Air Quality Monitoring System Using Arduino, LoRa

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Abstract—**Since the conclusion of the industrial revolution, governments have begun to focus on its shortcomings, spurring the emergence of Air Quality Monitoring. The usage of LoRa has completely transformed the world of wireless communication. This article describes the creation of a LoRa-based air quality monitoring system for representing the Air Quality Index (AQI). This paper also demonstrates the use of an Arduino and other sensors for data collecting, which will then be broadcast and received through LoRa. LCD (Liquid Crystal Show) has also been used to display data. The system has advantages over the previous technology, such as very low power consumption, real-time data transfer, extended range, and no separate antenna component.**

***Keywords*— LoRa, Air Quality Index (AQI), Arduino-UNO, DHT11, MQ135, MQ4, MQ7**

I. INTRODUCTION

Government agencies use an air quality index (AQI) to communicate to the public how dirty the air is now and how filthy it may become in the near future. A US environmental protection agency estimated it for the first time in the 1970s (EPA). Although air quality in India has been recorded since 1957, the System of Air Quality and Weather Forecasting And Research (SAFAR), the central agency for AQI computation, was established in 2005.

The AQI is calculated by measuring the concentration of specific gases that are detrimental to both living and non-living things above a set threshold. The project makes use of numerous sensors (digital and analogue) to detect the quantity of gases (CH4, CO, CO2) in the environment. Certain sensors function on particular compounds that have an affinity for these gases, which alters the value of resistance and, eventually, the voltage. In this project, we also use a sensor to compute the temperature and humidity of the surrounding environment.

My investigation was carried out through a review of several previous studies and the present method of calculating AQI. Current monitoring methods include Ozone-Ultraviolet Spectroscopy, chemiluminescence, and infrared spectroscopy. All of these methods of calculation require bulky, sophisticated, and expensive equipment, and on top of that, these equipment is heavy and requires skilled professionals for operation and maintenance.

Many previous papers were discovered to make use of Wi-Fi modules, cellular networks, SigFox, and Zigbee, whose usage of their respective projects was extensive but not without problems. As a result, the LoRa module was chosen for this project. Following more investigation on the aforementioned module, which was divided into advantages and negatives, with the former outweighing the latter, LoRa was chosen as the transmission technology.

Multiple microcontrollers were also evaluated for this project. Seeeduino, which utilises a micro-USB connection for power and programming, offers interface connectors with on-grooving, DC-DC converters, but Arduino was chosen since it outperforms the former in every way.

The purpose of this article is to describe how the following LoRa Air Quality Monitoring system works, as well as its potential use and scope. The paper illustrates how the monitoring system's components, the transmission end and the receiving end, function. Its application in assessing an area's AQI

Remotely by sitting in the comfort of one's workplace, home, or other location, and graphical presentation that makes it easy to grasp even for non-technical people

1.1The Air Quality Monitoring System

The significance of air in the survival of life on Earth is critical. Every living being uses air for respiration, and certain autotrophic beings use it to generate sustenance. All these aspects, as well as others, make air an absolute requirement. As pollution levels grow, the quality of air degrades, resulting in a slew of geological phenomena that endanger life's fundamental existence. As a result, air quality monitoring has become a necessity. The gathering of data, which is commonly done with sensors, the processing of data with microprocessors, and lastly the transmission and display or storage of the processed data are the three phases of most air quality monitoring systems. Four sensors will be used to collect data for this paper: MQ135 for CO2, MQ4 for methane, MQ7 for CO, and DHT11 for temperature and humidity. For data transfer communication, LPWAN LoRa is used. Temperatures are measured in degrees Celsius (Celsius) while humidity is measured in percentages (percentage). The gases identified in the atmosphere here, such as CO_2, CO, and CH_4, are measured in parts per million (ppm), as is customary around the world.

1.2PURPOSE

Degrading air quality is the root of a slew of geological events that have interrupted the bio cycle's natural flow. Considering the current situation, the average temperature in many of the world's largest cities has risen. According to a report provided by NBC News, global temperatures in 13,000 cities soared by 200 percent between 1986 and 2016. In addition to global warming, cities' air quality indexes are declining, with Delhi's AQI reaching an all-time high of 999 per cubic meter. As a result, an Air Quality Monitoring System is required.

