

CS408 TERM PROJECT:

Drone-Enabled Mobile Edge Computing for
Environmental Monitoring

Mehmet Altunören (Student ID:00022539)

Orhun Burak Kıyanç (Student ID:00022538)

Deniz Kaan Yılmaz (Student ID:00032117)

1:Introduction

We simulated sensors (temp, humidity), a battery-constrained drone, and a server—all talking JSON over TCP. This project proves you can do edge analytics without specialized hardware, handle flaky connections, and still look good in a GUI.

Problem Statement.

- Sensors go up, data flows in.
- Drone crunches numbers, flags anything ridiculous (like 800 °C), bails back to base when battery's low.
- Central server collects, logs, and displays.

2:System Design & Architecture

2.1 Components:

Sensor Nodes: CLI-driven, emit JSON {id,temp,hum,timestamp}, retry on drop.

Drone Edge Unit:

- **TCP Server** for sensors, **TCP Client** for central server.
- **Edge Logic:**
 - Rolling average over last N readings.
 - Threshold check → anomaly list.
 - Battery model → if \leq threshold, switch to "return to base."

Central Server: TCP server that accepts one drone, renders three tabs of GUIs.

2.2 Communication Protocol

- **Handshake:** Sensor connects, sends HELLO, gets ACK.
- **Payload:** UTF-8 JSON lines.
- **Reconnection:** Exponential backoff on failure.

3. Implementation Details

Here's the breakdown of what we actually wrote:

main.py

- Orchestrates everything. Parses CLI flags (`--drone-ip/--drone-port`, `--central-ip/--central-port`, `--num-sensors`, `--low-batt`, etc.)
- Spawns three subprocesses in threads: Central Server, Drone Server, and N Sensor Nodes.
- Handles Ctrl+C to cleanly shut down all children.

nodes.py

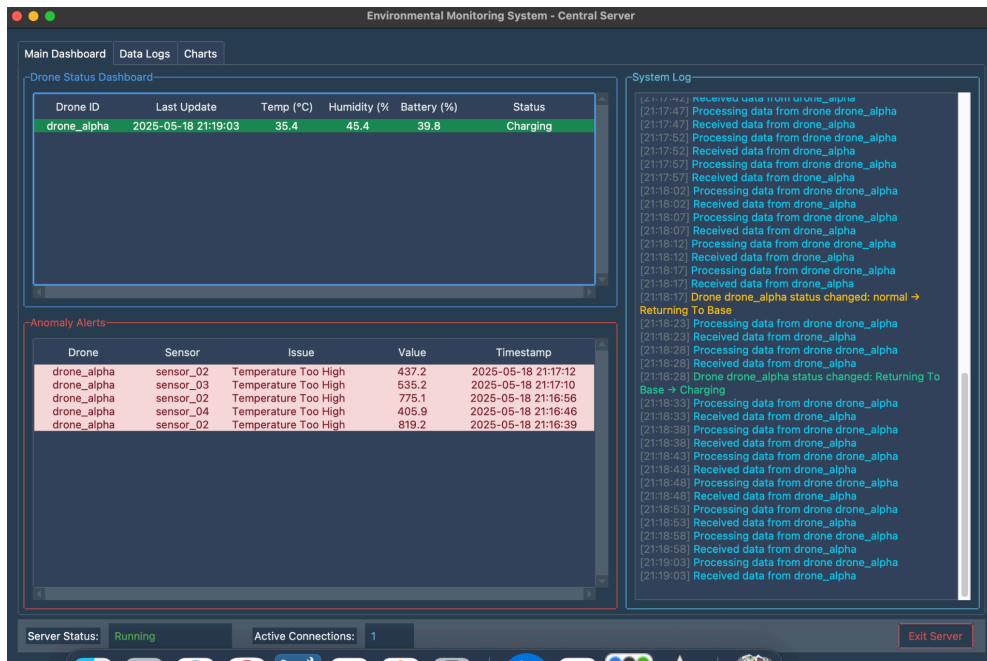
- `SensorNode` class: simulates temperature & humidity at random intervals.
- Connects over TCP to the Drone, emits JSON payloads, retries on failure.
- Uses Thread & Timer to schedule readings and random "failures."

