Utilizing IoT and Cloud Computing for Weather-Health Monitoring Application

ASIF GULRAIZ[1], HASEEB GULRAIZ[2], MOHIUDDIN ZIA[3], SHAHNILA BADAR[4], SYED SAJJAD HAIDER ZAIDI[5]
[1]Electrical Engineering Department DHA Suffa University / National Univeristy of Science & Technology Karachi, PAKISTAN
[2]Computer Engineering Department Sir Syed University of Engineering & Technology Karachi, PAKISTAN
[3]Electrical Engineering Dpartment DHA Suffa Univerity Karachi, PAKISTAN
[4]Electrical Engineering Department DHA Suffa University Karachi, PAKISTAN
[5]Electrical and Power Engineering Dept. National University of Sciences & Technology Karachi, PAKISTAN

Abstract: - In an era defined by increasing climate changes and an increasing importance of accurate weather information, there is a need for a smart IoT- based weather monitoring system. This paper proposes an innovative system that uses Internet of Things (IoT) technology to advance weather monitoring and global data accessibility using Cloud computing. By seamlessly connecting multiple devices, such as sensors, electronic gadgets, and automotive electronics, to the internet, this system offers a complete solution for monitoring environmental conditions such as temperature, relative humidity, pressure, and rain levels. Specialized sensors collect data, which is then transformed into graphical interface using an app, enabling real-time weather information access worldwide. This technology has the ability to rethink how we convey and analyze environmental data with optimal efficiency and reach in industries including agriculture, urban planning, and environmental research.

Key-words: - Cloud computing, Electrical measurements, health monitoring, Internet of Things (IoT), Intelligent sensors, Weather Monitoring.

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1. Introduction

Introducing a cutting-edge smart weather monitoring system ready to completely transform the availability and use of weather data. This effortlessly connects weather parameter reporting directly to consumers, beyond the traditional reliance on weather forecasting services. Fundamentally, this contemporary system makes use of the potential of cutting-edge innovations like cloud computing and the Internet of Things (IoT).

By incorporating temperature, humidity, light and rain sensors, the system continuously monitors and delivers real-time weather statistics. This dynamic sensor array enables users to obtain accurate weather information without any delay. IoT principles reinforce the system's architecture, linking a range of devices to the internet and enabling the effortless transfer of data to the Cloud. This cloud-based infrastructure works as a central hub for collecting, processing, and publishing weather data.

This useful and adaptable technology does more than just gather data. It is a clear example of an Internet of Things application, enabling the easy gathering, processing, and use of various meteorological data. With ease, users may receive warnings, set up alerts for certain weather events, modify appliances, and carry out comprehensive long-term analysis. Additionally, graphical interpretations improve data presentation by making it easier to read.

Main components of this system include the Arduino Nano board, a microcontroller board with versatile capabilities, and the DHT11 temperature and humidity sensor, involved in detecting and reporting these essential parameters. A WIFI module ESP32 is employed to transmit the collected data to a web server, ensuring real-time updates and accessibility from anywhere across the globe.

In a rapidly evolving world, the Internet of Things is prepared to reshape environmental monitoring, allowing for the capture, handling, and transmission of weather parameters through a network of sensors and devices. The Cloud aspect of the system provides necessary resources like data storage and computing power, all with minimal user involvement. This collaboration between IoT and Cloud technologies leads to a new era of weather monitoring and reporting.

The applicability of this approach spans numerous different fields, such as environmental research, urban planning, and agriculture. Users in various geographic places can effortlessly and remotely monitor the weather. Users are kept informed and ready thanks to the system's continuous data transmission, which guarantees that real-time information is quickly sent to the web server.

The system adds a layer of proactive functionality by enabling users to customize alerts for specific weather events in addition to its reporting capabilities. In today's connected world, our Internet of Things (IoT)-based Weather Monitoring and Reporting system offers a thorough, effective, and user-friendly method to weather data collecting and propagation.

2. Literature Review

2.1 Internet of Thing

The Internet of Things (IoT) represents a cutting-edge computerization and analytical framework that leverages networking, sensing capabilities, big data analysis, and artificial intelligence technology to offer comprehensive solutions for products or services. These integrated systems provide enhanced readability, control, and operational efficiency when installed in various industries and systems.

