ABSTRACT

This project entitled "*IoT based Weather Monitoring and Visualisation System*" explores an Internet of Things (IoT)-based approach for real-time weather parameter monitoring and visualization.

Weather monitoring is crucial for various applications, including agriculture, transportation, and disaster management. The system leverages an ESP32 microcontroller, BME280 sensor, and a custom REST API endpoint to collect and transmit weather data (temperature, humidity, and pressure) to a web server.

The data is then visualized on a web-based platform as well as a mobile application for user convenience.

Traditional weather monitoring systems often lack real-time data, have limited accessibility, and may not provide the desired level of granularity.

This project addresses these limitations by utilizing an IoT-based approach, offering real-time data collection, granular data specific to deployment locations, and remote accessibility through web and mobile applications.

The report details the system components, data flow, and visualization methods employed to provide users with a comprehensive and user-friendly weather monitoring solution.

This report elaborates on the motivation, contributions, existing systems, IoT approach, visualization techniques, experimental findings, and future directions, providing a comprehensive understanding of the proposed solution.

DEPARTMENT OF COMPUTER SCIENCE
MANIPUR UNIVERSITY
CANCHIPUR, IMPHAL-795003

ACKNOWLEDGEMENT

I express my sincere thanks and deep sense of gratitude to my guide **Sir Dr. Nazrul Hoque**, Assistant Professor, Department of Computer Science, Manipur University, for his endless guidance and valuable suggestions without which this project would not have been completed.

I would also like to convey my sincere thanks to all other faculty members of Department of Computer Science, Manipur University who helped me in overcoming my problems and giving me the right direction and active support.

Date:

Place: Imphal, Manipur

(Thokchom Abungo Meitei)

MCA 5th Semester Roll No. 215057

Registration No. A/F

Department of Computer Science

Manipur University Canchipur-795003

DEPARTMENT OF COMPUTER SCIENCE

MANIPUR UNIVERSITY

CANCHIPUR, IMPHAL-795003

CERTIFICATE

This is to certify that the project entitled "***IoT based Weather Monitoring and Visualization System***" is comprehensive work carried out by **Thokchom Abungo Meitei**, a student of MCA 5th semester in Department of Computer Science, Manipur University, bearing Roll No. 215057 under my supervision in partial fulfillment of the requirements for 5th Semester of Master of Computer Science under Manipur University.

I further certify that he has undertaken the project with sincerity and hard work for the full period prescribed and this report embodies the result of his investigation conducted during the period he had worked hard as MCA student under my supervision.

This report has neither been published in any Journal nor submitted by any institution before. This is truly authentic and original.

Date:

Place: Imphal, Manipur

Guide

(**Dr. Nazrul Hoque**)

Assistant Professor

Department of Computer Science

Manipur University Canchipur-795003

DEPARTMENT OF COMPUTER SCIENCE

MANIPUR UNIVERSITY

CANCHIPUR, IMPHAL-795003

CERTIFICATE

This is to certify that the project entitled "*IoT based Weather Monitoring and Visualization System"* is comprehensive work carried out by **Thokchom Abungo Meitei**, a student of MCA 5th semester in Department of Computer Science, Manipur University, bearing Roll No. 215057 under my supervision in partial fulfilment of the requirements for 5th Semester of Master of Computer Science under Manipur University.

I further certify that he has undertaken the project with sincerity and hard work for the full period prescribed and this report embodies the result of his investigation conducted during the period he had worked hard as MCA student under my supervision.

This report has neither been published in any Journal nor submitted by any institution before. This is truly authentic and original.

Date:

Place: Imphal, Manipur

(**Tejmani Sinam**)

Head

Department of Computer Science

Manipur University Canchipur-795003

A Project Report

On

IoT Based Weather Monitoring and Visualization System

Submitted in partial fulfillment of the requirements for 5th Semester of Master of Computer Application under Manipur University.