drone_server.py

- **EdgeProcessor**: rolling-window averages (default $N=10$), threshold checks for anomalies.
- **DroneServer**:
 - TCP **server** for sensors (threaded).
 - TCP **client** to forward aggregates/anomalies to Central Server.
 - GUI (Tkinter + ttkbootstrap):
 - Raw feed, Charts (Matplotlib), Anomalies list, Battery status (with "return to base"), Logs, Node stats.

central_server.py

- TCP **server** for one Drone connection.
- GUI (Tkinter):
 - **Main Dashboard** : status table, anomaly alerts, live log pane.



- **Data Logs**: history with return - to - base highlight.

Environmental Monitoring System - Central Server

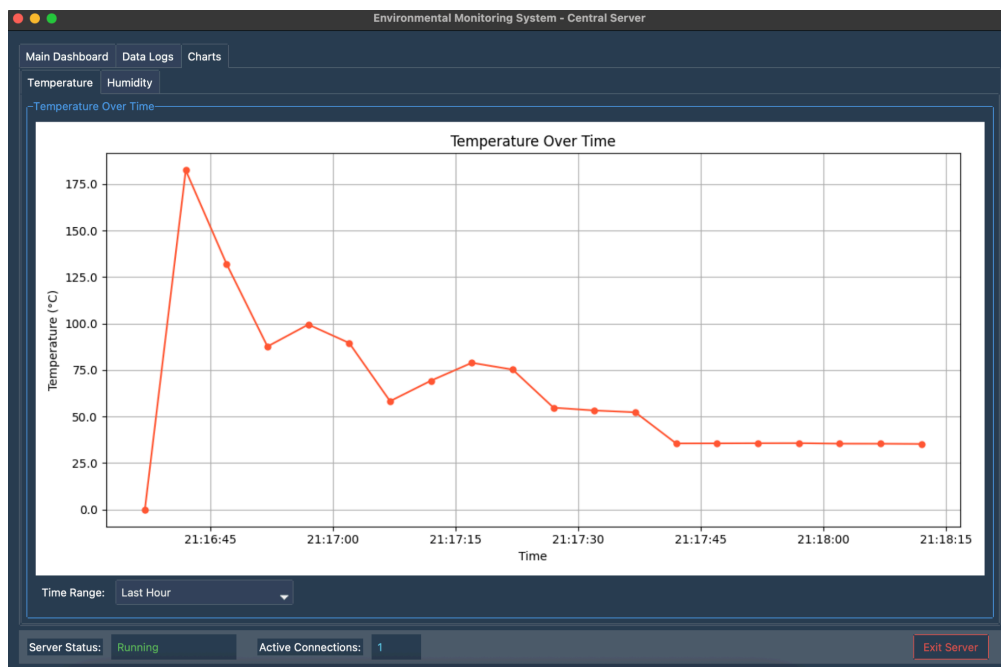
Main Dashboard Data Logs Charts

Data Logs

Timestamp	Drone ID	Temperature (°C)	Humidity (%)	Battery (%)	Status
2025-05-18 21:19:18	drone_alpha	35.4	45.4	47.3	Charging
2025-05-18 21:19:13	drone_alpha	35.4	45.4	44.8	Charging
2025-05-18 21:19:08	drone_alpha	35.4	45.4	42.3	Charging
2025-05-18 21:19:03	drone_alpha	35.4	45.4	39.8	Charging
2025-05-18 21:18:58	drone_alpha	35.4	45.4	37.2	Charging
2025-05-18 21:18:53	drone_alpha	35.4	45.4	34.7	Charging
2025-05-18 21:18:48	drone_alpha	35.4	45.4	32.2	Charging
2025-05-18 21:18:43	drone_alpha	35.4	45.4	29.7	Charging
2025-05-18 21:18:38	drone_alpha	35.4	45.4	27.2	Charging
2025-05-18 21:18:33	drone_alpha	35.4	45.4	24.7	Charging
2025-05-18 21:18:28	drone_alpha	35.4	45.4	22.2	Charging