IoT systems exhibit significant versatility and adaptability across diverse industries, making them compatible for deployment in any type of environment. They modernize data gathering, automation processes, and operational techniques by employing the capabilities of intelligent devices and robust enabling technologies.

2.2 Key Features (IoT)

•Artificial Intelligence (AI): IoT essentially infuses everyday objects with intelligence, enriching various aspects of life by hitching the potential of data gathering, AI algorithms, and interconnected networks.

•Connectivity: With promising networking technologies, including those specific to IoT, networks are no longer limited to major providers.

•Sensors: Sensors are integral to IoT, serving as pivotal instruments that advance IoT from a passive network of devices into an active system capable of seamless integration with the real world.

•Active Engagement: Much of the interaction with connected technology today is passive in nature. IoT introduces a fresh perspective, emphasizing active engagement with content, products, or services.

•Compact Devices: As anticipated, devices have increasingly evolved to become smaller, more affordable, and more powerful. IoT influences purpose-built, compact devices to deliver precision, scalability, and adaptability to its functionalities.

2.3 Work done in past

In this paper [1], the author discusses the increasing significance of weather prediction systems, particularly in the context of extreme weather events that have adverse impacts on both lives and property. The paper emphasizes the critical challenge of improving the accuracy of weather data to enhance predictive capabilities and bolster resilience against detrimental weather conditions. Developing countries, such as Uganda, and others face difficulties in generating timely and precise weather data due to limited weather observation resources and the high costs associated with developing automated weather monitoring systems. The inadequate financing available to national meteorological services in these countries intensifies this challenge.

To address these issues, the author recommends the development of an Automatic Weather Monitoring Station based on a wireless sensor network. The plan implies creating three generations of prototypes, with each iteration targeting to enhance functionality and utility based on the specific needs of its generation. The author also underlines the importance of improving non-functional aspects such as power efficiency, data accuracy, reliability, and data transmission while simultaneously decreasing the cost to make such technology more robust and affordable. The intended outcome of this proposed work is to enable developing nations, like Uganda, to acquire AWS systems in sufficient quantities, ultimately improving weather forecasting capabilities.

In a different research paper [2], the author introduces an IoT-based weather monitoring system. This system controls various sensors to collect environmental parameters, including humidity, temperature, pressure, rain levels, and light intensity using an LDR sensor. Additionally, the system calculates the dew point value from temperature data. The implementation includes an SMS alert system triggered when sensing parameters exceed predefined thresholds, enhancing the system's usefulness. In addition, the author integrates email and tweet alerting systems into the weather monitoring process. The hardware components of this system include the Node MCU 8266 and a range of sensors.

Another research paper [3], describes a low-cost live weather monitoring system incorporating an OLED display. The author highlights the transformative potential of IoT in various fields and describes this advanced system for real-time weather condition monitoring. The live weather monitoring system is placed as a valuable tool for farmers, industries, daily activities, and educational institutions, simplifying weather-related decision-making. The system utilizes an ESP8266-EX microcontroller-based WeMos D1 board, executed with Arduino, to retrieve data from the cloud. This board, equipped with 4MB of flash memory, is programmed with Node MCU and Arduino IDE. The system collects weather data using only two components: WeMos and OLED. Data is stored on the ThingSpeak cloud platform for accessibility and is simultaneously displayed on the OLED screen. The primary aim of this system is to present live weather information through the OLED display.

In a unique context, the author of reference [4], proposes a comprehensive weather monitoring and prediction system that can aid people in their day-to-day activities, particularly in sectors such as agriculture and industry. This system involves two stages: sensing weather conditions and utilizing deep learning technology for real-time reporting on stations and buses. Weather forecasting is accomplished through a friction model, with multilayer perception models and long-term memory used for training and verification. The system's performance is assessed against data from environmental safety agencies and observation systems. The author stresses the reliability of this system in monitoring weather conditions and its potential to provide one-day weather forecasts.

