International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 12 Issue: 03 | Mar 2025 www.irjet.net p-ISSN: 2395-0072

LoRa-Based Affordable Wireless Weather Station

Deepa B C[1], Neerajakshi G V[2], Kiran K N[3]

[1] Deepa B C, Student, Dept. of ECE, BNM Institute of Technology, Karnataka, India.
[2] Neerajakshi G V, Student, Dept. of ECE, BNM Institute of Technology, Karnataka, India.
[3] Kiran K N, Assistant Professor, Dept. of ECE, BNM Institute of Technology, Karnataka, India.

---***---

Abstract - *The LoRa Based Affordable Wireless Weather Station is a system aimed at providing weather data, that has obtained significant attention mainly because of its capability to assist long-range wireless-communication along with minimal power consumption. This makes it a good candidate for distant environmental observation systems. A LoRa-based weather station integrates various environmental sensors like air temperature, moisture level, wind velocity, atmospheric pressure, and rain gauges with a LoRa transceiver to collect and transmit real-time weather data over long distances. These weather stations are specifically useful in rural, remote, or disaster-prone regions where conventional communication systems are limited or unavailable. The low-power nature of LoRa allows weather stations to operate for continued time on battery, thus making them cost-effective and sustainable for long-term deployments. This paper explores the design, benefits, and challenges of implementing LoRa-based weather stations, highlighting their applications in agriculture, climate monitoring, disaster management, and smart city initiatives. Additionally, we discuss the potential for integrating LoRa technology with IoT platforms and advanced analytics aimed at enhancing the accuracy and predictive capabilities of weather monitoring systems.*

Key Words: **LoRa, Sensors, Weather Parameters and Wireless Station, ESP32 Wi-Fi module.**

1.INTRODUCTION

The requirement of accurate and real-time ecological data has become greater critical in various sectors, including agriculture, disaster management, climate research, and urban planning. Weather stations, which collect data on key atmospheric parameters like ambient temperature, moisture level, wind velocity, atmospheric pressure, and rain gauges, are essential tools in gathering this vital information. However, traditional weather stations often rely on extensive architecture, which can be costly and difficult to deploy, especially in remote or rural areas. Additionally, these stations typically require a continuous and uninterrupted power supply and reliable communication infrastructure, which may not be available consistently in such regions. The Wireless Sensor systems have now, emerged as flexible and scalable solutions for monitoring environmental conditions. These networks consist of distributed sensors that collect data and transmit it wirelessly to a central base station or cloud-based platform. Among the various communication technologies used in WSNs, the LPWANs have become popular, mainly due to their ability to provide long-range communication and low energy consumption. One such LPWAN technology that has proven to be highly effective in environmental monitoring applications is LoRa (Long Range), a wireless communication protocol developed explicitly for low-power and long-distance transmission.

Several significant features in LoRa technology, make it particularly well-suited for applications like wireless weather stations. LoRa offers long-range communication capabilities, enabling the devices to transmit data over several kilometres, even in areas with challenging terrain. This feature is especially beneficial for weather stations that need to cover vast and remote areas, such as rural farms, coastal regions, or mountainous terrains. In addition, LoRa's low power consumption allows devices' operation for longer duration without the need for frequent maintenance or battery expendable. This makes LoRa-based weather stations sustainable and provide a cost-effective solution, particularly in locations where access to electricity is limited.

A typical LoRa-based weather station integrates the range of environmental sensors, such as air temperature, moisture level, wind velocity, atmospheric pressure sensors, with a LoRa transceiver that transmits the collected data over long distances. These stations can be powered by alternate and renewable energy sources, thus ensuring that they operate constantly even in off-grid locations. By connecting multiple weather stations within a LoRa network, it becomes possible to have a large-scale, distributed weather observation system that can provide detailed and accurate insights into environmental conditions across a wide geographic area.

