Development of an integrated IoT-based Atmospheric Sensing Platform

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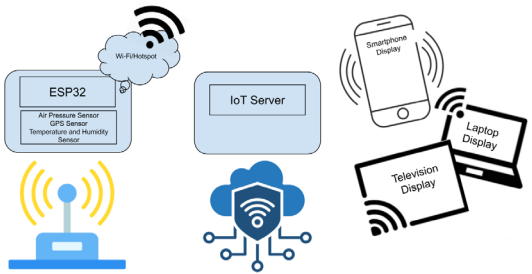
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Background

- Ground-based measurements of temperature, humidity, and air pressure provide accurate local atmospheric data that supports environmental monitoring, weather forecasting, and the calibration of satellite and remote sensing systems.
- An ESP32 microcontroller integrates multiple environmental sensors—including the DHT22 (temperature and humidity), Sensirion SDP810 (differential air pressure), and u-blox NEO-6M GPS—into a portable and expandable atmospheric sensing system.
- The ESP32's built-in Wi-Fi enables real-time transmission of sensor data to cloud platforms such as ThingSpeak, allowing remote monitoring, data visualization, and long-term storage for analysis.
- IoT-based sensing provides real-time data access, wireless communication, cloud storage, scalability, portability, and cost-effective deployment, making it suitable for environmental research, weather monitoring, and educational applications.

Objectives

- Design and develop a portable ESP32-based atmospheric sensing system capable of measuring temperature, humidity, differential air pressure, and GPS location.
- Integrate Internet of Things (IoT) technology to transmit environmental data wirelessly for real-time monitoring, visualization, and cloud storage.
- Evaluate the performance and reliability of the integrated sensor system by collecting and analyzing atmospheric data under real-world conditions.
- Demonstrate a low-cost, modular, and expandable solution for atmospheric sensing that can support environmental monitoring, weather observation, and future sensor integration.



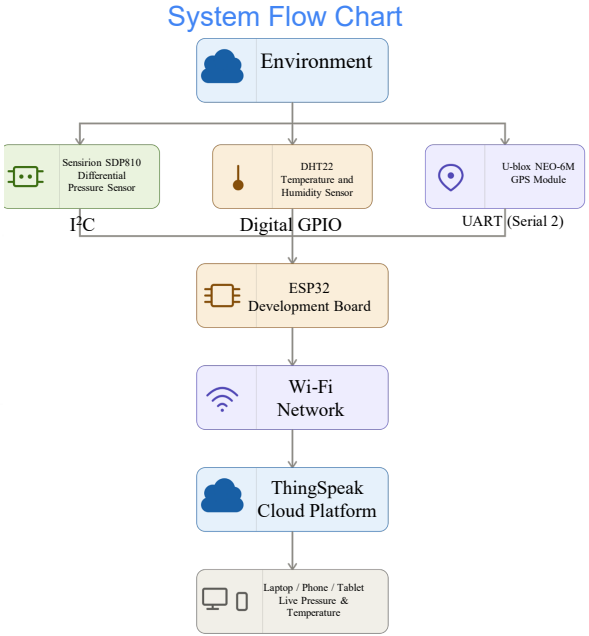


Figure 1. System architecture of the integrated IoT-based atmospheric sensing platform

System Design and Implementation

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System Design

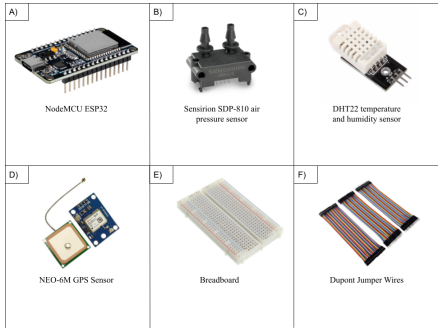


Figure 1. A chart containing all parts used in the system

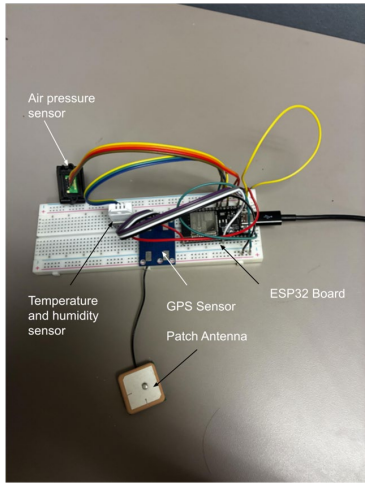


Figure 2. Assembled hardware prototype of the system including the DHT22, ESP32, SDP810, and NEO-6M GPS.

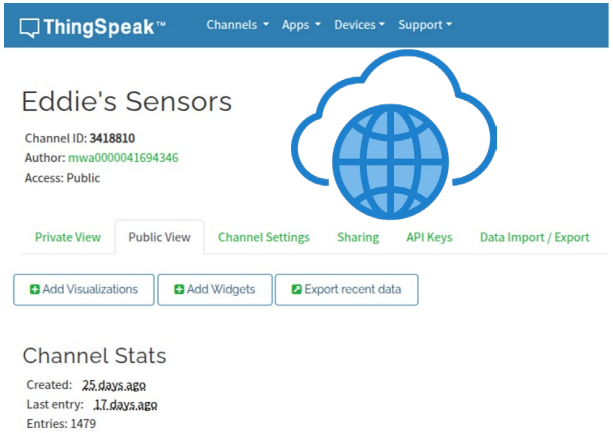


Figure 3. A public ThingSpeak channel used to display data in real-time.