Finally, in reference [5], the author implements an IoT-based weather monitoring system with a focus on using IoT technology to monitor weather conditions and detect climate-changing patterns. The system employs various sensors to collect climate data, which is then stored in the cloud for analysis and dissemination. The algorithm, known as the swarm algorithm, is used to enhance data accuracy. This project aims to raise awareness of climate condition changes and provides an accurate and efficient output. Rain detection is achieved using a rain sensor, which measures voltage changes when raindrops contact its strips.

These research papers collectively highlight the importance of weather monitoring and prediction systems in various contexts and present innovative approaches to address the associated challenges. They showcase advancements in sensor technology, data analysis, and communication methods, ultimately aiding to improved weather forecasting and awareness.

3. Methodology

The Arduino Uno serves as the main component of the Internet of Things-enabled weather monitoring system, and it is responsible for measuring four crucial weather parameters. These parameters, which are each precisely monitored by their own dedicated sensors, include temperature, humidity, light intensity, and rainfall levels. The Arduino Uno's built-in Analogue to Digital Converter (ADC) capabilities make it easy to integrate these sensors with the board and streamline the data acquisition process.

This weather monitoring system's primary goal is to provide unmatched precision and dependability in the fields of climate observation and weather tracking. By utilizing renewable energy sources—mainly solar panels for charging the attached battery—it accomplishes this feat.

One of the system's standout features is its ability to access real-time weather information and data via the World Wide Web. This dynamic connectivity opens up a world of possibilities, allowing users to stay informed about current weather conditions and any ongoing climate changes at their fingertips. Moreover, the system is designed to communicate seamlessly through WIFI networks, further enhancing its accessibility and reach.

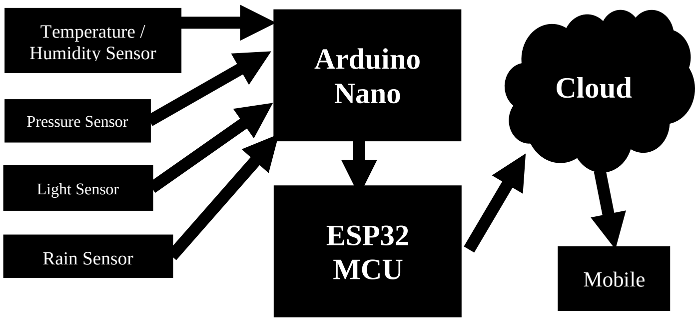

Figure 1: Project Block Diagram

The system is comprised of a microcontroller serving as central processing unit that organizes the entire operation is shown in figure-1. The microcontroller acts as a hub, allowing seamless connections with a variety of sensors and devices. These interconnected sensors are under the control of the microcontroller, which efficiently extracts data from them. It takes the responsibility of collecting data from these sensors, harnessing their capabilities to monitor and analyze key environmental parameters. These parameters include temperature, humidity, atmospheric pressure, and rainfall. Through this detailed data collection process, the system gains a type of understanding of the current environmental conditions.

Data is transmitted on the internet which is achieved through a Wi-Fi module that is seamlessly integrated into the system. This connection is managed with an app, a user-friendly platform that streamlines the route of sharing the sensor data with the online world.

By harnessing this connectivity, the system transcends geographical boundaries, making it possible for users to access real-time information about temperature, humidity, pressure, and rainfall from anywhere with an internet connection. This data becomes a valuable resource for various applications, including weather forecasting, environmental monitoring, and even smart home automation.

In figure 2, a project flow chart is shown. Initially data is read from sensors by the controller, which is forward to the JSON packets, then the data is transmitted to ESP32 controller which further process it to the firebase station where the data is logged and transmitted to cell phones via an android app.