Submitted By

Thokchom Abungo Meitei

MCA 5th Semester

Roll No.: 215057

Regd. No.: A/F

Under the guidance of

Dr. Nazrul Hoque

Assistant Professor

Department of Computer Science

Manipur University

DEPARTMENT OF COMPUTER SCIENCE

MANIPUR UNIVERSITY

CANCHIPUR, IMPHAL - 795003

2023-2024

CONTENTS:-

IOT based Weather Parameter Monitoring and Visualization System

Abstract

This project explores an Internet of Things (IoT)-based approach for real-time weather parameter monitoring and visualization. Weather monitoring is crucial for various applications, including agriculture, transportation, and disaster management. The system leverages an ESP32 microcontroller, BME280 sensor, and a custom REST API endpoint to collect and transmit weather data (temperature, humidity, and pressure) to a web server. The data is then visualized on a web-based platform and a mobile application for user convenience. Traditional weather monitoring systems often lack real-time data, have limited accessibility, and may not provide the desired level of granularity. This project addresses these limitations by utilizing an IoT-based approach, offering real-time data collection, granular data specific to deployment locations, and remote accessibility through web and mobile applications. The report details the system components, data flow, and visualization methods employed to provide users with a comprehensive and user-friendly weather monitoring solution. This report elaborates on the motivation, contributions, existing systems, IoT approach, visualization techniques, experimental findings, and future directions, providing a comprehensive understanding of the proposed solution.

1. Introduction:

In today's interconnected world, the need for reliable and real-time weather monitoring has never been more critical. Weather monitoring plays a pivotal role across numerous sectors, including agriculture, aviation, and disaster management. However, conventional methods often struggle to offer real-time data access and remote monitoring capabilities, hindering efficient decision-making processes. In response to these challenges, this project endeavors to revolutionize weather monitoring through the development of an Internet of Things (IoT) based system.

Utilizing the ESP32 microcontroller, renowned for its low-cost, low-power features and integrated wireless connectivity such as 2.4 GHZ Wi-Fi and Bluetooth LE 4.2 , this system incorporates the Bosch's BME280 Temperature, Humidity, and Pressure Sensor to accurately capture key weather parameters. Through the I2C Serial interface, this sensor seamlessly communicates with the ESP32, ensuring precise data acquisition.

The core objective of this project is to bridge the gap between traditional weather monitoring methods and modern technological advancements. By leveraging IoT capabilities, the system establishes a custom-made REST API endpoint to transmit sensor data to the cloud. This enables remote monitoring and facilitates real-time access to weather information from any location, at any time.

Motivated by the pursuit of cost-effectiveness, accuracy, and real-time data availability, this project aims to redefine weather monitoring paradigms. Through open-source principles, it offers a platform for data visualization and analysis, empowering stakeholders to make informed decisions based on comprehensive and up-to-date weather data.

In essence, this project not only contributes to the evolution of IoT applications but also showcases the transformative potential of IoT in enhancing traditional weather monitoring systems. Through innovation and collaboration, it lays the foundation for a more efficient, accessible, and responsive approach to weather monitoring and visualization.

2. Project Analysis:

1. **Technical Feasibility:** The project demonstrates technical feasibility by utilizing readily available hardware components (ESP32 microcontroller, BME280 sensor) and established communication protocols (I2C, REST API). The integration of these components enables real-time weather data monitoring and transmission to a cloud-based platform.
2. **Market Potential:** Given the widespread applications of weather monitoring across various industries such as agriculture, aviation, and disaster management, the project holds significant market potential. The ability to provide accurate and real-time weather data remotely addresses a key need in these sectors, potentially attracting interest from both commercial and governmental organizations.
3. **Cost-effectiveness:** The use of low-cost hardware components and open-source software solutions contributes to the overall cost-effectiveness of the project. However, there will be expenses related to cloud storage and maintenance when it is deployed at scale.
4. **User Accessibility:** The project aims to enhance user accessibility through remote data access and a user-friendly interface for data visualization and analysis. This accessibility is crucial for stakeholders who may need to monitor weather conditions from remote locations or on-the-go.
5. **Scalability and Flexibility:** The modular design of the system allows for scalability and flexibility, enabling additional sensors or functionalities to be integrated as needed. This adaptability ensures that the system can accommodate evolving requirements and technological advancements in the future.
6. **Security Considerations:** The project prioritizes security measures to protect sensitive data transmitted over the internet. It implements encryption protocols, access controls, and regular security audits to mitigate potential security risks and safeguard the integrity and confidentiality of the data.

