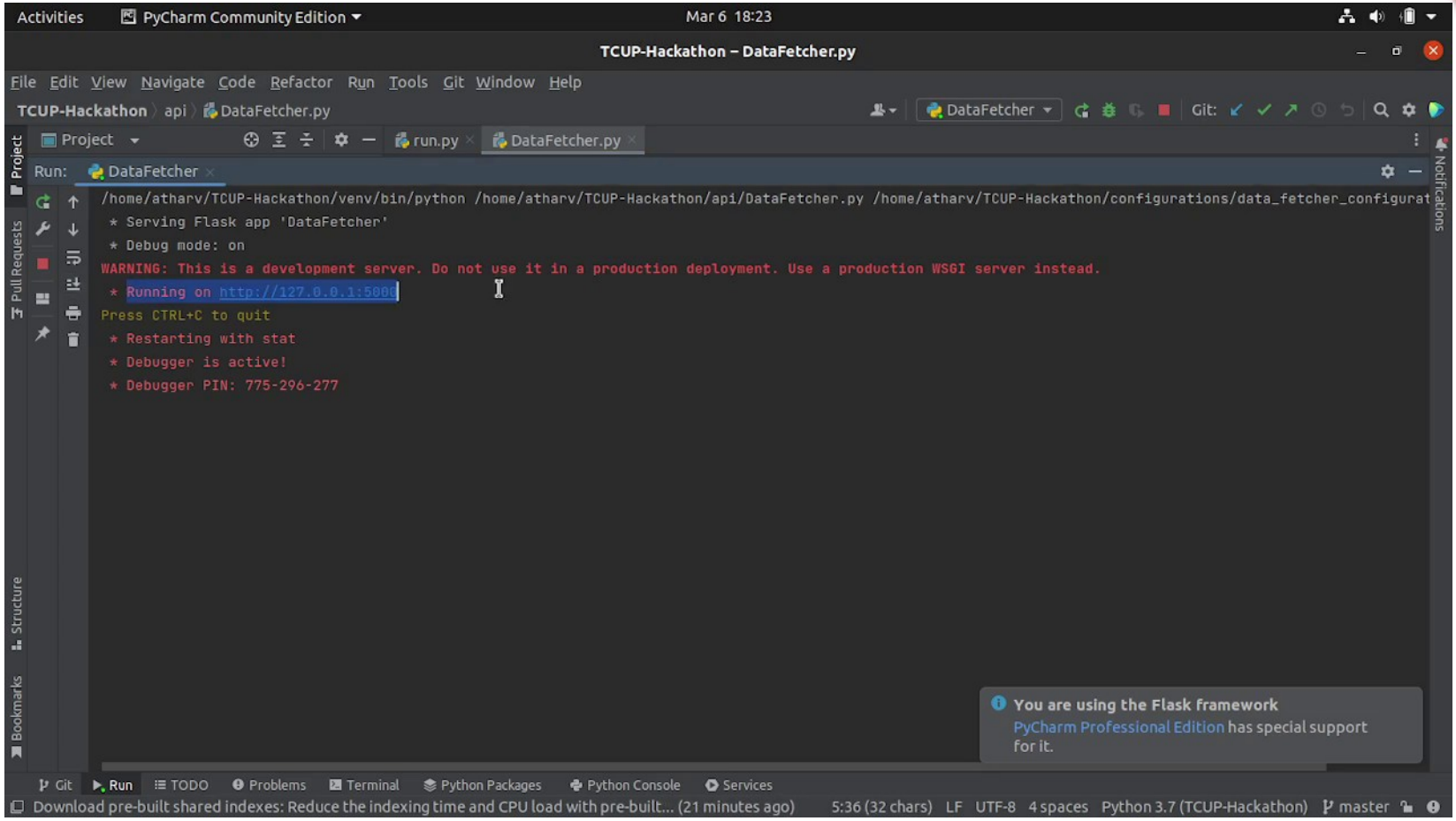