2025-05-18 21:18:23	drone_alpha	35.4	45.4	19.9	Returning To Base
2025-05-18 21:18:17	drone_alpha	35.4	45.4	19.9	Returning To Base
2025-05-18 21:18:12	drone_alpha	35.2	45.5	20.4	normal
2025-05-18 21:18:07	drone_alpha	35.4	45.3	24.6	normal
2025-05-18 21:18:02	drone_alpha	35.4	45.7	28.7	normal
2025-05-18 21:17:57	drone_alpha	35.7	46.5	32.9	normal
2025-05-18 21:17:52	drone_alpha	35.6	45.5	37.1	normal
2025-05-18 21:17:47	drone_alpha	35.6	45.1	41.5	normal
2025-05-18 21:17:42	drone_alpha	35.5	45.9	45.6	normal
2025-05-18 21:17:37	drone_alpha	52.3	45.2	49.8	normal
2025-05-18 21:17:32	drone_alpha	53.2	44.9	54.0	normal
2025-05-18 21:17:27	drone_alpha	54.7	45.0	57.9	normal
2025-05-18 21:17:22	drone_alpha	75.2	45.1	62.0	normal
2025-05-18 21:17:17	drone_alpha	78.9	44.7	66.2	normal
2025-05-18 21:17:12	drone_alpha	69.3	45.6	70.3	normal
2025-05-18 21:17:07	drone_alpha	58.2	47.2	74.5	normal
2025-05-18 21:17:02	drone_alpha	89.5	47.0	78.4	normal
2025-05-18 21:16:57	drone_alpha	99.5	47.8	82.3	normal
2025-05-18 21:16:52	drone_alpha	87.7	49.7	86.5	normal
2025-05-18 21:16:47	drone_alpha	132.0	49.5	91.2	normal
2025-05-18 21:16:42	drone_alpha	182.5	48.3	95.8	normal
2025-05-18 21:16:37	drone_alpha	0.0	0.0	99.9	normal

Server Status: Running Active Connections: 1 Exit Server

■ Charts : temperature vs. time.



- Stores everything in memory (defaultdict) for quick access.

4. Drone Edge Unit GUI

- Data Stream
 - Raw sensor feed table.