Overall, the project analysis highlights the potential of the IoT-based weather monitoring system to address critical needs in weather monitoring and planning while emphasizing the importance of addressing technical, market, and ethical considerations for successful implementation and adoption.

2.1 Objectives of the Project:

1. **System Development:** Design and develop a robust IoT-based weather monitoring system using the ESP32 microcontroller and BME280 sensor for accurate measurement of temperature, humidity, and atmospheric pressure.
2. **Real-time Data Acquisition:** Implement mechanisms to ensure real-time acquisition of weather data and transmission to a cloud-based storage system for immediate access and analysis.
3. **Remote Accessibility:** Establish a custom-made REST API endpoint to facilitate remote access to weather data, enabling users to monitor and analyze weather conditions from anywhere with internet connectivity.
4. Accuracy and Reliability: Calibrate and optimize the sensor readings to ensure high accuracy and reliability of weather data, thereby enhancing the usefulness of the system for monitoring and planning activities.
5. **Cost-effectiveness:** Explore cost-effective hardware and software solutions to minimize the overall system cost without compromising on performance or functionality, making the system accessible to a wide range of users.
6. User-friendly Interface: Develop a user-friendly interface for data visualization and analysis, allowing users to easily interpret weather data and make informed decisions based on the insights provided by the system.
7. **Scalability:** Design the system with scalability in mind, allowing for easy integration of additional sensors or functionalities to accommodate future expansion or customization requirements.
8. **Documentation and Knowledge Sharing:** Thoroughly document the system design, implementation, and operation processes to facilitate knowledge sharing and replication of the project by other researchers, developers, and practitioners in the field of weather monitoring and IoT.

2.2 Merits and Demerits:

Merits of the System:

a. **Real-time Monitoring:** The IoT-based weather monitoring system offers real-time access to weather data, enabling users to make timely decisions and respond swiftly to changing weather conditions.
b. **Remote Accessibility:** Through the use of cloud-based storage and custom REST API endpoints, users can access weather data from anywhere, facilitating monitoring and analysis even in remote locations.
c. **Accuracy:** Utilizing high-quality sensors like the BME280 ensures accurate measurement of key weather parameters, providing reliable data for monitoring and planning purposes.
d. **Cost-effectiveness:** The system leverages low-cost components like the ESP32 microcontroller and BME280 Sensor, making it an affordable solution compared to traditional weather monitoring systems.
e. **Scalability:** The modular design of the system allows for easy scalability, enabling additional sensors or functionalities to be integrated as needed to meet evolving requirements.

Demerits of the System:

a. **Dependency on Internet Connectivity:** Since the system relies on cloud-based storage and data transmission, a stable internet connection is essential for its operation. In areas with limited connectivity, this dependency can pose challenges.
b. **Potential Security Risks:** Even though measures are in place to protect sensitive data sent through the internet,connecting the system to the internet introduces security vulnerabilities, which could be exploited by malicious actors to access sensitive weather data or disrupt system operations.
c. **Complexity of Implementation:** Setting up and configuring an IoT-based weather monitoring system may require technical expertise, particularly in the areas of sensor integration, programming, and cloud deployment.
d. **Power Consumption:** While the ESP32 microcontroller is known for its low-power consumption, continuous operation of the system may still consume significant power, especially if deployed in remote locations without access to mains electricity.

3. Systems Requirements:

a. Hardware:

1. **ESP32:** To serve as the central processing unit for data acquisition, processing, and communication. This Microcontroller is a very powerful one and has 36 GPIO pins and integrated WiFi and Bluetooth.
2. **2.8" ILI9431 LCD Display:** It is a LCD Display used to display the real time weather data at the Weather Station .
3. **BME280:** It is a temperature, humidity, and atmospheric pressure sensor made by BOSCH. It is used to measure the weather parameters.

