IoT Environmental Monitoring and Control System using ESP32, MQTT, Node-RED, InfluxDB, and Grafana

Project Overview

This project demonstrates an IoT-based environmental monitoring and control system leveraging the ESP32 microcontroller. The system integrates multiple sensors and actuators to monitor and respond to environmental conditions, specifically light intensity, temperature, pressure, and altitude. The data is transmitted wirelessly and visualized using modern data handling and visualization tools.

System Components

1. **ESP32 Microcontroller**:
    - The central unit of the system, responsible for reading sensor data and controlling actuators.
2. **Sensors**:
    - **TSL2561 Light Sensor**: Measures ambient light intensity.
    - **BMP180 Sensor**: Measures temperature, atmospheric pressure, and altitude.
3. **Actuator**:
    - **Fan**: Connected to GPIO pin 18 of the ESP32, activated based on temperature thresholds.
4. **MQTT Protocol**:
    - Utilized for efficient wireless communication between the ESP32 and the server.
5. **Node-RED**:
    - Hosted in a Docker container, Node-RED processes and forwards sensor data.
6. **InfluxDB**:
    - Also hosted in a Docker container, InfluxDB is used to store time-series data received from Node-RED.
7. **Grafana**:
    - Utilized for the real-time visualization of the stored data, offering insightful dashboards.

System Functionality

1. **Data Collection**:
    - The ESP32 reads light intensity from the TSL2561 sensor and temperature, pressure, and altitude from the BMP180 sensor at regular intervals.

2. **Data Transmission**:
    - Sensor readings are sent to the MQTT broker running on the server. The MQTT protocol ensures reliable and low-latency data transmission.
3. **Data Processing**:
    - Node-RED, running within a Docker container, subscribes to the MQTT topics and processes the incoming data. Node-RED then forwards the processed data to the InfluxDB database.
4. **Data Storage**:
    - InfluxDB, also running in a Docker container, stores the time-series data for efficient retrieval and analysis.
5. **Data Visualization**:
    - Grafana retrieves data from InfluxDB and displays it on user-friendly dashboards, providing real-time insights into environmental conditions.
6. **Automated Control**:
    - The ESP32 continuously monitors the temperature data. If the temperature exceeds a predefined threshold (e.g., 32°C), the ESP32 activates the fan connected to GPIO pin 18. The fan remains off when the temperature is below the threshold, ensuring efficient environmental control.

Project Benefits

- **Real-Time Monitoring**: Continuous data collection and real-time visualization enable prompt detection of environmental changes.
- **Automated Control**: The system automatically regulates temperature, ensuring optimal conditions without manual intervention.
- **Scalability**: Leveraging MQTT, Docker, and scalable databases like InfluxDB allows for easy expansion of the system.
- **Open-Source Tools**: Utilization of open-source platforms and protocols ensures cost-effectiveness and flexibility.

Conclusion

This project showcases an integrated IoT solution for environmental monitoring and control, combining sensor data acquisition, wireless communication, data processing, and real-time visualization. The implementation of automated control mechanisms enhances the system's functionality, providing a comprehensive and scalable solution for various applications.