Drone Edge Computing Unit

CHARGING AT BASE

Data Stream

Charts

Anomalies

Battery Status

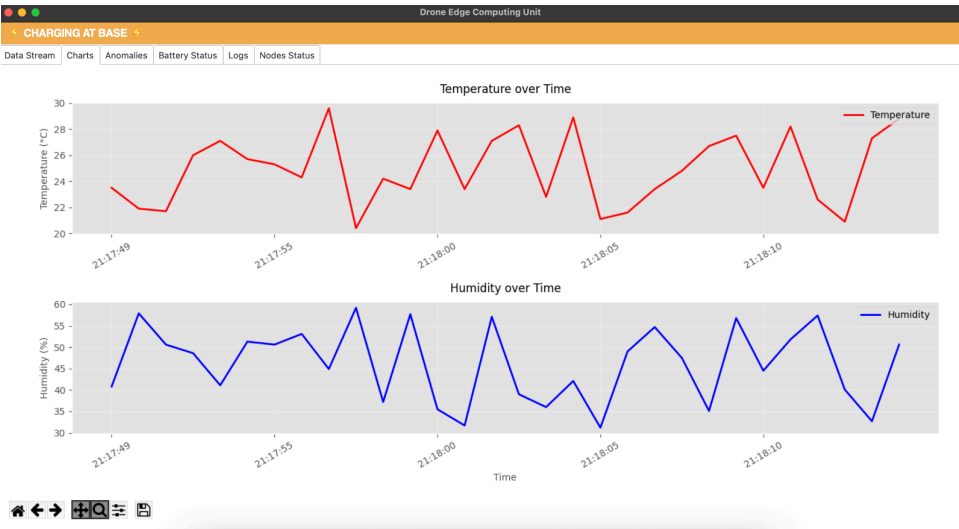
Logs

Nodes Status

Sensor Data Stream

Index	Sensor ID	Temperature	Humidity	Timestamp
23	sensor_03	21.90°C	55.70%	2025-05-18T21:16:55Z
24	sensor_01	28.20°C	34.40%	2025-05-18T21:16:56Z
25	sensor_02	775.10°C	34.50%	2025-05-18T21:16:56Z
26	sensor_04	24.40°C	32.80%	2025-05-18T21:16:57Z
27	sensor_01	20.80°C	44.20%	2025-05-18T21:16:58Z
28	sensor_02	26.00°C	36.80%	2025-05-18T21:16:59Z
29	sensor_05	24.00°C	57.90%	2025-05-18T21:17:00Z
30	sensor_01	20.60°C	45.30%	2025-05-18T21:17:00Z
31	sensor_02	29.30°C	34.60%	2025-05-18T21:17:01Z
32	sensor_04	29.40°C	43.00%	2025-05-18T21:17:02Z
33	sensor_01	21.60°C	42.30%	2025-05-18T21:17:02Z
34	sensor_03	24.20°C	45.20%	2025-05-18T21:17:03Z
35	sensor_02	28.30°C	54.30%	2025-05-18T21:17:04Z
36	sensor_01	20.70°C	57.00%	2025-05-18T21:17:05Z
37	sensor_05	21.10°C	50.10%	2025-05-18T21:17:06Z
38	sensor_01	22.50°C	44.20%	2025-05-18T21:17:07Z
39	sensor_02	24.40°C	33.30%	2025-05-18T21:17:07Z
40	sensor_04	28.30°C	59.90%	2025-05-18T21:17:07Z
41	sensor_01	23.80°C	52.90%	2025-05-18T21:17:09Z
42	sensor_02	27.20°C	39.40%	2025-05-18T21:17:10Z
43	sensor_03	535.20°C	32.60%	2025-05-18T21:17:10Z
44	sensor_01	23.20°C	30.80%	2025-05-18T21:17:11Z
45	sensor_05	26.30°C	36.50%	2025-05-18T21:17:12Z
46	sensor_02	437.20°C	48.80%	2025-05-18T21:17:12Z
47	sensor_04	28.40°C	48.00%	2025-05-18T21:17:13Z
48	sensor_01	25.70°C	32.10%	2025-05-18T21:17:13Z
49	sensor_02	21.90°C	37.80%	2025-05-18T21:17:15Z
50	sensor_01	23.70°C	38.10%	2025-05-18T21:17:15Z
51	sensor_03	20.30°C	46.10%	2025-05-18T21:17:17Z
52	sensor_01	29.80°C	40.90%	2025-05-18T21:17:18Z
53	sensor_04	25.30°C	59.60%	2025-05-18T21:17:18Z
54	sensor_02	26.00°C	33.00%	2025-05-18T21:17:18Z
55	sensor_05	25.10°C	44.10%	2025-05-18T21:17:18Z
56	sensor_01	26.20°C	45.50%	2025-05-18T21:17:20Z
57	sensor_02	26.50°C	47.60%	2025-05-18T21:17:21Z
58	sensor_01	20.90°C	51.30%	2025-05-18T21:17:22Z
59	sensor_04	23.90°C	31.40%	2025-05-18T21:17:23Z
60	sensor_03	21.70°C	20.60%	2025-05-18T21:17:23Z

- Charts
 - Live temperature & humidity plots (two panels).



- **Anomalies**

- List of detected readings out of thresholds.