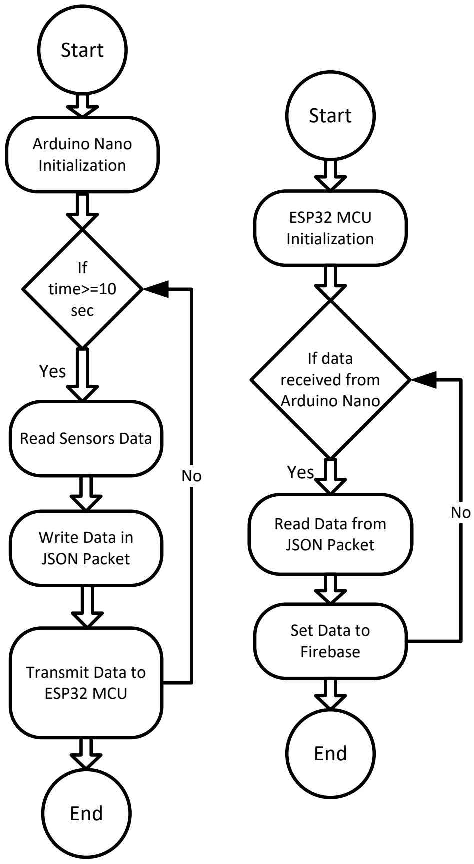

Figure 2: Project Flowchart

4. Project Hardware

4.1 Arduino Nano

The Arduino Nano is a compact yet powerful microcontroller board, built around the ATmega328P microcontroller chip. At its core, the Arduino Nano features 14 digital input/output pins, with six of them capable of serving as PWM (Pulse Width Modulation) outputs. Additionally, there are six analog input pins, which are useful for interfacing with sensors and analog devices. The board operates with a 16 MHz ceramic resonator for precise timing.

4.2 ESP32 MCU

The ESP32 features a powerful dual-core Xtensa LX6 microprocessor, which provides substantial processing power for a wide range of tasks. This microcontroller board further distinguishes itself by offering a built-in Wi-Fi and Bluetooth connectivity module. This feature opens the door to seamless wireless communication and control, making it an ideal choice for IoT applications. It’s a highly versatile microcontroller board renowned for its advanced capabilities and broad applicability in the realm of embedded systems and IoT (Internet of Things) projects.

4.3 DHT11(Temperature & Humidity sensor)

The DHT11 is a basic but reliable temperature and humidity sensor. Its sensor provides two essential measurements: temperature and humidity. It uses a capacitive humidity sensor and a thermistor for temperature measurement. This compact sensor module consists of a sensor element and a small circuit that converts the analog sensor data into digital signals, making it easy to interface with microcontrollers. The

DHT11's output is digital, and it communicates over a single-wire interface, simplifying its integration into various projects.

4.4 BMP180 (Pressure Sensor)

The BMP180 is a precise sensor that offers in measuring atmospheric pressure and temperature. BMP180 consists of a a robust and sensitive sensor element that can provide precise measurements of both barometric pressure and temperature. This sensor is paired with an integrated circuit that processes the data and delivers it in a convenient digital format, facilitating unified integration with microcontrollers and other electronic devices.

4.5 MH-RD (Rain Sensor)

To detect moisture and rainfall, a rain sensor module is used. The sensor board houses the rain-sensitive component typically a hygroscopic substance that collects moisture makes up the rain sensor module. The electrical conductivity or resistance of the sensor is altered when moisture or raindrops come into contact with its surface. The rain sensor module's ability to generate a binary output that indicates whether or not it is raining at the moment is one of its main uses. The module normally generates a digital signal to indicate the presence of rainfall when rain is detected. This signal frequently changes from a high state to a low state.

4.6 LDR Module (Light Sensor)

The photoresistor module, called the Light Dependent Resistor (LDR) module, is a crucial component that makes ambient light level sensing possible. Many application are exist for this sensor, including environmental monitoring and automated lighting control. The LDR module's unique feature is its real-time light level feedback, which enables automation and dynamic modifications in response to shifting lighting circumstances. Because of this feature, it is useful in applications such as smart homes, security systems, street lighting management, and weather monitoring.

