Weather and Air Quality Monitoring System(WAAQ)

Deepanshu Yadav
deepanshuyadav.dee@gmail.com
Computer Science and engineering department, Netaji Subash University of Technology, New Delhi

Abstract

This paper proposes a system for weather and air quality monitoring system, which can be used to send data over the online database and to send data to a nearby node using LoRa technology, in case the end-user doesn't have internet connectivity. Firstly we will be sending the data collected through all the sensors on the transmitter node to the thinkSpeak cloud and we will also transmit the data using radio-frequency bands to transmit data to a long range where a receiver node can receive it and display it to the user using a mobile application with the help of Bluetooth, in doing this task we will be using simple and cost-efficient sensors instead of costly and sophisticated sensors to reduce the cost of the system and creating a cheap network of a long area weather reporting.

1. Introduction

Weather forecasts these days are highly unpredictable due to the unmatched growth of industries, traffic, and continuous emission of toxic gases which are making a huge impact on the purity of air and ultimately affecting the environment. Reporting of weather and the quality of air is increasingly becoming more and more important because the environment is getting polluted every day and it affects the health of every living individual. We use weather reporting to see the changes in the environmental conditions like temperature, humidity, air quality, and rain. Satellite weather reporting gives weather reports which are not always accurate so we need some weather stations to report the weather and air quality parameters.

We are aiming to design weather and air quality reporting system that will sense and give us the environmental parameters like temperature, humidity, air quality, and rain. These parameters ultimately can be used in agriculture, as it is very important to know whether it is going to rain or not in order to water the crops and the temperature and humidity for the health of the crops. Reporting will also be used in household, industries sectors, etc. In our daily lives, we need reporting of the air quality and the temperature to have credible data for exact location, so that we know the environmental parameters that will affect our health severely and take precautions to avoid them. Our model will detect these environmental variables and transmit them to the cloud which the user can access anywhere in the world using internet connectivity, we will also transmit this data to local receiver nodes using LoRa communication and the receiver node will receive data and display this data to the user using Bluetooth to an android application.

We are aiming to minimize the error in weather and air quality reporting and give accurate reports of these parameters in real-time to the users. It will help people

who are currently facing respiratory diseases such as asthma, lung cancer, chronic obstructive pulmonary disease, etc to know about the air quality around them and take necessary precautions to avoid them.

Our system will contribute in the following ways

- It will precisely detect the weather and air quality parameters for an area.
- It will display these parameters to the user oner the internet. Users will be able to access them anywhere in the world using the internet.
- Our system will also store these parameters over the cloud, which further can be used to analyze the environment.
- The system will locally transmit the data in radio-frequency bandwidth to the receiver node using LoRa communication so that, in case the user doesn't have internet connectivity can still be able to know about these important environmental parameters.

The introduction to the problem statement and the proposed solution are discussed in Section 1, Section 2 focuses on the conclusions drawn from the past works. Section 3 will elaborate on the Methodology of the model. Section 4 will show the results, Section 5 contains the conclusion and the future scope of the system.

2. Literature Review

Sarmad Nozad Mahmood [1] has discussed mainly two things, first is collecting data using sensors and then creating a real database system to store that data. They used sensors to detect mainly temperature, humidity, and airspeed and they display this data by using a LED screen to directly display it to the user, and the database they have locally created stores these three parameters. Arduino used is Arduino UNO and sensor for temperature and humidity which is DHT and an LCD 16*2 display and LDR sensor to detect day and night time and a wind speed meter. They stored the data in a local database and then used that data to analyze weather conditions.

Vaishnavi Lakhara [2] proposes a weather monitoring system that collects its data from different sensors which were used and then their main aim was to do weather forecasting from this data for the particular areas from which this data is collected. They have used an artificial neural network for the predictions of the weather parameters and they also have made an application using a javascript framework with angular JS. Model view, to view a single page application for forecasting weather. Their main objective was to use an artificial neural network for weather forecasting. They have used Arduino UNO as their main microcontroller and DHT sensor to detect temperature and humidity and gas sensor and noise sensor. They also display all the recorded parameters from the sensor over the LED display.

P.Susmitah [3] had built an embedded system for weather reporting and they primarily build it for the industries to monitor industrial weather parameters. They had used an ARM9 as their main microcontroller and are detecting weather parameters such as temperature, humidity, and gas. After collecting this data they are sending this data to LABVIEW using serial communication and then store it in the excel file. They also used a GSM module to send the recorded data directly to the user via SMS.

Escobar, Castineria, and Redondo [4] have created a communication protocol JMAC and they have used LoRa and Sigfox technology for their task, they have created a multi-hop communication protocol for communication between thousands of devices, the mesh actions of wireless communication are used by them and they are trying to improve the long-range communication between devices in the modern cities. They have used LoRa for its long-range and low power benefits and it also helps in building a sustainable and long lifetime system.

