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LoRa Based Wireless Weather Monitoring Station

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Abstract*:* A LoRa-based wireless weather station is an advanced system designed to monitor and report environmental conditions in real time, utilizing LoRa (Long Range) communication technology. The primary function of this system is to collect data on various weather parameters, such as temperature, humidity, benzene, co2, spo2, ozone , solar radiation , wind speed, and wind direction, using a network of sensors. The data is then transmitted over long distances to a central server or gateway via LoRa, a low-power, wide-area network (LPWAN) protocol. This system provides real-time weather updates, which are essential for agricultural planning, environmental monitoring, and disaster management. Furthermore, the data can be analyzed and visualized through IoT platforms, enabling predictive weather analysis and long-term climate studies.

Keywords: LoRa, WiFi, Sensors, Weather Parameters and Wireless Station.

I.INTRODUCTION

Weather monitoring systems is a vital component in numerous sectors, including agriculture, transportation, and disaster management. These systems provide critical data on atmospheric conditions like temperature, humidity, pressure, and precipitation, which are essential for decision-making processes, resource allocation, and risk mitigation strategies. Traditional weather stations, comprising wired sensors connected to a central data collection unit, have long been the cornerstone of meteorological observation networks. However, they are often constrain by limitations such as restricted coverage, high installation and maintenance costs, and susceptibility to damage from severe weather events. The weather is generally always changing. Sometimes there is a dry season, rain, until snowfalls. The weather is generally influenced by three elements namely the sun, water, and wind. Sunlight produces energy that can control the water cycle. The wind carries clouds that contain water vapor moving towards places with lower air pressure. The air and clouds shrink to become heavier and fall to the ground so that it rains. Weather conditions are very influential in human activity so it is very necessary to measure weather conditions in real-time.

Fig .1 Weather Monitoring Station

In the process of weather observation, a set of instruments is needed to be placed in a certain location to represent the environmental conditions of the surrounding area. A weather station is a set of tools used to observe conditions or changes in weather, climate, and atmosphere in an area and record it in the form of data.

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After being recorded, the data is stored in a data logger and subsequently to be studied by users or researchers. An automatic weather station is an instrument that measures and records meteorological parameters using sensors. This sensor serves as a measuring tool to measure any changes in the weather. After the measurement data from the weather station is collected, the process can be carried out locally at the location of the weather station or the data can also be collected at the acquisition data center unit, which later the data collected is automatically forwarded to the data processing center and then processed as needed .

A LoRa-based wireless weather station utilizes LoRa WAN technology to provide efficient, long-range environmental monitoring in remote and hard-to-reach areas. Designed for low power consumption, these weather stations can operate on battery or solar power, enabling continuous data transmission of key weather parameters like temperature, humidity, wind speed, barometric pressure, and rainfall. LoRa's extensive communication range (up to 15 km) and scalability make it ideal for deploying multiple stations across wide areas, supporting applications in agriculture, environmental research, disaster management, and smart city infrastructure. With robust data security and cost-effective setup, LoRa-based weather stations offer a reliable solution for real-time, remote weather monitoring.

II.LITERATURE REVIEW

1. ***M. Dhilip et al LoRa based wireless weather station with web server , Volume 4, Issue 6, June 2022*** **.** This study develops a prototype of a weather station network with wireless LoRa infrastructure. The use of the LoRa network serves to increase the range of wireless cells that can reach distances of up to 5 Kilometers while still having low power consumption. This project aim is to measure the various parameters like Temperature, humidity, wind speed and direction , solar radiation continuously monitor. The system uses a good combination of Analog and digital sensors in wire and wireless mode of operation.

2. ***Ravi Sai Manasa et al LoRa based wireless weather station with web server , volume 9,issue 11,June 2023***. Different parts are associated with Micro Controller-Arduino and different sensors are associated with it. Here these sensors gather the information from environment i.e., Climatic circumstances utilizing individual sensors and sends every one of the information to Arduino Uno. Where the Arduino Uno will send this information to Receiver module utilizing LoRa part . The Arduino nano is programmed in such a way that it transmits the information collected to the web server where the data is monitored.

3. ***D. Sri Harsha Vardhan et al LoRa based wireless weather monitoring system ,volume 11, issue 5, May 2024***
This study develops a prototype of a weather station network with wireless LoRa infrastructure. Weather parameters measured include air temperature, air humidity, air pressure, rainfall and wind speed. The number of end-nodes in the prototype developed is two. But in practice later if needed it can be multiplied by dozens of end-nodes. End-nodes consisting of various sensors will be placed in an area within the reach of LoRa to process weather monitoring results in that area. Weather monitoring is a tricky activity as the environmental conditions can easily change from point to point even at small distances. The paper demonstrates simple and low-cost system architecture for accurately measuring climatic parameters. All the weather parameters successfully stored in Firebase real time database and displayed on a mobile application.