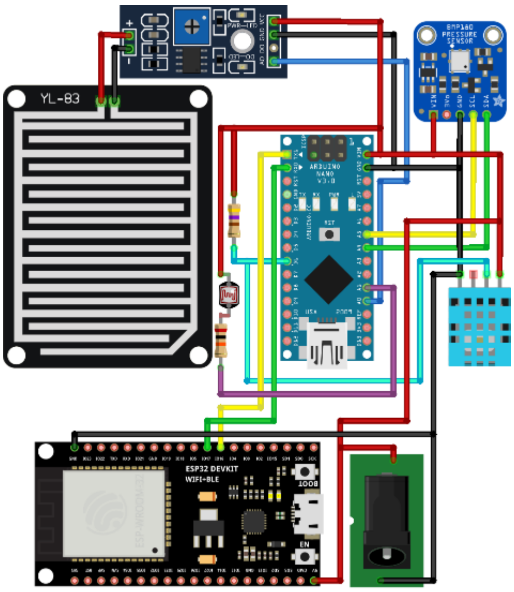

Figure 3: Project PCB Diagram

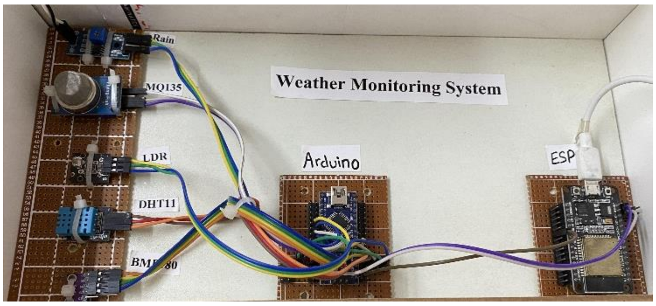

Figure 4: Hardware in the box

5. Results

A proactive approach to environmental protection is achieved through a smart weather monitoring station using Wi-Fi-connected sensors as shown in figure 4. This embedded system ensures cost-effective environmental monitoring, transmitting data to the cloud for analysis and sharing. Its adaptability extends to tracking pollution in urban and industrial areas, safeguarding public health. Realtime databases are designed to have all the updates of the weather in real time. Cloud computing is enabled to process all the data and maintain database on remote location. This database will be accessible through an android app as shown in figure 6 and using firebase link as in figure 5.