Drone Edge Computing Unit

CHARGING AT BASE

Data Stream

Charts

Anomalies

Battery Status

Logs

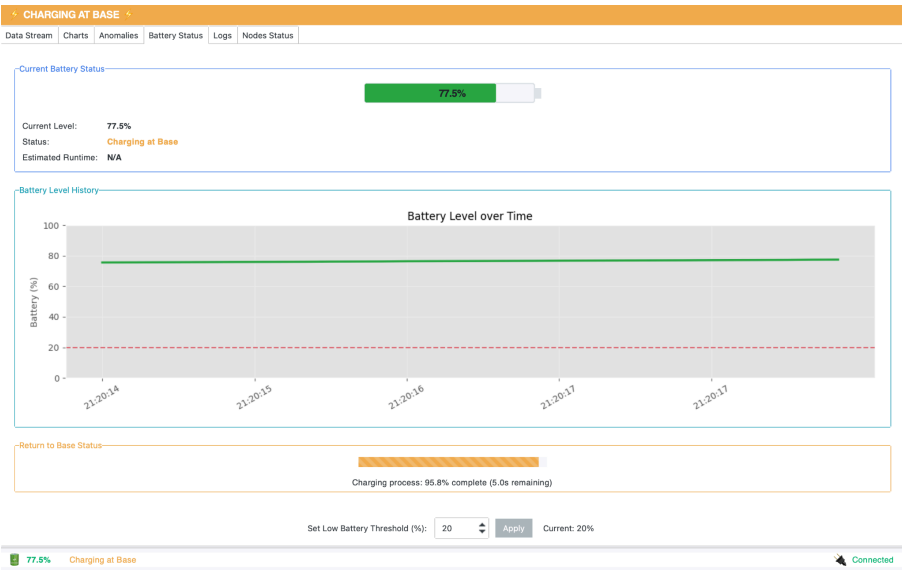
Nodes Status

Detected Anomalies

Index	Sensor ID	Issue	Value	Timestamp
1	sensor_02	temperature_too_high	819.20	2025-05-18T21:16:39Z
2	sensor_04	temperature_too_high	405.90	2025-05-18T21:16:46Z
3	sensor_02	temperature_too_high	775.10	2025-05-18T21:16:56Z
4	sensor_03	temperature_too_high	535.20	2025-05-18T21:17:10Z
5	sensor_02	temperature_too_high	437.20	2025-05-18T21:17:12Z

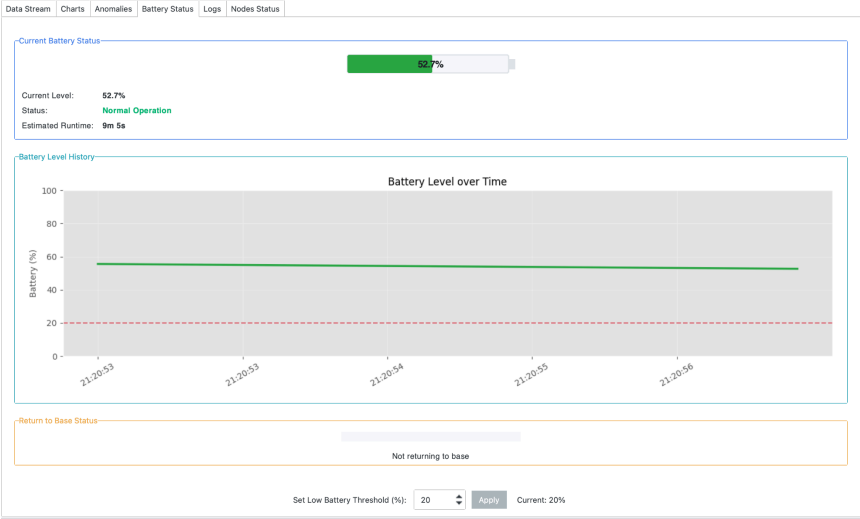
- **Battery Status**

- Charging at Base view with progress bar.