2. LITERATURE SURVEY

The integration of LoRa (Long Range) technology in wireless weather stations has appeared as a potential remedy for real-time environmental monitoring, particularly in remote or off-grid areas where traditional infrastructure is either insufficient or non-existent. LoRa, as a low-power wide-area network (LPWAN) technology, provides an efficient way to collect and transmit weather data above extended distances with very minimum energy consumption that makes it well-suited for applications such as weather monitoring stations, where long-term operation in isolated environments is crucial. Several studies have explored the design, development, and applications of LoRa-based wireless weather stations.[1]

A significant portion of the research focuses on the architecture and deployment of LoRa-based weather stations. These stations are typically composed of multiple environmental sensors such as temperature, wind speed, humidity, rain gauges, and atmospheric pressure sensors. The data from these sensors is collected by a central microcontroller and transmitted over the LoRa network to a gateway or cloud platform. Several studies have demonstrated the successful deployment of the weather station systems in rural areas, where the long-range capabilities of LoRa except for data transmission over several kilo meters without the need for traditional cellular or Wi-Fi networks. The low-power nature of LoRa is a critical advantage, enabling these stations to operate for continuous time, many times with solar panels or battery-based power sources. This makes LoRa-based systems particularly viable in areas where conventional power grids are unavailable.[2]

The effectiveness of LoRa technology in weather station applications has been the focus of thorough investigation in lately literature. Numerous studies have highlighted the ability of LoRa to maintain reliable communication even in challenging environments, such as forests, mountainous regions, or agricultural fields. For example, researchers have explored the propagation characteristics of LoRa signals in different terrains and weather conditions, establishing the feasibility of deploying LoRa-based systems for large-scale weather monitoring networks. The robustness of LoRa communication, even in harsh conditions, has been validated by successful deployments in remote regions, where traditional communication technologies would either be impractical or prohibitively expensive.[3] Additionally, studies have explored possibility of integrating LoRa-based weather stations with broader IoT (Internet of Things) ecosystems. This integration allows for absolute data transmission to cloud platforms, where advanced analytics, data visualization, and predictive modelling can be applied. In some cases, LoRa-based weather stations extended integrated into smart agriculture systems, providing farmers with real-time insights into environmental conditions that help optimize irrigation, crop management, and pest control. The data gathered by these stations are useful for the early warning systems in disaster-prone areas, such as floods etc. LoRa technology-based weather monitoring system are useful in wildfire detection, since quick responses are critical for protecting lives and property. These applications underscore its value in enhancing sustainable agriculture, promoting climate resilience, and supporting disaster mitigation efforts[4]. However, despite its advantages, the use of LoRa-based weather stations presents certain challenges.

One key limitation, is the low data transmission rate of LoRa, which can be restrictive for applications that require high-frequency or large-volume data transfer. In weather monitoring, where sensors generally transmit small, periodic updates, this limitation is less impactful. Network congestion, is a concern, particularly in areas with a high concentration of devices, which usually results in delays or data loss. To address this, various strategies for optimizing LoRa networks have been explored. These include techniques like adaptive transmission power control, data aggregation, and collision avoidance, all of which aim to enhance network reliability and performance, especially in large-scale deployments.[5] Another critical aspect discussed in the literature is the reliability and sustainability of power sources for LoRa-based weather stations. While LoRa's low power consumption reduces the overall energy demand, ensuring long-term operation in remote locations still requires careful planning. Many studies have focused on hybrid power systems, which combine solar panels, batteries, and energy management techniques to ensure that weather stations remain operational year-round, even in regions with fluctuating sunlight.[6]

3. METHODOLOGY

The proposed flowchart for the LoRa-Based Affordable Wireless Weather Station is shown in Figure 1.

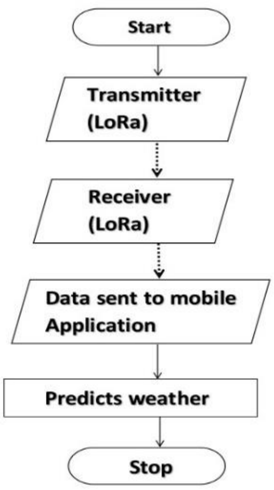

Fig -1: Flow Chart

The system begins by collecting relevant data that includes weather related parameters such as temperature, light intensity, humidity, and rainfall. The values are acquired through various sensors. The acquired data is subsequently processed by an ESP32 microcontroller. It converts the raw sensor readings into a usable format for transmission. The processed data is then sent via the LoRa module, which enables long-range wireless communication while consuming minimal power. This ensures that weather data can be transmitted even from remote locations. At the receiver end, the LoRa gateway node receives the transmitted data. This gateway includes a LoRa module and an ESP32 Wi-Fi module, which serves as a bridge between LoRa network and an external monitoring system. The received data is forwarded via the ESP32 module to a cloud-based platform for real-time monitoring and analysis. The transformer in the gateway ensures proper voltage levels for accurate transmission. The final step in the flowchart involves displaying the processed data in a user-friendly format on a mobile or web-based application. This allows users to access real-time environmental conditions and trends for decision-making.