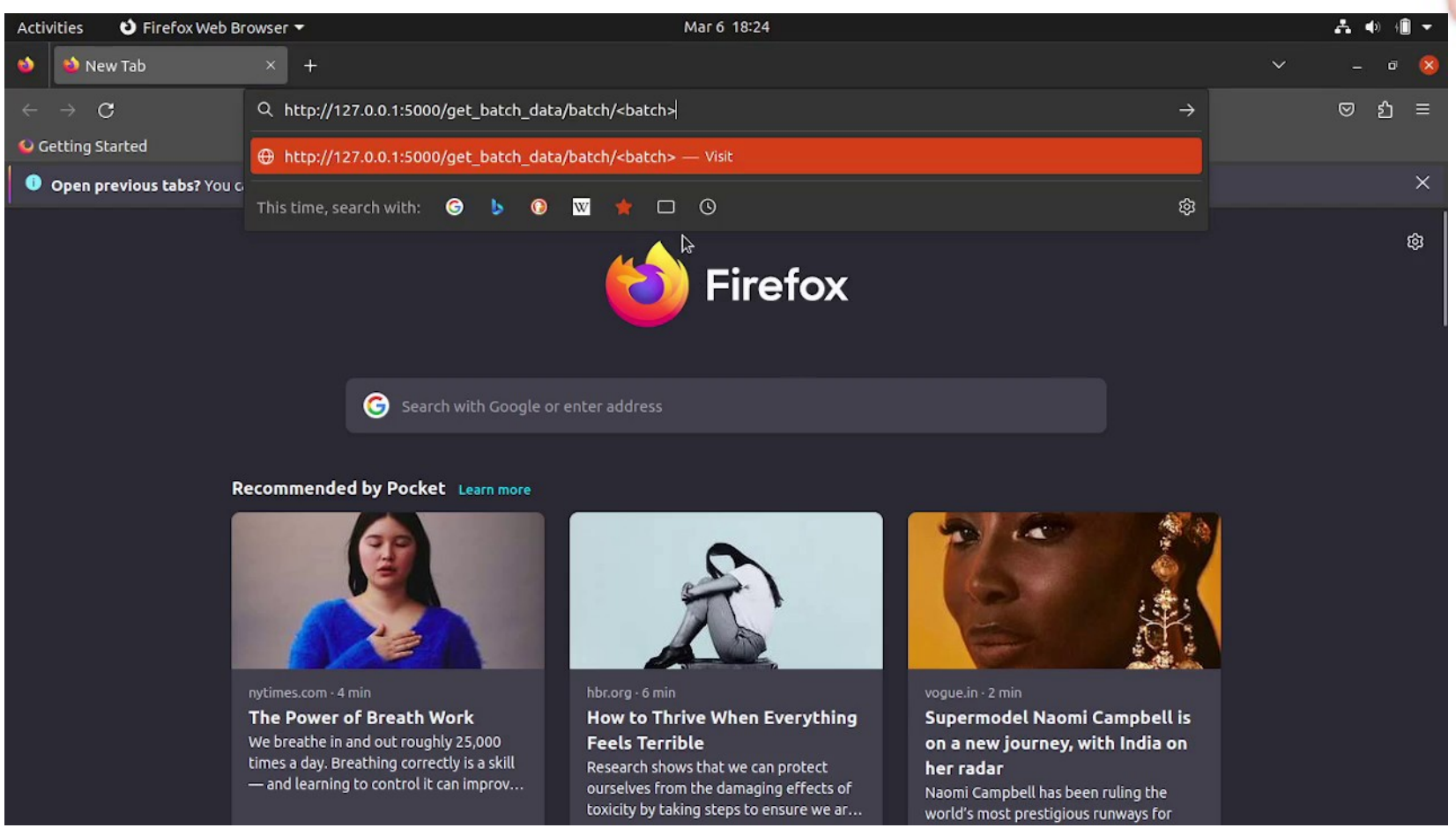