Accuracy:	**Range:**
a. **Humidity:** +-3.0%	**a. Humidity:** 0% - 100%
b. **Temperature:** +-1.0 C	**b. Temperature:** -40^{0}C - 85^{0}C
c. **Pressure:** 1 hPa	**c. Pressure:** 300 hPa - 1100 hPa

4. **Power Supply:** To ensure continuous operation of the system, either through mains electricity or battery power, depending on deployment location.
5. **Internet Connectivity:** Reliable internet connection to transmit weather data to the cloud and facilitate remote access.
6. **Cloud based Storage:** Cloud-based storage solution to store and manage weather data efficiently.

b. Software:

1. Micropython IDE: To develop and upload firmware to the ESP32 microcontroller.
2. Libraries: Required libraries for interfacing with the BME280 sensor and LCD Display as well as communication protocols such as I2C and REST API.
3. Cloud Platform: A cloud-based platform or service provider to host the REST API endpoint and manage data storage and transmission.

c. Network Infrastructure:

1. **Router or Access Point:** To establish a local network for communication between the ESP32 microcontroller and other devices, if applicable.
2. **Internet Service Provider (ISP):** Reliable internet service provider to ensure uninterrupted connectivity for data transmission to the cloud.

d. User Interface:

1. **Web Browser:** Website where users can access weather data and visualization through a web browser interface.
2. **Mobile Application :** A mobile application for enhanced user accessibility and convenience, allowing users to monitor weather conditions on-the-go.

e. Security Measures:

1. **Encryption Protocols:** Implement secure communication protocols (e.g., HTTPS) to encrypt data transmitted over the internet and protect against unauthorized access.
2. **Access Controls:** Establish user authentication mechanisms to control access to sensitive weather data and system functionalities.

4. Existing (Traditional) Weather Monitoring Systems and Tools

Traditional weather monitoring systems often involve manual data collection and lack real-time updates. These systems are also typically expensive and not easily accessible for personal use. They rely on large, fixed weather stations that collect data at specific intervals. This data is then processed and used for weather forecasting. However, these systems often lack the ability to provide real-time updates and are not suitable for remote monitoring.

5. IoT-based Approach for Weather Monitoring

The proposed system overcomes the limitations of traditional systems by leveraging IoT. The ESP32 microcontroller collects data from the BME280 sensor and sends it to the cloud via a custom REST API endpoint. This allows for real-time data collection and remote monitoring. The system also includes a power management module to ensure continuous operation.

5.1 Block Diagram:

The project block diagram illustrates the components used in this project. The system operates with a single ESP32 microcontroller board, which handles both the controlling and monitoring modes. The ESP32 collects sensor data (temperature, humidity, and pressure) directly from the sensor and displays it on an LCD screen in the monitoring mode. Additionally, the ESP32 sends this sensor data to a custom REST API endpoint for storage and retrieval. The client can access the data via a custom web interface hosted on the API. Data analysis is performed locally on the ESP32 using simple formulas to determine the actual weather conditions. This information is then communicated to the user through the LCD display, indicating the current weather conditions.