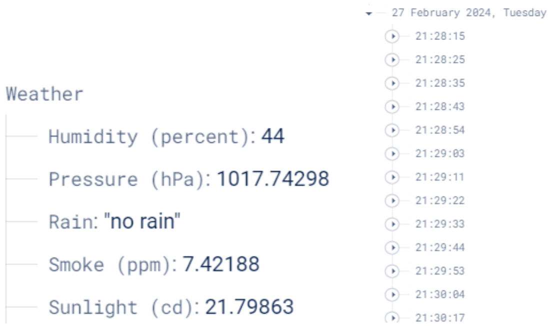

Figure 5: Realtime Database at Firebase Cloud Computing

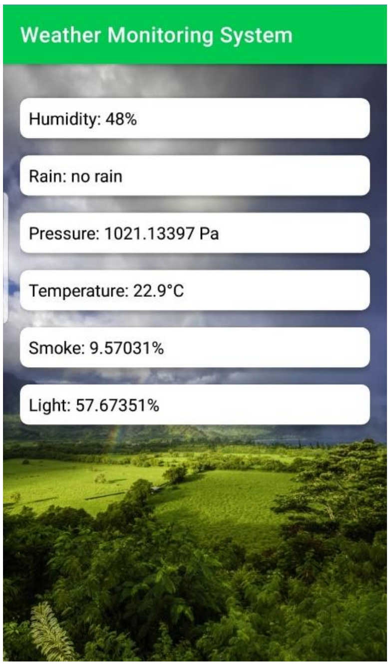

Figure 6: Weather health monitoring app on Android

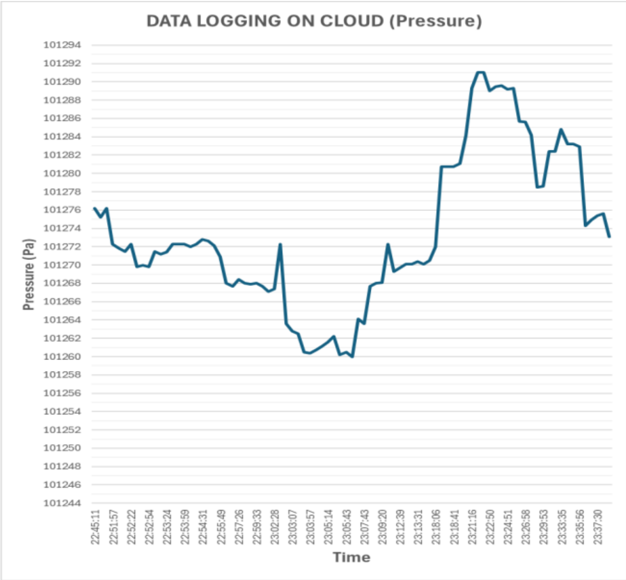

Figure 7: Pressure Vs Time graph

Figure 7 depicts the temporal progression of monitored pressure levels, showing a consistent trend characterized by relatively minor fluctuations in atmospheric pressure. The graphical representation underscores the stability typically observed in atmospheric pressure variations. Notably, the x-axis presents time intervals during which readings are documented, highlighting the frequency of data logging to be approximately once per second. This real-time data stream is seamlessly transmitted to cloud storage, facilitating its potential visualization on weather monitoring applications.

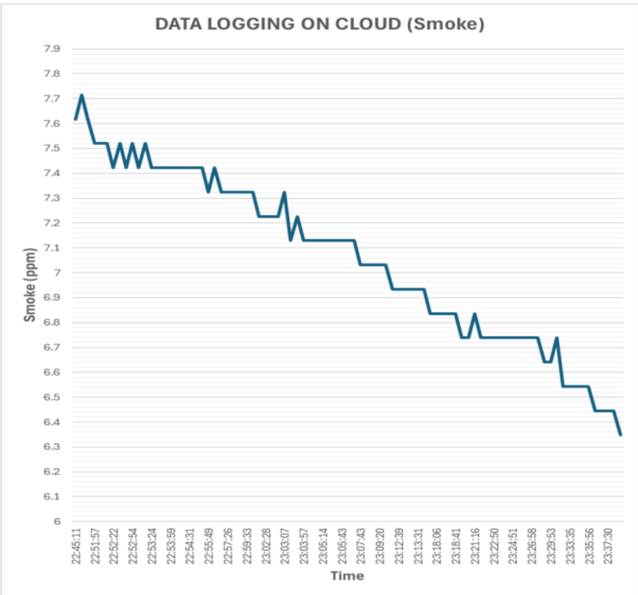

Figure 8: Smoke Vs Time graph

Figure 9 clearly represents a notable decrease in smoke levels as the night progresses, showcasing a dynamic trend that is continuously updated in real-time across both the website and the corresponding application platforms. This visual representation not only highlights the continuous patterns in smoke concentration but also highlights the seamless synchronization of data propagation across digital interfaces, ensuring users are promptly updated about environmental conditions.

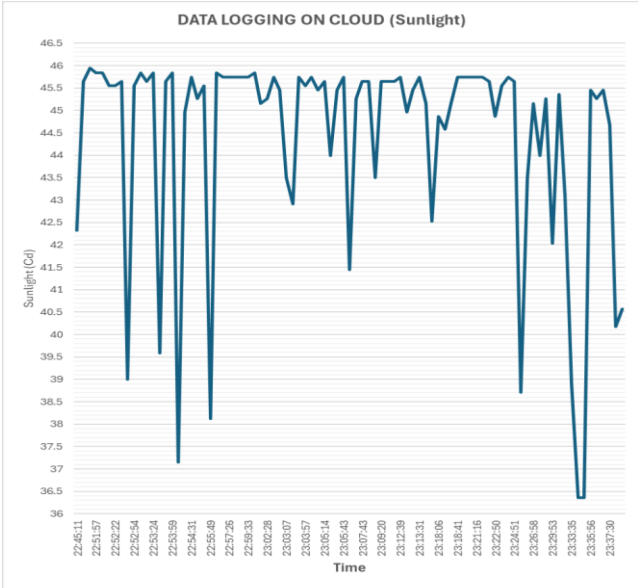

Figure 9: Sunlight Vs Time graph

The values shown in Figure 9 are related to light intensity, showcasing the present positioning of the device within an environment illuminated by artificial light sources. This relative backdrop underscores the known fluctuations observed, directly influenced by the intermittent switching of lights. Consequently, these alterations apply an evident impact on the recorded dataset, interpreting the dynamic interplay between environmental factors and measured parameters.