1.3 SCOPE

Air Quality Monitoring System has a lot of potential in the future; right now, it's being used to collect data, such as calculating the concentration of different gases that cause geographical anomalies in the atmosphere and depicting the result, which can then be used in research and analysis, as well as warning the public and recommending safety measures. Currently, the technology also allows for real-time measurement access. This system can be updated to a monitoring and purifying system in the future, which will not only change but also purify the air using natural cleaners like activated charcoal.

II. LITERATURE SURVEY

There were a few drawbacks to the many systems that were explored before we developed our own. One of the initiatives attempts to create an air quality monitoring system to transform cities into environmentally friendly zones and combat climate change. The Wi-Fi network continuously monitors the air for harmful gases, feeding that data into a Big Sensor Data system and showing air quality information to the user. However, using Wi-Fi for transmission makes it difficult to send data over long distances and raises the system's overall cost [1].

Another system proposes the creation of a smart wireless sensor network for air pollution monitoring. The device is used to monitor air pollution, and Zigbee is utilized as the wireless communication gateway. This information is saved in the gateway's local database and then transferred to an external database via a Wi-Fi connection. Although the usage of the Zigbee protocol lowers the cost of the system, the range is still limited when compared to the LoRa Gateways that we propose for our system [2].

The project's goal is to use LoRa as a transceiver to monitor air quality, with three sensors: MQ-7 for CO detection, MQ-135 for NO_2 detection, and MQ-136 for SO_2 detection. The Raspberry–Pi is used to process data from the sensor, and the data is then delivered to the user via the LoRa Module. The Raspberry Pi was used to develop the prototype, which necessitates a complicated and costly system design that may not be suited for large-scale deployment [4]. The use of Raspberry Pi for working and implementation was highlighted [5].

III. PROPOSED SYSTEM

2.1 LoRa Module

The hardware design and technical operation of the proposed system are presented in this part.

The LoRaWAN technology is used in this system, and it is its USP. First and foremost, we wanted to create a system that was both cost-effective and energy-efficient, and the LoRa module fitted perfectly into that category. To demonstrate our thesis, it is a cost-effective technique to move data from one location to another because it operates on freely available frequency ranges. In India, the accessible frequency is 868MHz. When it comes to battery life, the LoRa module claims to last up to a year on a single 12V battery.

The goal of using the LoRa module is to install the main system in the surrounding area and then use a receiver device to acquire data on air quality in your home without having to access the internet. Because LoRa uses point-to-multipoint communication, a single transmitter device can broadcast data to several receivers in different places if they are within range (which depends on the type of antenna used).

Another advantage of LoRa over Bluetooth, Wi-Fi, and Zigbee is its extremely long-range, which can reach tens of kilometers in some cases. The module we use is the RFM95-W, which requires a 3.3V power for operation, which is easily obtained, and we can also use a wire as an antenna if we only need to connect for a few meters.

2.2 ARDUINO-UNO

Our system's processor is an Arduino Uno. It is inexpensive and has all the characteristics needed to make the system operate, therefore it is ideal for our system because we didn't need a powerful microcontroller when we could acquire the same capability as a basic microcontroller.

The Arduino UNO can operate at both 5 and 3.3 volts. Our sensors are powered by 5V, while the LoRa module is powered by 3.3V. It also contains enough analog and digital pins to convert data from the sensors as well as connect the LoRa module.

2.3 MQ Sensors (MQ135, MQ7, MQ7)

The MQ135, MQ7, and MQ4 sensors are utilized in this application to calculate different pollutants such as CO_2 (Carbon Dioxide), CO (Carbon Monoxide), CH_4 (Methane), and Smoke. These MQ sensors feature a SnO_2 (Tin Oxide) coating on top that detects the specified gas. The resistance of these sensors changes after sensing this gas (R0). This alters the voltage (between 0 and 5V) of these sensors, which influences the data we generate.

MQ135 is used to detect CO2, MQ7 is used to detect CO, and MQ4 is used to detect CH4 and smoke. The values are expressed in parts per million (ppm).

2.4 DHT 11

The DHT11 sensor consists of a capacitive humidity measuring element and a thermistor for temperature detection. A moisture-holding substrate serves as a dielectric between the two electrodes of the humidity sensor capacitor. The capacitance value changes as the humidity level changes. The IC measures, processes, and converts the resistance values into digital form.

