Virtual Environmental Station Using MQTT and ThingSpeak

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1. Brief Explanation of Steps

In this assignment, I developed a cloud-based IoT system using MQTT and ThingSpeak. I created a virtual environmental station in Python that simulates three sensors: temperature, humidity, and CO_2 levels. The sensor data is published using MQTT with a unique client ID to a topic hosted on a public broker.

A separate Python script subscribes to the topic and sends the incoming data to a ThingSpeak channel using its Write API key. I then used a third script to fetch and plot the last five hours of data from ThingSpeak for each sensor using its Read API key.

I used Python libraries like paho-mqtt, requests, and matplotlib to implement the system. All scripts were tested and verified using real-time plotting and successful HTTP responses from ThingSpeak.

virtual_environmental_station.py


```
manasb@Mac-493 Downloads % python3 virtual_environmental_station.py
/Users/manasb/Downloads/virtual_environmental_station.py:17: DeprecationWarning: Callback API version 1 is deprecated, update to latest version
    client = mqtt.Client(client_id=CLIENT_ID, protocol=mqtt.MQTTv311)
Published: {'temperature': 44.76, 'humidity': 43.95, 'co2': 1104.11}
Published: {'temperature': -32.02, 'humidity': 28.91, 'co2': 666.67}
Published: {'temperature': -37.21, 'humidity': 25.58, 'co2': 998.58}
Published: {'temperature': -0.64, 'humidity': 14.17, 'co2': 915.02}
Published: {'temperature': 2.24, 'humidity': 90.46, 'co2': 714.52}
Published: {'temperature': -6.22, 'humidity': 31.54, 'co2': 1109.05}
Published: {'temperature': 49.05, 'humidity': 84.01, 'co2': 431.58}
Published: {'temperature': 49.12, 'humidity': 27.19, 'co2': 1951.83}
Published: {'temperature': 36.12, 'humidity': 4.33, 'co2': 1074.71}
Published: {'temperature': -23.56, 'humidity': 68.89, 'co2': 1933.89}
Published: {'temperature': 19.83, 'humidity': 31.89, 'co2': 1941.77}
Published: {'temperature': 41.39, 'humidity': 79.87, 'co2': 1474.21}
Published: {'temperature': 41.21, 'humidity': 70.04, 'co2': 1710.69}
Published: {'temperature': 19.71, 'humidity': 6.47, 'co2': 1495.25}
Published: {'temperature': 2.55, 'humidity': 10.7, 'co2': 1548.89}
Published: {'temperature': 11.31, 'humidity': 36.39, 'co2': 477.25}
Published: {'temperature': 15.23, 'humidity': 85.99, 'co2': 1244.62}
Published: {'temperature': -37.44, 'humidity': 22.07, 'co2': 586.05}
Published: {'temperature': 38.38, 'humidity': 88.39, 'co2': 1116.71}
Published: {'temperature': 25.5, 'humidity': 81.41, 'co2': 400.17}
Published: {'temperature': 21.74, 'humidity': 42.74, 'co2': 1724.0}
Published: {'temperature': -16.43, 'humidity': 76.02, 'co2': 1167.52}
Published: {'temperature': -3.79, 'humidity': 24.65, 'co2': 1668.77}
```

thingspeak_publisher.py


```
manasb@Mac-400 iot_virtual_station_full_assignment % python3 thingspeak_publisher.py
/Users/manasb/Downloads/iot_virtual_station_full_assignment/thingspeak_publisher.py:30: DeprecationWarning: Callback API version 1 is deprecated, update to latest version
    client = mqtt.Client()
Connected with result code 0
Received: {'temperature': 44.76, 'humidity': 43.95, 'co2': 1104.11}
Data sent to ThingSpeak: 200
Received: {'temperature': -32.02, 'humidity': 28.91, 'co2': 666.67}
Data sent to ThingSpeak: 200
Received: {'temperature': -37.21, 'humidity': 25.58, 'co2': 998.58}
Data sent to ThingSpeak: 200
Received: {'temperature': -0.64, 'humidity': 14.17, 'co2': 915.02}
Data sent to ThingSpeak: 200
Received: {'temperature': 2.24, 'humidity': 90.46, 'co2': 714.52}
Data sent to ThingSpeak: 200
Received: {'temperature': -6.22, 'humidity': 31.54, 'co2': 1109.05}
Data sent to ThingSpeak: 200
Received: {'temperature': 49.05, 'humidity': 84.01, 'co2': 431.58}
Data sent to ThingSpeak: 200
Received: {'temperature': 49.12, 'humidity': 27.19, 'co2': 1951.83}
```