Fadzly, Rosli, Amarul, and Effendi [5] have created an air quality monitoring system. They are detecting temperature and air dust density levels and also have made a system to alert users when the conditions are above the danger mark using a buzzer. They have used an API to check the average temperature and Dust density levels for an area and then compare them with the currently measured values from sensors, and if the temperature and dust density values are within the danger limit, they alert the user using a buzzer module. They have used Arduino Mega for their project and they display the values of temperature and dust over the LCD display, they also used red, green, and yellow LED signals to alert the user according to values measured by the sensors. They created a healthcare system for all groups of age which alerts them based on the quality of air around them and help them in taking necessary precautions if needed.

3. Methodology

In this section, we discussed the architecture of our weather and air quality reporting system. It used LoRa technology for long-range and low-power transmission of data between transmitter and receiver node.

The implemented system of the transmitter block consists of a microcontroller Arduino nano and all the sensors required to detect the environmental parameters such as temperature, humidity, air quality, and rain are connected to the microcontroller which after detecting the data sends to the Think Speak cloud using a wifi module which is making an HTTP request to send and receive data from the ThinkSpeak server. And it also sends data to the Receiver node using LoRa which used radio-frequency signals for long-range transmission of the data packet. Theoretically, LoRa can send data up to 3 miles(5 Kilometers) in urban areas where there are huge buildings to block the signals, and in rural areas or the places where the signal can’t be blocked by physical things LoRa can transmit up to 10 miles(15 kilometers). The range of the LoRa module communication between transmitter and receiver node also depends on the sending signal strength and the size of the antenna on the receiver node.

In the Receiver block, we have a microcontroller Arduino nano and a LoRa module for receiving data from the transmitter block, after receiving data from the transmitter node it will send this data to the user using a Bluetooth module, the user will receive this data in a mobile application which uses Bluetooth to receive the data from the receiver node. Final users don’t need to have any kind of network connectivity to receive the data on weather and air quality.

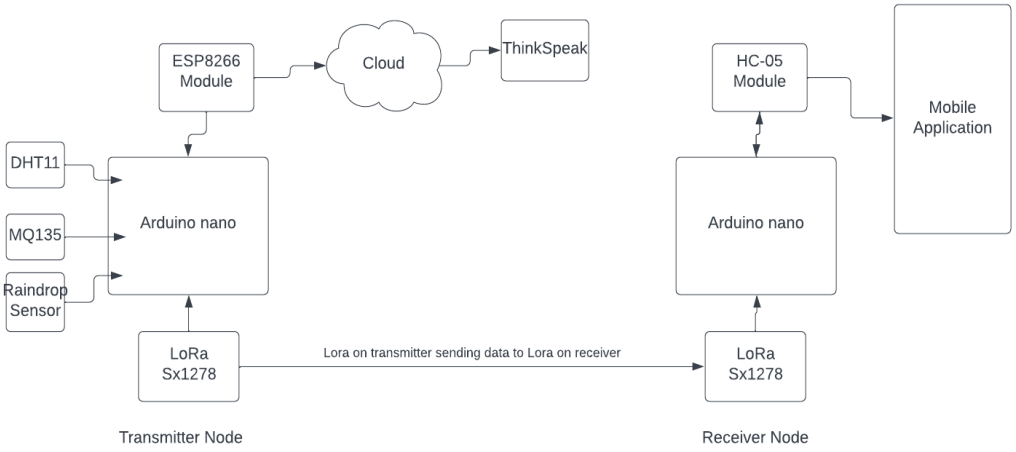

Fig. 3.1: Block Diagram of Weather and Air Quality Monitoring System

A. Components used: Hardware

a. Transmitter Node

i. Arduino Nano
ii. DHT11 sensor
iii. MQ-135 sensor
iv. Raindrop sensor
v. ESP8266 module
vi. LoRa SX1278 module