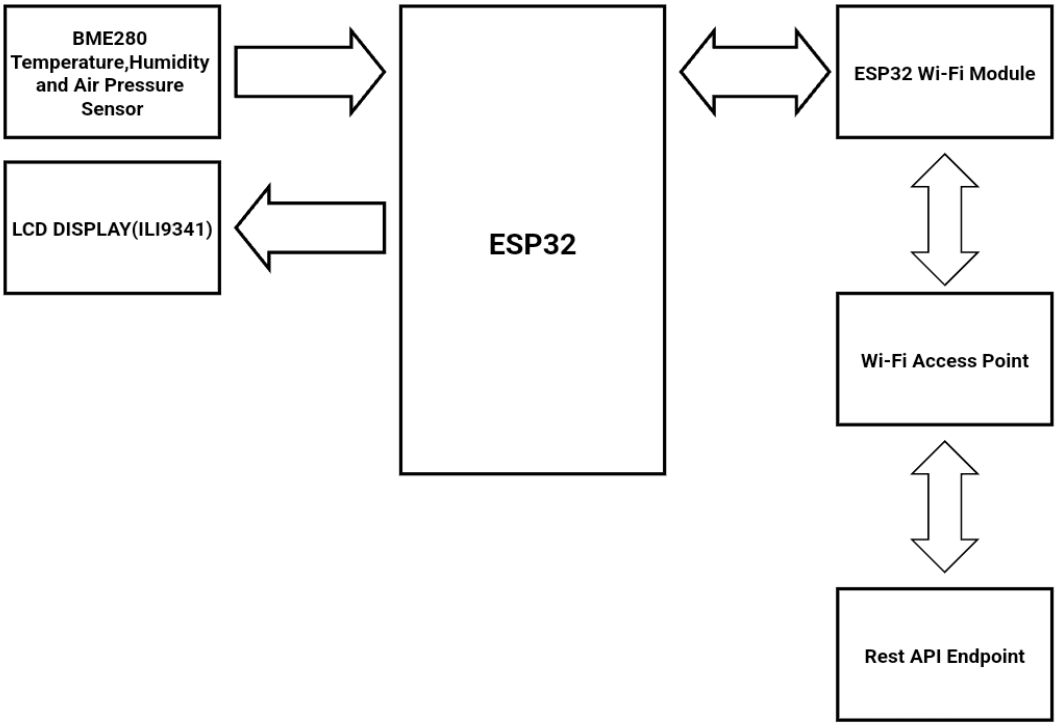

Figure 1. Project Block Diagram

5.2 Flowchart:

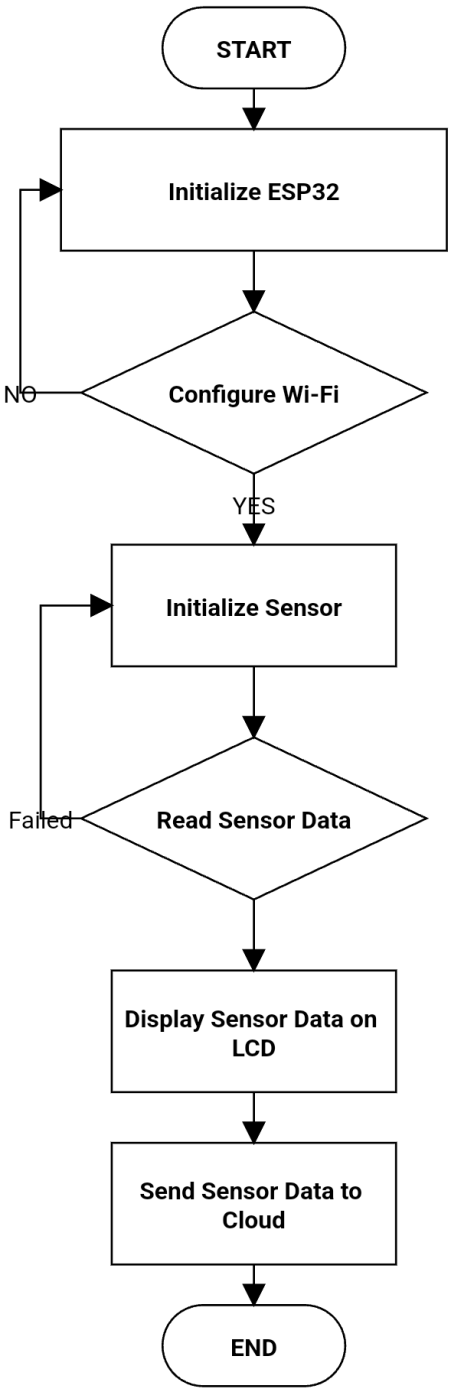

Figure 2. Project Flowchart

6. Visualization of Weather Data

a. Web-Based

A website hosted at www.abungo.pythonanywhere.com visualizes the weather data in real-time. The website provides a user-friendly interface for viewing the weather data. It includes graphs and charts to represent the data in an easy-to-understand format.

b. Android Based

An open-source Android app, available on GitHub at https://www.github.com/Abungo/WeatherStation , also provides real-time data visualization. The app includes features like push notifications for weather updates and a user-friendly interface for viewing the data.

7. Experimental Observations

The system was tested under various weather conditions and performed well in terms of accuracy and reliability. The sensor readings were consistent with the readings from a commercial weather station, demonstrating the accuracy of the system. The system also demonstrated good reliability, with no significant downtime or data loss during the testing period.

8. Conclusion and Future Work

The project successfully demonstrates an IoT-based weather monitoring system. The system provides real-time weather updates and allows for remote monitoring, making it a viable alternative to traditional weather monitoring systems. Future work includes integrating more sensors to measure other weather parameters and improving the data visualization platform as well as adding forecasting feature with the use of **Machine Learning**.

9. References:

[1] A F Pauzi, M Z Hasan1 (2020). “Development of IoT Based Weather Reporting System”

[2]