Figure 2, shows the transmitter section of the LoRa-based wireless weather station consisting of multiple environmental sensors, including the DHT11 temperature and humidity sensor, BH1750 light intensity sensor, LCD, and rain sensor module. These sensors collect real-time weather data, such as temperature, light intensity, humidity, and rainfall, which is processed by an Arduino Uno microcontroller. The processed data is subsequently transmitted using a LoRa module, which enables long-range, low-power communication. This transmission ensures that weather data is sent efficiently over significant distances to a central receiver.

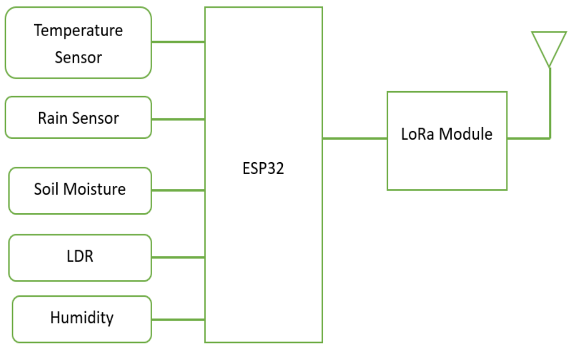

Fig -2: LoRa Transmitter

Figure 2, illustrates the sensor nodes equipped with sensors interfaced to an Arduino Uno microcontroller. The sensors, measure the physical parameters, transmit the data to the gateway node through the microcontroller and LoRa module. The light intensity sensor measures the amount of light in the environment, providing data about the surrounding brightness or darkness. This sensor node plays an important role in environmental monitoring systems, gathering important data to the environment.

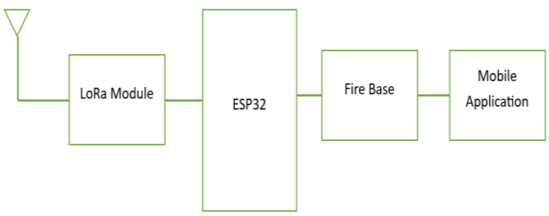

Fig -3: LoRa Gateway

Figure 3, shows the receiver section consists of a LoRa gateway node, which includes a LoRa module, an ESP32 Wi-Fi module, and a transformer. The gateway node receives the data from sensor nodes and acts as a bridge between LoRa network and an external application. The ESP32 module forwards the received data to a cloud-based application for real-time monitoring and analysis. The transformer is used to regulate voltage levels to ensure proper data transmission. This setup enables efficient data reception, storage, and visualization of weather conditions through a mobile or web application. The LoRa is a remote transceiver designed with the Arduino board, featuring an open-source library that enables transmission of data over large distances along with low data rates. Additionally, the LoRa LG01-S serves as an open-source gateway that bridges LoRa wireless networks to various IP networks, such as WiFi, Ethernet, 3G, or 4G. It operates on an embedded Linux system, which is also open-source.

4. IMPLEMENTATION

The sensor nodes support long-range data transmission, with minimal power consumption, thus making it suitable for IoT applications. The transformer is made use for adjusting voltage levels for proper data transmission. Overall, the gateway node is crucial in facilitating data transfer from sensor nodes to external systems, enabling efficient monitoring followed by analysis of environmental conditions across various applications.