III.PROPOSED METHODOLOGY

A. BLOCK DIAGRAM OF TRANSMITTER

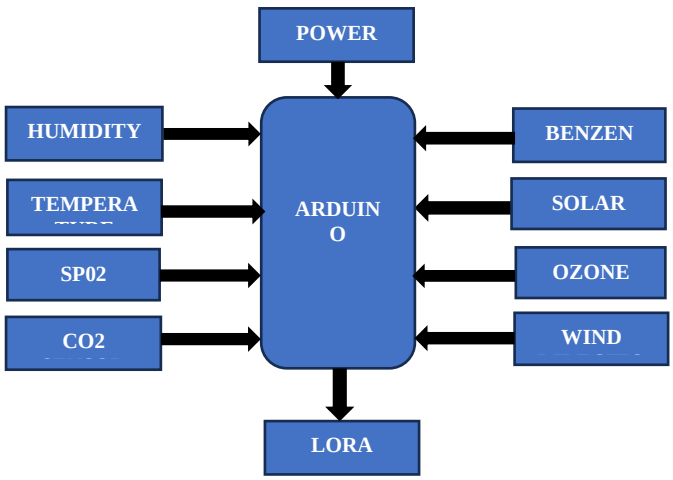

Fig. 2 Transmitter Block Diagram

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B. BLOCK DIAGRAM OF RECEIVER

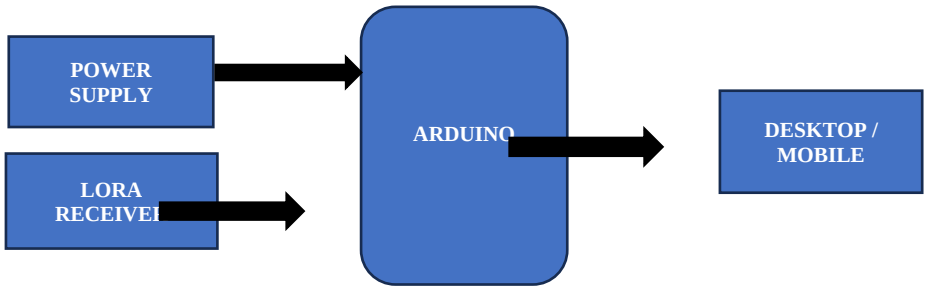

Fig. 3 Receiver Block Diagram

The proposed system consists of two LORA transceivers which used to transmits and receives the data from the sensors along with arduino to the LORA configured PC (receiver section). The transceiver of LORA which was present at the transmitter end along with microcontroller will takes the data from the sensors and then sends that information to another transceiver through wireless communication. Finally that information will display on PC screen then the user or operator will take the required operations to control that pollution. LORA is a device which will transmits the obtained information to another configured transceiver within the range of 1000mtrs in rural areas and also its battery lifetime is up to 10 years. The LORA unit gathers air pollutants levels (Co2 [14], No [18], Co [17]) and packs them in a frame with the GPS [19] physical location. The frame is transmitted to the user PC

IV.WORKING PRINCIPAL

A LoRa-based wireless weather station operates by using sensors, a Arduino , and a LoRa transmission module to collect and transmit environmental data over long distances with minimal power. This setup allows real-time weather monitoring even in remote areas. The weather station's sensors measure key environmental parameters such as temperature, humidity, air pressure, wind speed, and rainfall. These sensors are configured to periodically gather data at set intervals, like every minute or hour, depending on the use case and power requirements.

Once data is collected, it is processed by a central arduino, which filters, organizes, and compresses the data if needed. This preparation ensures that the information is efficiently transmitted, taking advantage of the LoRa module's low bandwidth capabilities. LoRa (Long Range) technology is well-suited for this type of application, as it operates in the ISM band (usually at 868 MHz in Europe or 915 MHz in North America), providing the ability to transmit data over distances of up to 10-15 kilometers in rural areas and a few kilometers in urban areas with obstacles. The LoRa module ensures low power consumption while covering extended distances, making it ideal for locations where power sources are limited.

Once the data is transmitted, a nearby LoRa gateway receives it and sends it to a cloud server via the internet. In the cloud, the data is stored, analyzed , and visualized on dashboards, allowing users to monitor real-time and historical weather patterns. Often, LoRa WAN (a network protocol on top of LoRa) enhances data management with features like adaptive data rates and secure communication. This setup provides a cost-effective, low-maintenance solution for reliable, remote weather monitoring, supporting applications in environmental monitoring, agriculture, and climate research where consistent data access is essential.

V. CONCLUSION

The LoRa-based Wireless Weather Monitoring Station is an efficient, cost-effective, and scalable solution for real-time environmental monitoring. By leveraging LoRa technology, the system enables long-range, low-power communication, making it ideal for deployment in remote and rural areas where traditional networks are unavailable. With multiple sensors, the system provides accurate data on temperature, humidity, pressure, wind speed, rainfall, and air quality, which can be accessed remotely through a cloud-based platform or a mobile application. The integration of solar power ensures continuous operation with minimal maintenance, further enhancing its usability in off-grid locations.

This solution has wide-ranging applications in agriculture, disaster management, smart cities, and industrial monitoring, offering real-time insights for better decision-making. Future advancements, such as AI-driven weather prediction and integration with LoRa WAN networks, can further enhance its capabilities.

In summary, a LoRa-based Weather Monitoring System is a reliable, energy-efficient, and scalable technology that significantly contributes to environmental data collection and climate resilience, paving the way for smarter and more sustainable weather monitoring solutions

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