Implementation

The platform integrates an ESP32 microcontroller with three sensors: a Sensirion SDP810 differential pressure sensor (I^2C), a DHT22 temperature and humidity sensor (digital), and a u-blox NEO-6M GPS module (UART). The ESP32 reads all sensors and uploads the measurements to ThingSpeak over Wi-Fi, where the data can be visualized in real time. The embedded software was developed using the Arduino IDE and relevant libraries (DHT, TinyGPS++, etc.). The ESP32 connects to a local Wi-Fi network and uploads to ThingSpeak every 20 seconds (ThingSpeak free tier requires more than 15 seconds). Sensor readings are also printed to the serial monitor every 2 seconds for local debugging.

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Data collection from ESP32 based IoT system

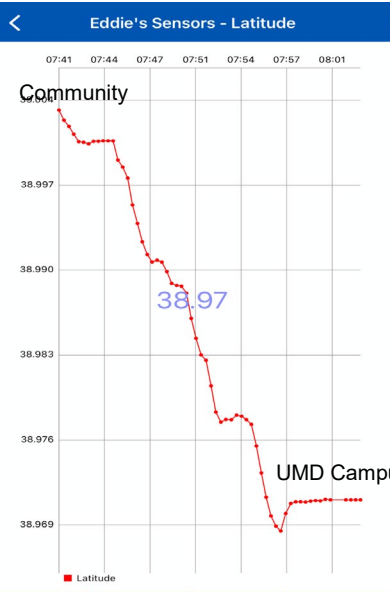
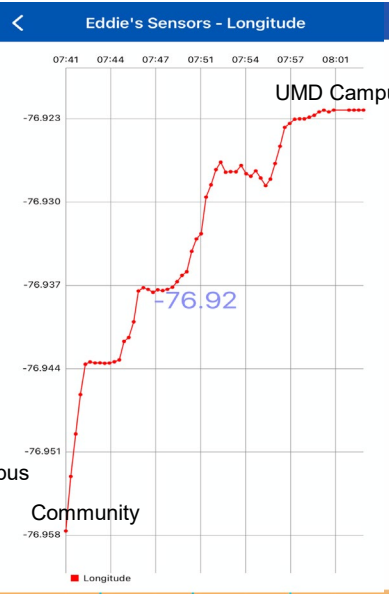


Figure 1. Real-time latitude/longitude tracking on ThingSpeak — captured while riding a moving bus.



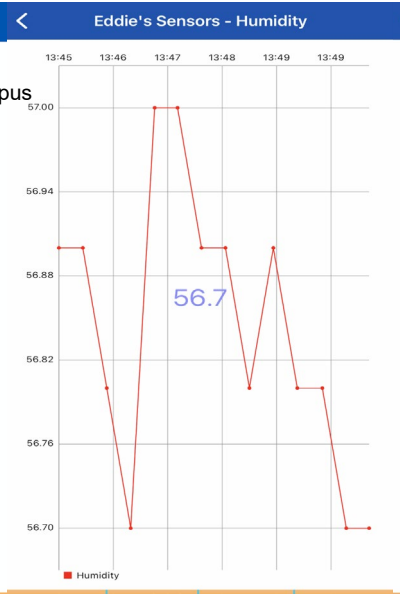
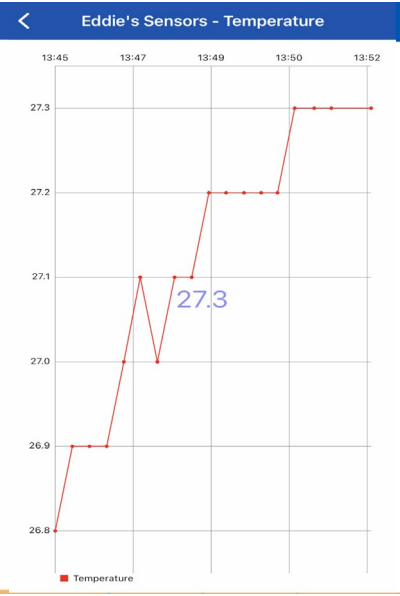


Figure 2. Live temperature and humidity data streamed to ThingSpeak. Note: the apparent volatility is a scaling artifact — the y-axis range is small, so minor fluctuations appear exaggerated.



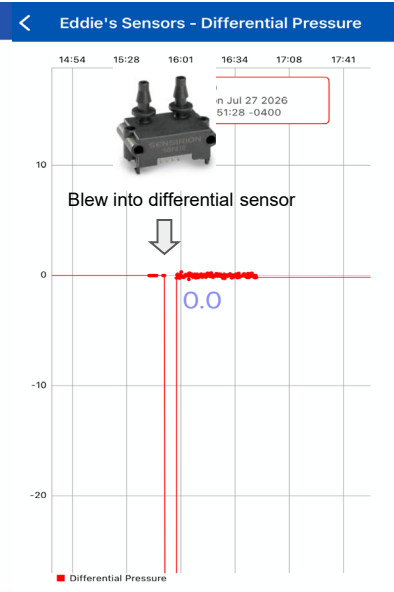


Figure 3. ThingSpeak channel dashboard showing live pressure data. Note: The pressure