8. Test the API.



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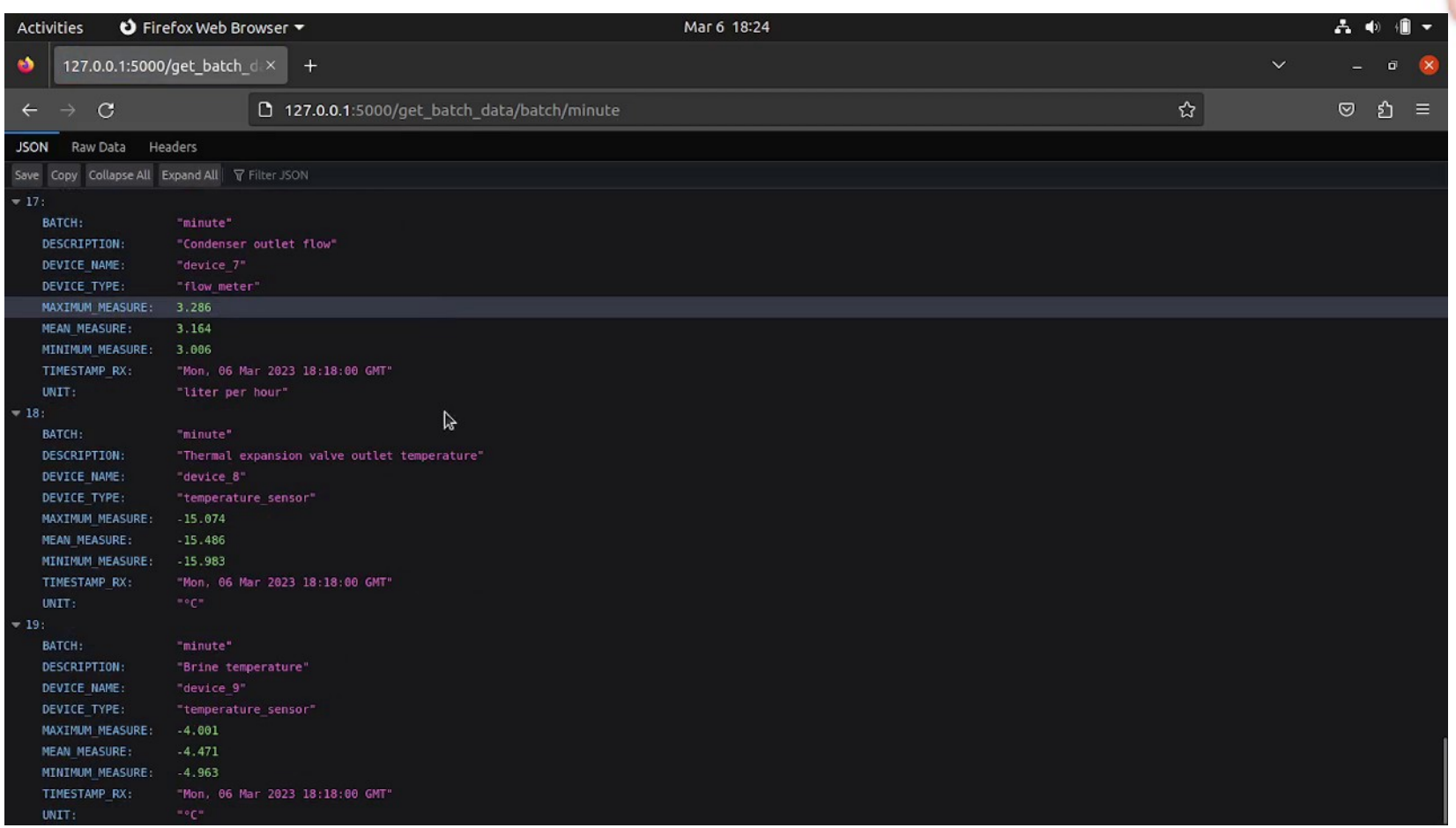

8. Test the API.

```
mysql> USE ICE_PLANT;
Reading table information for completion of table and column names
You can turn off this feature to get a quicker startup with -A

Database changed
mysql> SELECT * FROM PROCESSED_DATA WHERE BATCH='MINUTE';
+---------------------+-------------+-------------------+-----------------------------------------+----------------+-------------+-------------
---+---------------+--------+
| TIMESTAMP_RX        | DEVICE_NAME | DEVICE_TYPE       | DESCRIPTION                             | MAXIMUM_MEASURE | MEAN_MEASURE | MINIMUM_MEASU
RE | UNIT          | BATCH  |
+---------------------+-------------+-------------------+-----------------------------------------+----------------+-------------+-------------
---+---------------+--------+
| 2023-03-06 18:17:00 | device_1    | voltmeter         | Compressor                              |         229.372 |      225.469 |         220.0
21 | V             | minute |
| 2023-03-06 18:17:00 | device_10   | temperature_sensor | Evaporator outlet temperature          |          -5.076 |       -5.547 |          -5.9
74 | °C            | minute |
| 2023-03-06 18:17:00 | device_2    | ammeter           | Compressor                              |          49.713 |       48.078 |          45.3
33 | A             | minute |
| 2023-03-06 18:17:00 | device_3    | pressure_sensor   | Compressor inlet pressure               |           0.545 |        0.513 |           0.4
54 | bar           | minute |
| 2023-03-06 18:17:00 | device_4    | pressure_sensor   | Compressor outlet pressure              |           9.994 |        9.777 |           9.5
18 | bar           | minute |
| 2023-03-06 18:17:00 | device_5    | temperature_sensor | Compressor outlet temperature          |          54.957 |       53.357 |          52.0
31 | °C            | minute |
| 2023-03-06 18:17:00 | device_6    | temperature_sensor | Condenser outlet temperature           |           30.96 |       30.104 |          29.0
56 | °C            | minute |
| 2023-03-06 18:17:00 | device_7    | flow_meter        | Condenser outlet flow                   |           3.289 |        3.191 |           3.0
16 | liter per hour | minute |
| 2023-03-06 18:17:00 | device_8    | temperature_sensor | Thermal expansion valve outlet temperature |       -15.09 |      -15.558 |         -15.9
01 | °C            | minute |
| 2023-03-06 18:17:00 | device_9    | temperature_sensor | Brine temperature                      |          -4.002 |       -4.407 |          -4.9
44 | °C            | minute |
| 2023-03-06 18:18:00 | device_1    | voltmeter         | Compressor                              |         229.955 |      224.542 |         220.0
89 | V             | minute |
| 2023-03-06 18:18:00 | device_10   | temperature_sensor | Evaporator outlet temperature          |          -5.058 |       -5.484 |          -5.9
```

8. Test the API.

```
54 | bar             | minute |