display_last_5_hours.py

manasb@Mac-493 Downloads % python3 display_last_5_hours_final_fix.py

Requesting: https://api.thingspeak.com/channels/2892593/feeds.json with params: {'api_key': 'XHD340PCLOUPXFW6', 'start': '2025-03-26T11:38:15Z', 'end': '2025-03-26T16:38:15Z'}
Status Code: 200
Raw Text Sample: {"channel":{"id":2892593,"name":"Primary Channel","latitude":"0.0","longitude":"0.0","field1":"Tempe
2025-03-26 12:38:16.008 Python[20906:16881427] +[IMKClient subclass]: chose IMKClient_Legacy
2025-03-26 12:38:16.008 Python[20906:16881427] +[IMKInputSession subclass]: chose IMKInputSession_Legacy
Requesting: https://api.thingspeak.com/channels/2892593/feeds.json with params: {'api_key': 'XHD340PCLOUPXFW6', 'start': '2025-03-26T11:39:27Z', 'end': '2025-03-26T16:39:27Z'}
Status Code: 200
Raw Text Sample: {"channel":{"id":2892593,"name":"Primary Channel","latitude":"0.0","longitude":"0.0","field1":"Tempe
Requesting: https://api.thingspeak.com/channels/2892593/feeds.json with params: {'api_key': 'XHD340PCLOUPXFW6', 'start': '2025-03-26T11:39:41Z', 'end': '2025-03-26T16:39:41Z'}
Status Code: 200
Raw Text Sample: {"channel":{"id":2892593,"name":"Primary Channel","latitude":"0.0","longitude":"0.0","field1":"Tempe
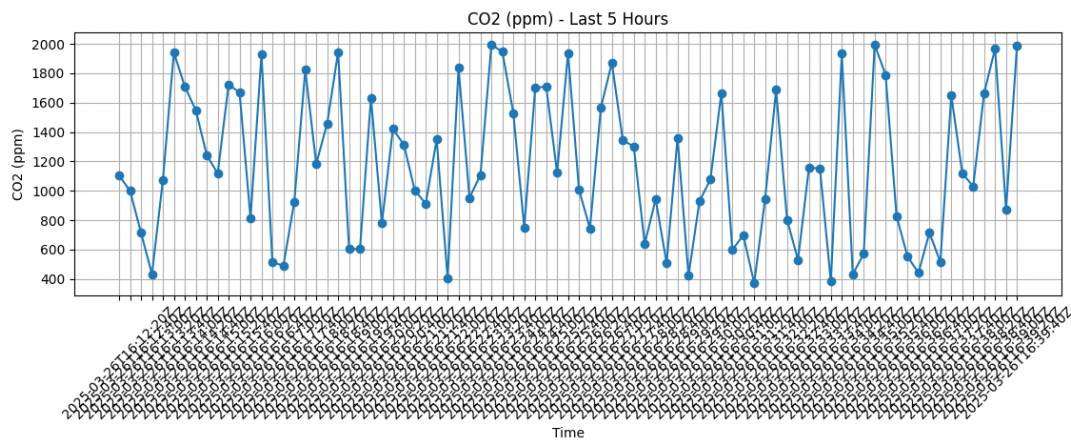
2. Output Plots

Temperature graph

Humidity graph

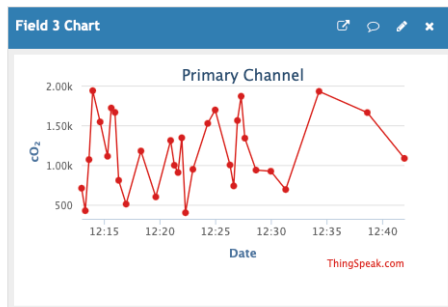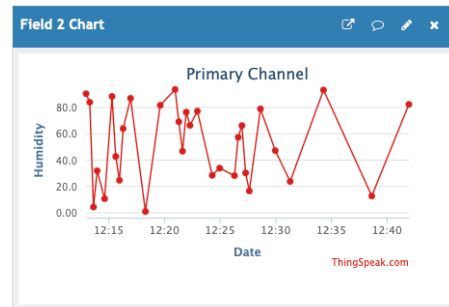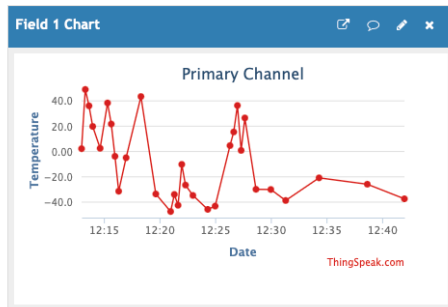Humidity (%) - Last 5 Hours