This sensor measures temperature with a Negative Temperature coefficient thermistor, which causes its resistance value to drop as the temperature rises. This sensor is often built of semiconductor ceramics or polymers to get higher resistance values even with minor temperature changes.

2.5 LCD

The LCD module is installed on the receiver, and it shows the data received by the LoRa module.

Because the display is 16*2, we display the data three times, overwriting the previous values every three seconds.

2.6 SOFTWARE ARCHITECTURES

2.6.1 ARDUINO-IDE

The Arduino IDE (Integrated Development Environment) is used to program the Arduino Uno, which is present on both the transmit and receive sides.

For the transmission portion of our system, we utilize Arduino libraries like as 'LoRa.h,' 'MQUnified.h,' 'MQ7.h,' 'MQ135.h,' and 'DHT.h.' All these libraries are used to compute sensor values in their respective parameters before sending the data to the receiver module.

We utilize 'LoRa.h' for the receiver component of our system (to receive data from the transmitter) and 'Liquid Crystal I2C.h' for displaying the data received on the LCD.

IV. BLOCK DIAGRAM

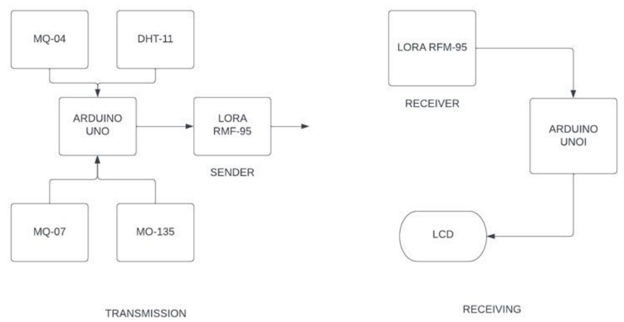

Figure 4.1 Block Diagram

- The connection of the sender is as follows: MQ-04, MQ-07, MQ-135, and DHT-11 are connected using Arduino and LoRa modules respectively.
- The LoRa module operates at 3.3V volts.
- MQ sensors are carefully calibrated to give precise value.
- The gas sensors detect the gases in the open environment.
- Lora Module helps us to deliver this sensor value to the other end of another LoRa module waiting to receive that sensor value.
- The connection of receiving end is as follows: LoRa module, LCD connected to Arduino UNO.
- At receiving end, the LoRa module captures the sensor values and we print the value on the LCD.

V. PROCEDURE

5.1 TRANSMISSION

We connect all of the sensors to the Arduino UNO for the transmission portion of the system, which will calculate the values of pollutants as well as temperature and humidity. We do this by connecting the MQ135, MQ7, MQ4, and DHT11 sensors to the Arduino Uno's analogue pins and powering them with 5V from the Arduino Uno. Because the LoRa module is for communication, we connect it using the digital pins of the Arduino Uno and power it with the Arduino's 3.3V.

To programme the Arduino, we first use the Arduino IDE to calibrate the sensors, and then we utilise the calibrated readings to obtain the values of various pollutants, as well as temperature and humidity. The estimated values are subsequently transferred as packets to the receiver side of the system through the LoRa module.

To program the Arduino we use Arduino IDE first to calibrate the sensors and then use the calibrated values appropriately to get the values of different pollutants along with temperature and humidity. The calculated values are then sent via the LoRa module in form of packets to the receiver side of the system.

5.2 RECEIVER

Another LoRa module linked to an Arduino Uno is required to receive and interpret the packets provided by the transmission side. We analyse the incoming packets and then divide the data into sub-packets that truly separate all of the values, which are then shown on the LCD.

5.3 TESTING

Following code creation, software testing begins. The code, as well as the sensors, are tested under various settings and compared to the real results to ensure that they are correct and in sync with the ambient conditions.

VI. IMPLEMENTATION

The design must be converted to machine-readable code. This is done at the implementation process. During this step, the code is produced. The entire system is separated into two parts: transmission and reception.