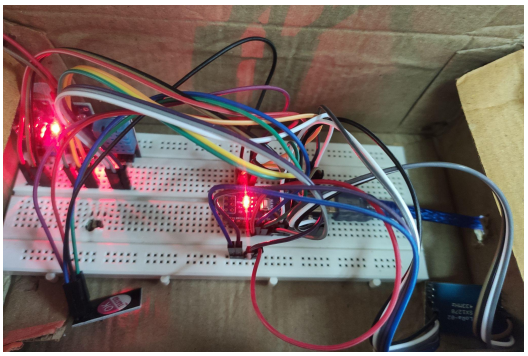

Fig. 3.2: Transmitter Node

b. Receiver Node

i. Arduino UNO
ii. HC-05 module
iii. LoRa SX1278 module

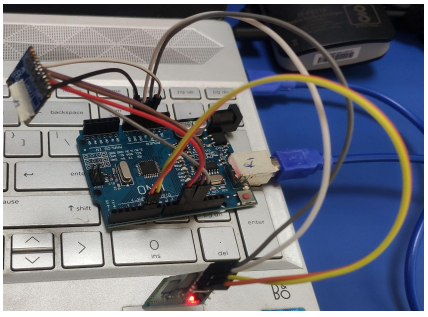

Fig. 3.3 Receiver Node

B. Component used: Software

a. Arduino IDE

An ESP8266 is a wifi module that is used to transmit data to the thinkSpeak cloud. It can act as a WiFi AP for other wireless devices to connect, or it can act as a client device connected to the existing network. It uses TCP/IP protocol stack to give WiFi access to the microcontroller used in the prototype.

Fig. 3.4: ESP8266 module

An Arduino nano and Arduino UNO are used in the transmitter and receiver node respectively, they act as the main processing unit for the nodes. It receiver data from the sensors in the transmitter node and it passed the received message packet from LoRa to Bluetooth in the receiver node. It uses an ATmega328 microcontroller for its computation tasks.

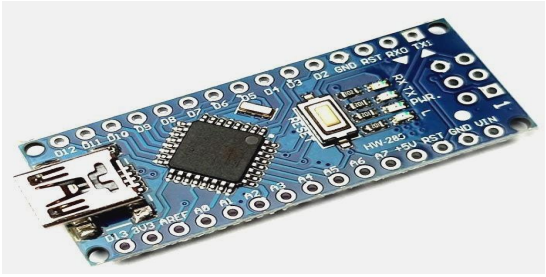

Fig. 3.5: Arduino Nano

Two LoRa(AI-Thinker Ra-02 SX1278) modules enable communication between the transmitter node and the receiver node. LoRa sends radio-frequency signals which consume very low transmission power and the signal also travels a longer distance(many kilometers). This helps us to transmit the data packet long distances.

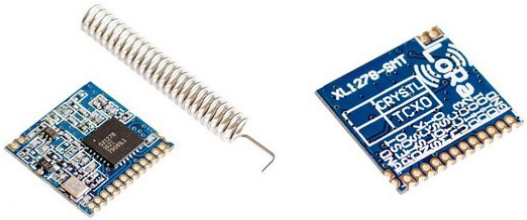

Fig. 3.6: LoRa SX1278

We are using a Bluetooth module(HC-05) in the receiver node to transmit the data Received from the LoRa module to the user android application. It has 5 pins VCC, Ground, UART_RXD, UART_TXD, and KEY which are used for mode switch.

Fig. 3.7: HC-05 Bluetooth module

The sensors used are DHT11 to sense the temperature and the humidity in the air, MQ-135 to detect harmful gases like smoke, NO, NH3, benzene, etc in the air, and a raindrop sensor which detects whether its raining or not based on the change of resistor and a threshold value.

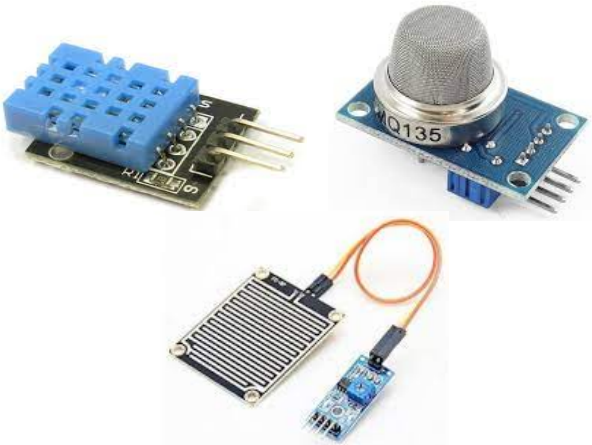

Fig. 3.8: DHT11, MQ-135, and Raindrop sensors

4. Result

When the prototype was assembled, and the individual nodes were turned on the system started its operation. We initialize LoRa to transmit data at 433MHz frequency and set up the ESP8266 module with the WiFi router. We also initialized the DHT11, Mq-135, and raindrop sensor. The transmitter node was sensing the temperature, humidity, rain conditions, and air quality every second, and the WiFi module(ESP8266) establish its connection with the WiFi router and started sending its data to the thinkSpeak cloud by making an HTTP request and AT commands. After sending data to the cloud then we broadcast the data packet using LoRa at 433MHz frequency.