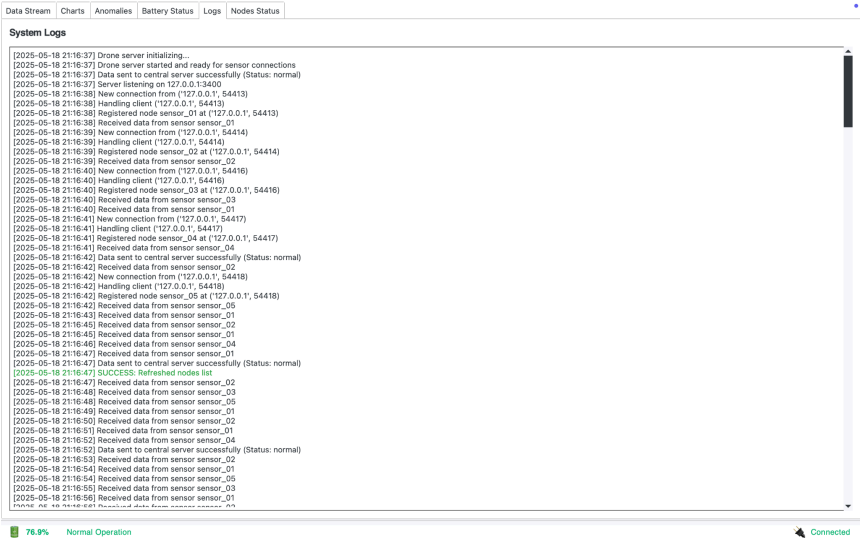
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- **Normal Operation** view with estimated runtime.



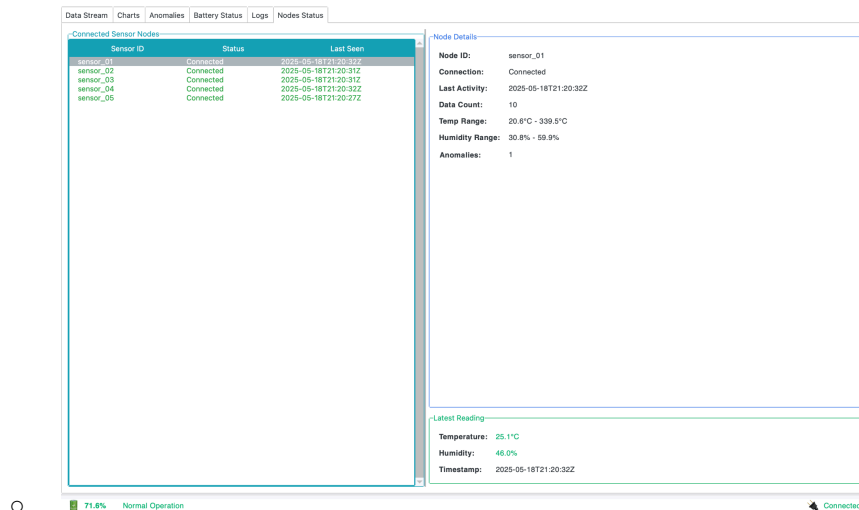
- **System Logs**

- Connections, data receipts, state transitions.



- **Nodes Status**

- Per-node stats: last seen, data count, min/max ranges.



5. Test Scenarios & Results

1. Normal Operation

- Launched 3 sensors → drone → server.
- Data flows, charts update. No errors.

2. Sensor Disconnection

- Killed sensor_03 mid-stream.
- Drone logged drop, retried every 2 s.
- Table grayed after 10 s inactivity.

3. Low-Battery Return

- Set threshold = 20 %.
- Drone battery dropped to 19.9 % → state flipped to "Returning To Base."
- Highlighted in Data Logs.

4. Anomaly Injection

- Manually injected temp = 800 °C at sensor_02.
- Drone flagged anomaly, forwarded to server, turned row red. As seen in charts.

6. Discussion

- **Performance:** Handles 5 sensors \times 1 Hz easily, end-to-end latency < 200 ms.
- **Robustness:** TCP retries and state logic survive sensor/server restarts.
- **Usability:** GUIs give instant feedback; no pointless buttons.
- **Limitations:**
 - single-server proof-of-concept.
 - No real radio link or encryption.

7. Conclusion & Future Work

We built a cool prototype that does edge analytics on a simulated drone and pushes everything to a server. It's reliable, configurable, and the code's clean enough not to embarrass you. Only issue? There are 3500 lines of code. But we are chill guys. Don't worry about it. Next steps:

- Swap TCP for real wireless links (UDP + FEC).
- Add ML-based anomaly prediction.
- Mobile-friendly server dashboard.