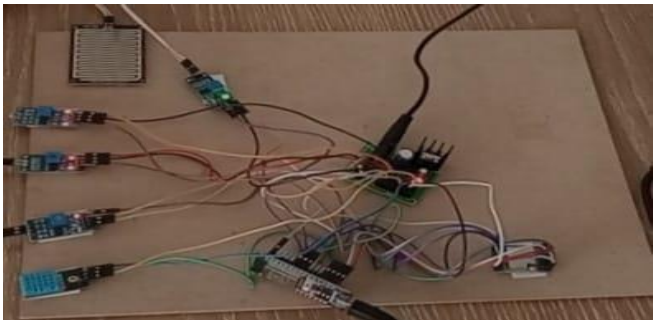

Fig -4: Circuit Implementation

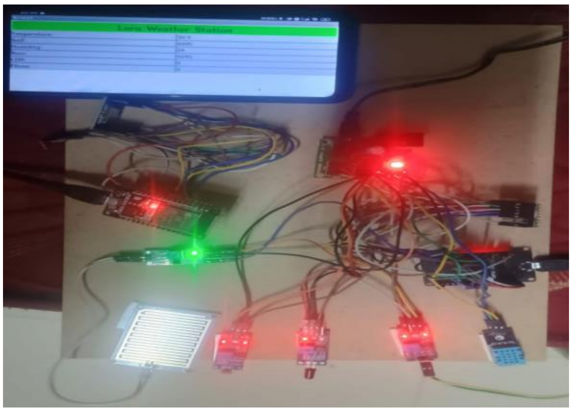

FIGURE 5: Circuit Implementation

Figure 5, displays the physical parameters such as temperature, light intensity, humidity and rainfall. This application provides real-time updates on weather conditions, immediately reflecting any changes. The data is transmitted through the Wi-Fi module in the gateway node, enabling the application to receive and display the information promptly.

5. RESULTS

The LoRa-Based Wireless Weather Station results, demonstrate the successful implementation of a low-cost, energy-efficient, and long-range communication system for weather monitoring. These sensor nodes transmit real-time weather data through a LoRa module to a central gateway node.

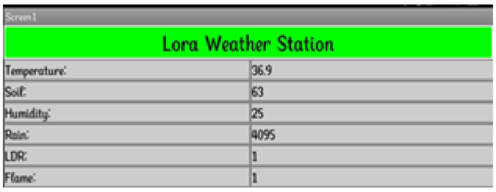

Fig -6: Output messages

The gateway node, equipped with a LoRa module, ESP32 Wi-Fi module, and a transformer, receives the transmitted data and forwards it to a cloud-based application via Wi-Fi. This setup ensures seamless real-time monitoring followed by analysis of weather conditions. The data obtained is stored in a Firebase real-time database, allowing the users to access weather updates instantly using a mobile application.

Furthermore, the system effectively provides accurate and reliable weather data, that can be used in applications such as agriculture, disaster management, and environmental research. The low power requirements and long range capabilities of LoRa technology make the system ideal for deployment in remote or off-grid locations where traditional infrastructure is limited.

6. CONCLUSION

Weather monitoring is a challenging task due to frequent changes in environmental conditions, even over short distances. This paper presents a simple, low-cost system for accurately measuring various climatic parameters. The proposed Wireless Weather Station system is highly advantageous for use in weather-related applications such as transportation, aviation, and agriculture, providing quick, timely and accurate environmental data for decision-making. The LoRa-based wireless weather station highlights its effectiveness and efficiency in remote weather monitoring, by leveraging LoRa technology. Thus, the system transmits weather related data over long distances with significantly low power consumption, thus becoming extremely suitable for areas with limited infrastructure or harsh environments. The system ensures accurate and real-time weather tracking. This technology also enhances the scalability of the system, allowing the deployment of multiple weather stations in diverse locations, allowing for environmental monitoring, disaster management, and agricultural applications. Thus, the LoRa-based weather stations provide a reliable, cost-effective solution for comprehensive weather data collection in remote or difficult-to-reach areas.

REFERENCES

[1] T. Amulyaf, B.Vyshnavi, B. Shravani, Dr. S. Ibrahim Sadhar,"IoT Weather Station Using Arduino Uno", JETIR, June 2021, Volume 8, Issue 6

[2] Karthik Krishnamurthi, Suraj Thapa, Lokesh Kothari, Arun Prakash, "Arduino Based Weather Monitoring Systems", International Journal of Engineering Research and General Science, Volume 3, Issue 2, March 2015.

[3] N. Sabharwal, R. Kumar, A. Thakur, J. Sharma, "A Low-Cost Zigbee-Based Automatic Wireless Weather Station with GUI and Web Hosting Facility", ICRTEDC, Vol. 1, Spl. Issue 2, May 2014.

[4] D. V. Sose, A. D. Sayyad, "Weather Monitoring Station: A Review", International Journal of Engineering Research and Applications, ISSN: 2248-9622, Vol. 6, Issue 6, (Part-1), June 2016, pp. 55-60.

[5] Hakkı Soy, Yusuf Dilay, "A Conceptual Design of LoRa-Based Weather Monitoring System for Smart Farming", DOI: 10.31590/ejosat.1011947.

[6] Chen Jianyun, Sun Yunfan, Lin Chunyan, "Research on the Applications of Automatic Weather Stations Based on the IoT", DOI: 10.1088/1755-1315/104/1/012015.