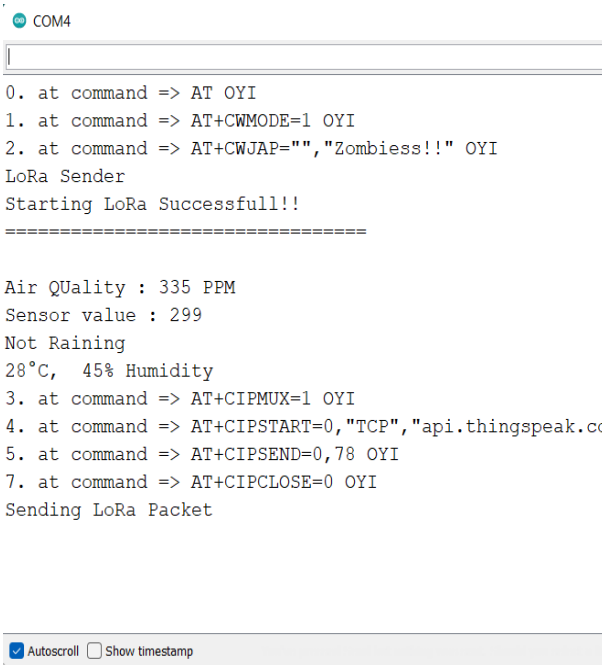

Fig. 4.1: Transmitter Node

ThinkSpeak is an open-source public cloud, which is used to transmit and receive data. It shows the received data in graphical form. The sender can send data to it and view it in the private view and can share that data with anyone or can make it publicly available and can set the formatting of the data and the graph and choose what the viewer can see. The user can view it in the public view. It also has MATLAB software support integrated with it for data visualization.

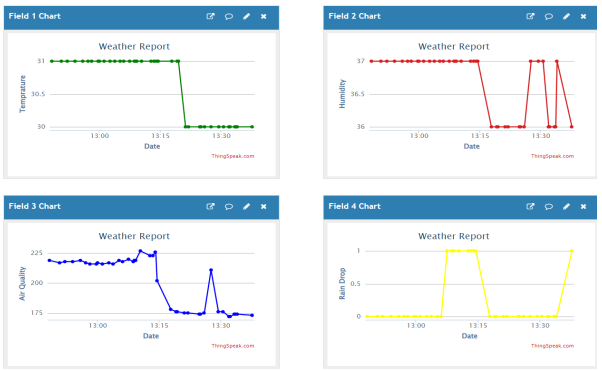

Fig. 4.2: ThinkSpeak

Four graphs illustrate the temperature, humidity, air quality, and rain status of the particular area. The graph shows changes in the weather and air quality parameters over time, which can be set by the data provider.

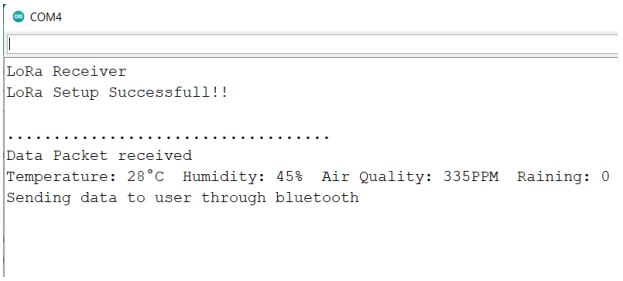

Fig. 4.3: Receiver Node

When the data packet is available through the LoRa then the receiver node takes the packet parses it and takes the temperature, humidity, air quality, and rain parameters, and transmits it through Bluetooth to the user. Users receive this data in the application. Users can view current the data in the application anytime just by opening the application and connecting it with the Bluetooth from the list of paired devices the serial screen will open and the user will start receiving the data whenever the receiver node will send the data. The receiver node will send the data whenever it receives the data from the transmitter node through LoRa communication.

Fig. 4.5: User's Application view

5. Conclusion and Future work

This prototype is scalable, as we can add the number of receiver nodes to receive the transmitted weather and air quality data for the number of users and it is also very price efficient as we don't need to sense the environmental parameters at the receiver node, we are just receiving these parameters for the particular area from the transmitter node. The transmitter and receiver node are using very less power so they are sustainable for years without the need to replace batteries continuously and data will be transmitted long distances, which allows the users who don't have internet connectivity to gain access to these environmental parameters.

We can add a buzzers module in the receiver's circuit to warn the user in drastic weather or air quality conditions like very poor quality of air etc. And we can also display data of the weather and air quality reports in the receiver node to the user using an LCD or OLED display. And we can use the data stored on the thinkSpeak cloud for further analysis like using it to build a machine learning model for weather forecasting for that specific area and study long-term climatic changes for that area or can provide the data collected for the region over the long period of time for further research purposes.

6. Acknowledgements

The author would like to thank Dr. Gaurav Singal, for patiently and passionately guiding them through the prototype, research, and development phase of the project. His regular meet-ups and interactions were a great help and allowed the author to find the shortcomings of the process and come up with efficient alternatives to their approach.

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