| 2023-03-06 18:17:00 | device_4    | pressure_sensor    | Compressor outlet pressure               |          9.994 |       9.777 |          9.5
18 | bar             | minute |
| 2023-03-06 18:17:00 | device_5    | temperature_sensor | Compressor outlet temperature            |         54.957 |      53.357 |         52.0
31 | °C              | minute |
| 2023-03-06 18:17:00 | device_6    | temperature_sensor | Condenser outlet temperature             |          30.96 |      30.104 |         29.0
56 | °C              | minute |
| 2023-03-06 18:17:00 | device_7    | flow_meter         | Condenser outlet flow                    |          3.289 |       3.191 |          3.0
16 | liter per hour  | minute |
| 2023-03-06 18:17:00 | device_8    | temperature_sensor | Thermal expansion valve outlet temperature |         -15.09 |      -15.558 |        -15.9
01 | °C              | minute |
| 2023-03-06 18:17:00 | device_9    | temperature_sensor | Brine temperature                        |         -4.002 |      -4.407 |         -4.9
44 | °C              | minute |
| 2023-03-06 18:18:00 | device_1    | voltmeter          | Compressor                               |        229.955 |      224.542 |        220.0
89 | V               | minute |
| 2023-03-06 18:18:00 | device_10   | temperature_sensor | Evaporator outlet temperature            |         -5.058 |      -5.484 |         -5.9
68 | °C              | minute |
| 2023-03-06 18:18:00 | device_2    | ammeter            | Compressor                               |         49.943 |      46.984 |         45.0
27 | A               | minute |
| 2023-03-06 18:18:00 | device_3    | pressure_sensor    | Compressor inlet pressure                |          0.547 |       0.499 |          0.4
52 | bar             | minute |
| 2023-03-06 18:18:00 | device_4    | pressure_sensor    | Compressor outlet pressure               |          9.984 |       9.717 |          9.5
07 | bar             | minute |
| 2023-03-06 18:18:00 | device_5    | temperature_sensor | Compressor outlet temperature            |         54.945 |      53.443 |         52.0
29 | °C              | minute |
| 2023-03-06 18:18:00 | device_6    | temperature_sensor | Condenser outlet temperature             |         30.927 |      30.017 |         29.
29 | °C              | minute |
| 2023-03-06 18:18:00 | device_7    | flow_meter         | Condenser outlet flow                    |          3.286 |       3.164 |          3.0
06 | liter per hour  | minute |
| 2023-03-06 18:18:00 | device_8    | temperature_sensor | Thermal expansion valve outlet temperature |         -15.074 |      -15.486 |        -15.9
83 | °C              | minute |
| 2023-03-06 18:18:00 | device_9    | temperature_sensor | Brine temperature                        |         -4.001 |      -4.471 |         -4.9
63 | °C              | minute |
+---------------------+-------------+--------------------+------------------------------------------+----------------+--------------+--------------
---+----------------+--------+
20 rows in set (0.00 sec)
```

THANK YOU…!