CO₂ graph

CO2 (ppm) - Last 5 Hours
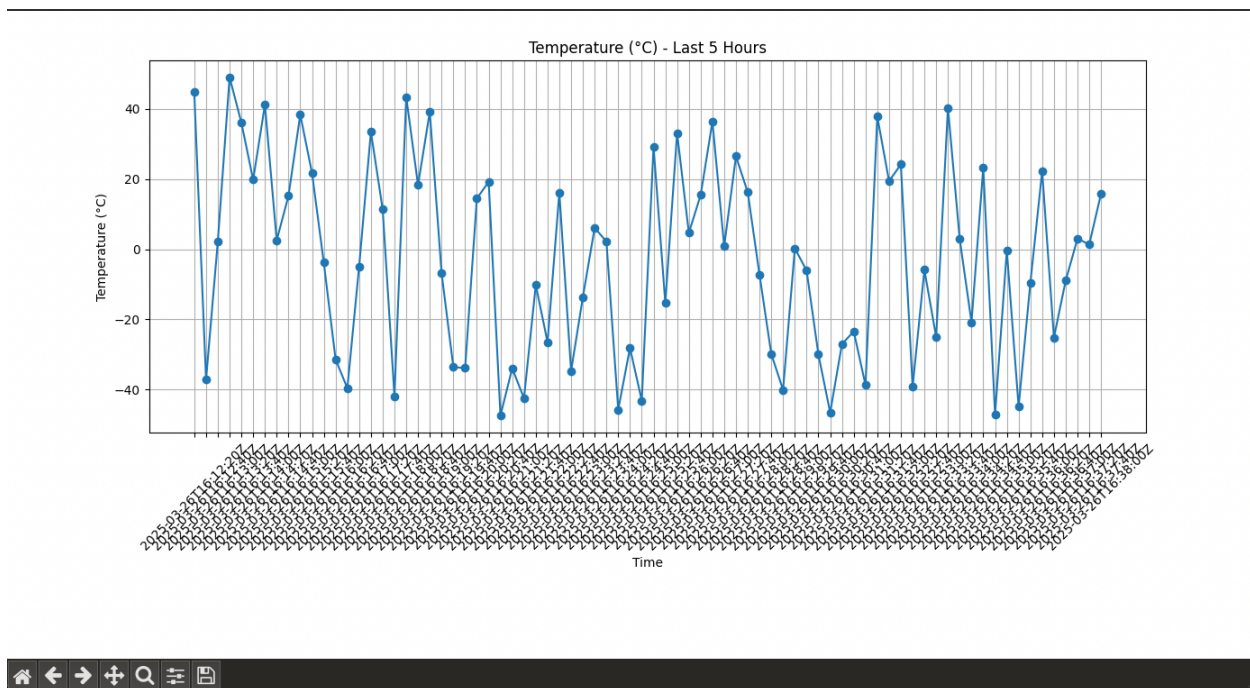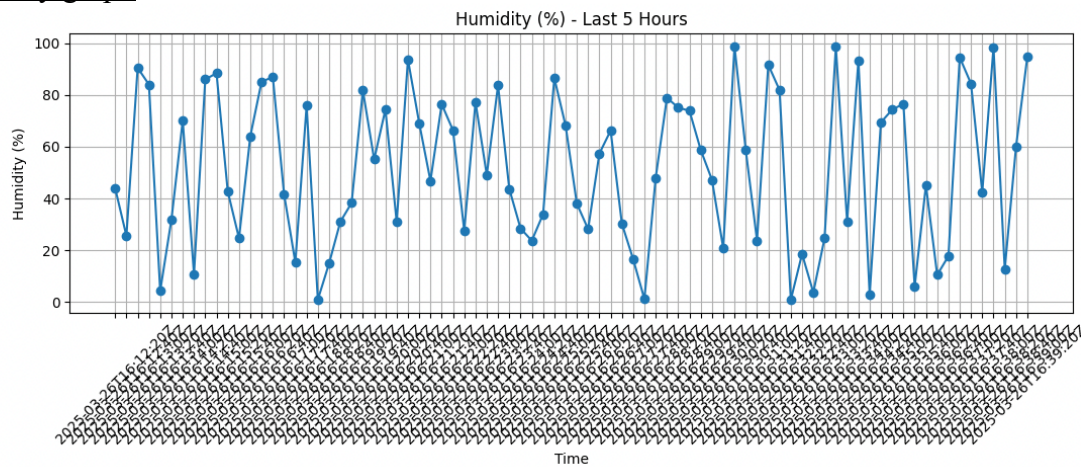
ThingSpeak channel stats view

Channel Stats

Created: about 12 hours ago
Entries: 90

3)
All the code used in this assignment is available on GitHub at:

https://github.com/ManasBhilare/virtual-environmental-station-iot

4) Reflection

This assignment was a great learning experience as it combined multiple areas—MQTT protocol, cloud integration, and Python programming. I learned how to simulate sensor data, send it to a public broker, and connect it to a cloud platform like ThingSpeak. Debugging the API issues and verifying data flow helped me understand real-world IoT communication flows and troubleshooting techniques. Overall, it gave me hands-on experience building and deploying a mini IoT pipeline.