On the transmitter side, all of the sensors needed to detect temperature, humidity, CO2, CO, CH4, and smoke are linked to an Arduino Uno, which is in charge of processing the data from the sensors. Because MQ135, MQ7, and MQ4 are analogue sensors, they must be calibrated beforehand in order to get near-accurate results. A LoRa module is also connected to an Arduino Uno, which serves as a transmitter, sending data from the sensors in the form of packets.

The Arduino Uno is connected to a LoRa module and an LCD on the receiving side. The LoRa module on this site is in charge of receiving and interpreting the data supplied by the transmitter. The recorded data is now shown on the LCD.

VII. RESULT

The readings were taken in the early morning period in the Katraj area in the city of Pune, India.

Parameter Being measured	Calculated reading	Actual reading
CO (Carbon mono oxide)	8.4 PPM	8.38 PPM
CO2 (Carbon dioxide)	587.55 PPM	587.5 PPM
CH4 (Methane)	0.07 PPM	0.071 PPM
Temperature	31.80 C	31.8 C
Humidity	70%	70.11%

Table 7.1

The readings which are obtained are in coherence with the actual readings and the AQI is proven to be good.

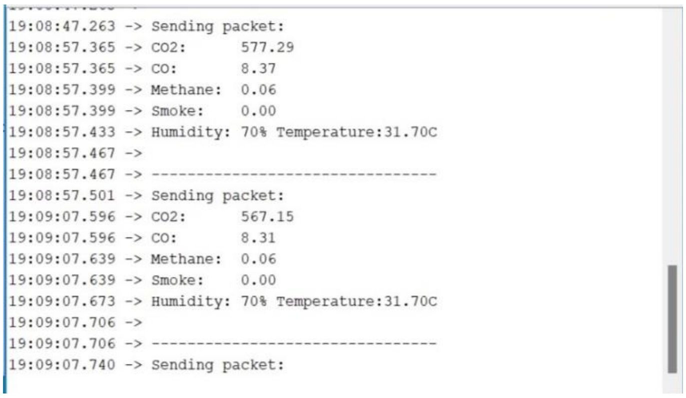

Figure 7.1 Sending Data Packets

Alt Text for Numerical Data [16 words]: Figure depicting the transmission of packets with values of CO2, CO, Methane, Smoke, Humidity, and Temperature.

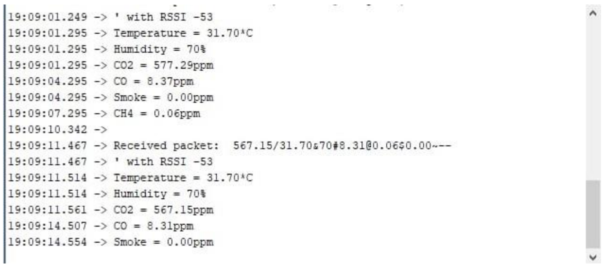

Figure 7.2 Received Data Packets

Alt Text for Numerical Data [16 words]: Figure depicting the reception of packets with values of CO2, CO, Methane, Smoke, Humidity, and Temperature.

Figure 7.3 LCD Display-1

Alt Text for LCD Display [10 words]: Values of CH4 and AQI being displayed in the LCD monitor

Figure 7.4 LCD Display-2

Alt Text for LCD Display [10 words]: Values of CO and smoke being displayed in an LCD monitor

Figure 7.5 LCD Display-3

Alt Text for LCD Display [11 words]: Values of Temperature, humidity, and CO2 being displayed in an LCD monitor

VIII.CONCLUSION

The Air Quality monitoring system described in this study addresses many of the drawbacks of standard pollution measuring systems, which rely on wireless transmission technologies with a range of little more than 100 metres, such as ZigBee and Wi-Fi. My suggested method is a low-cost alternative that does not require any phone or data expenses (as a cellular-based system would). It has a compact size and transmits in real time..

Based on realistic studies conducted in both indoor and outdoor contexts, the system has demonstrated its capacity to detect and categorise pollution levels. In comparison to other wireless transmission approaches, the experience with LoRa transmission has proven that LoRa technology is extremely suited for the air pollution system, especially in long-range transmission. Meanwhile, the dashboard simplifies the viewing of real-time data. The system consumes far less power than conventional systems and can readily function on battery power for several days.

With air pollution becoming such a serious concern, there is a lot of potential for this project.

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