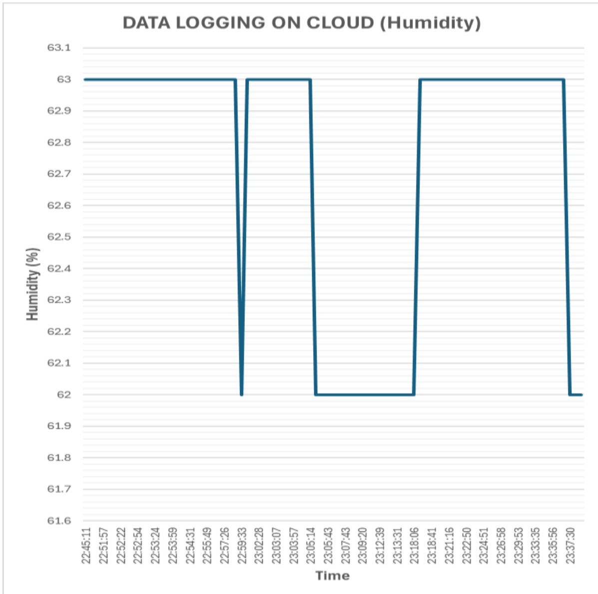

Figure 10: Humidity Vs Time graph

Humidity, as depicted in Figure 10, is presented in percentage format, suggesting relatively stable variations. Nonetheless, upon examining the X-axis, it becomes apparent that the time periods for all these parameters are updated simultaneously.

Figure 11 depicts the trend in temperature value changes over a span of 1 hour, demonstrating the effectiveness of the temperature sensor and the efficiency of data logging.

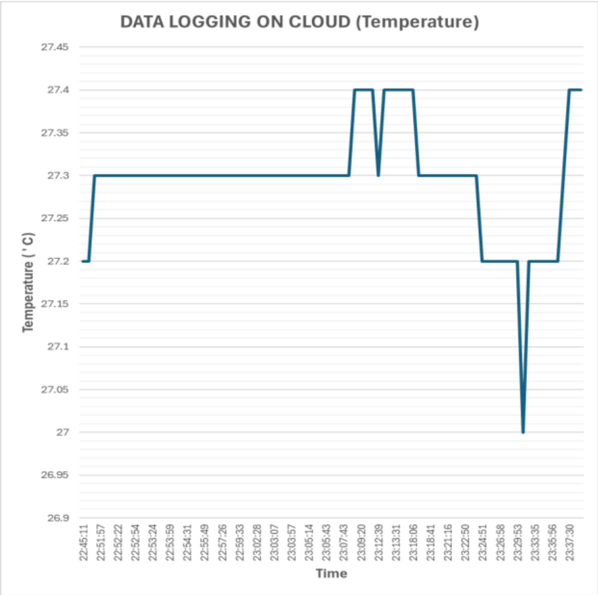

Figure 11: Temperature Vs Time graph

6. Conclusion

The establishment of a continuous weather monitoring station within the natural environment serves as a form of proactive environmental protection, essentially giving rise to what can be described as a "smart environment." This endeavor entails the strategic deployment of sensor devices throughout the environment, enabling the collection and analysis of critical data. This innovative approach effectively bridges the natural world with the digital realm, facilitating real-time data access for users through Wi-Fi connectivity. The paper introduces a highly efficient and cost-effective embedded system tailored for intelligent environmental monitoring. Moreover, it streamlines the transmission of sensor parameters to cloud storage, ensuring data availability for future analysis and sharing with a broader audience. Significantly, the model's adaptability extends to monitoring burgeoning urban areas and industrial zones for comprehensive pollution tracking, offering an economical and efficient solution for ongoing environmental monitoring aimed at safeguarding public health from pollution-related hazards.

7. Future Scope

There are multiple opportunities to grow and improve this system in the future. A viable path would be to install more sensors and develop satellite connectivity to make it a platform for monitoring the environment on a global scale. This expansion can include monitoring more environmental data, such as air pressure, concentrations of oxygen, and CO2 levels, among others. Moreover, the system has great promise in fields where real-time data is critical, like navigation, aviation, and military operations. Its application can also reach medical research centres and hospitals, enabling research on the "Effect of Weather on Health."

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

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Conflict of Interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.