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Design and Implementation of a Smart Network Using Lora for Measuring Environment Parameters

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Abstract: With the rapid development of the Internet and The Internet of Things (IoTs), various convenient service applications are being used in various fields. In recent years, weather forecast and air quality monitoring plays a vital role in the modern era as agricultural and industrial sectors are principally dependent on environment parameters. The proposed system is an intelligent service platform that is based on a wireless sensor network and LoRa communication technology. The proposed system uses LoRa as a network transmission interface to solve problem of communication failure and save energy as most of the wireless communication technologies have a high-power consumption and short transmission distances therefore it doesn't meet the requirement of IoT applications for communication. Consequently, LoRa technology has been proposed. It is battery-powered and operates for several years without the need for a battery replacement, so it can be used in outdoors. We use several temperature, gaseous and meteorological sensors (MQ-2 &MQ-135) which are interfaced to the Arduino board that monitors changes in the physical world and the information collected is send to an Arduino Uno for pre-processing. Arduino Uno uses LoRa communication components for information exchange and the data is stored in the cloud server i.e., Thing Speak so the user can see the real time data and its changes with the help of a smart phone or a PC connected to the internet.

Keywords: MQ-2, MQ-135, DTH11 Sensors, IoT, LoRa

1. Introduction

In recent years, weather forecast and air quality monitoring had been playing a vital role in the modern era as the agriculture and industrial sectors are primarily dependent on environmental parameters. The farmers need a more reliable source to monitor the changes in the weather and the urban citizens also need a reliable source to monitor the air quality in their neighbourhood. In current conditions it won't be too long before these requirements become our necessities. So, what if these two tasks can be accomplished by one system. This idea had laid a foundation for doing this project. We had stumbled upon this project to find a solution for the above problem.The proposed system is an intelligent service platform that uses numerous wireless sensor networks and LoRa communication modules for the purpose of sensing the information and transmitting it without the problem of communication failure. In this system all the sensors are interfaced with the Arduino Uno board and the sensed values from the sensors get back to the Uno board and then the data is transmitted and uploaded to the ThingSpeak API so that the user can see the real time data with accurate changes.

2. Literature Survey

There have been several researches in the field of weather forecast and air quality monitoring which had been used to develop a very good model for sensing the accurate changes in temperature and concentration of various gases in the nearby vicinity and we had got a few valuable notes from the completed models as from the below mentioned journals:

[1]Yi-Wei Ma and Jiann-Liang Chen, "Toward Intelligent Agriculture Service Platform with LoRa- based wireless Sensor Network"-The data from various sensors is analysed and sent to a central node using LoRa so it can be sent to the users. By using LoRa we can overcome long distance communication problems.

[2] J. Haxhibeqiri, A. Karaagac,F. Van den Abeele, W. Joseph, I. Moerman and J. Hoebeke, "LoRa indoor coverage and performance in an Industrial environment"-By using LoRaWAN and a gateway we can communicate with 6000 trolleys or nodes within a distance of 34000m² so that we can track each and every trolley in an auction.

[3] S. Persia, C. Carciofi and M. Faccioli, "NB-IoT and LoRa connectivity analysis for M2M/IoT smart grids applications"-When we combine both cellular technologies and LoRa we can cover large area and can address many solutions basing the new combined technology.

[4] A. Makhoul and H. Harb, "Data Reduction in Sensor Networks: Performance Evaluation in a Real Environment"-By changing some parameters like sampling rate and sensing rate we can overcome the large data transmission and power loss.

[5] Ravi Kishore Kodali, Subbachari Yerroju and Shubhi Sahu, "Smart Farm Monitoring Using LoRa Enabled IoT"- The Smart farm monitoring model proposed in this Paper utilizes LoRa communication mechanism to send sensor data like temperature, humidity and soil moisture from transmitter node to receiver node using LoRaWAN or LPWAN and the data is stored in the IBM Watson IoT platform for monitoring.

[6] Tommaso Addabbo, Ada Fort, Marco Mugnaini, Lorenzo Parri, Stefano Parrino, Alessandro Pozzebon, Valerio Vignoli, "An IoT framework for the pervasive monitoring of chemical emissions in industrial plants"- In this work an IoT framework for the monitoring of chemical emissions in industrial plants is presented. The proposed system can embed different sensors. In particular, each sensor node manages a humidity sensor and an array of temperature and electrochemical gas sensors for the detection of CO, NOx and O2. Then we use LoRa LPWAN connectivity which allows Wide area data transmissions.

[7] Jithina Jose & T. Sasipraba, "Indoor air quality monitors using IOT sensors and LPWAN" -In this paper we are identifying the indoor air quality with the help of internet of things by using the sensors BME680 from bosch,SGP30 and CCS811 and low power wide area network (LPWAN) for the data transfer. Here we are separating the gases CO2 equivalent, Ethanol, TVoC and so on. For transmitting this IOT information, we require high vitality productive sensor hubs that can impart crosswise over long separation. This propels the improvement of some Low-Power Wide Area Networks (LPWAN) advances, for example, LoRa, to satisfy these requirements. The reports are exhibiting the destructiveness of air that we are taking in step by step. Here we are trying to give a social awareness by using this paper.

[8] T. Porselvi; Sai Ganesh CS; Janaki B; Priyadarshini K; Shajitha Begam S, "IoT Based Coal Mine Safety and Health Monitoring System using LoRaWAN" -In the mine laborer area, air contamination is primarily due to the outflows because of emissions of particulate matter and gases incorporate such as Sulphur dioxide (SO2), Nitrogen dioxide (NO2), Carbon monoxide (CO) and so forth we are utilizing two smoke sensors to monitor the diverse type of smoke level in the mine. To monitor the concentration level of unsafe gases, semiconductor gas sensors are utilized. If any smoke sensor value goes beyond the threshold range at that point the microcontroller will allow an alert to the person through a buzzer and sends the information to the monitoring section through the LoRaWAN module and in the monitor received data will be uploaded in the webpage through IoT.

[9] Josh Lentz, Skyler Hill, Benjamin Schott, Mert Bal, Reza Abrishambaf, "Industria-l Monitoring and Troubleshooting based on LoRa Communication Technology" - The general procedure and the details of implementation are presented through a prototype implementation performed on production machines of a food processing plant. Proposed system consists of LoRA-based wireless motes that record the variations in operating temperature and vibrations on production machines through sensors and, wirelessly report summary data in real-time to a developed monitoring software interface for system diagnostics, troubleshooting and preventative maintenance.

[10] Chiao-Lun Lee and Jin-Shyan Lee, "Development of Indoor Air Quality Supervision Systems Using ZigBee Wireless Networks" - Recently, due to the increase of environmental awareness, air quality has attracted much more attention. In this paper, an indoor air quality supervision system using ZigBee wireless networks has been proposed. The developed system provides a simple way to monitor and control the indoor air quality (IAQ) for residential building applications. In this present scheme, several sensors are employed to detect a variety of gases, such as carbon monoxide (CO), carbon dioxide (CO2), as well as the fine particulate matter (PM2.5). In addition, by using the developed user interface APP, people could observe the real-time status anytime and anywhere.

3. Proposed System

The proposed system is an Intelligent Service platform which uses several temperature, gaseous and meteorological sensors and LoRa communication modules. All the sensors are interfaced with the Arduino Uno board and the changes or the valued sensed by the sensors are then sent to the Arduino Uno board and in turn the Arduino Uno board make use of the LoRa transmitter to transmit the sensed environment parameters. And the LoRa receiver part decodes the information which had been received from transmitter, which had been sent in an encoded format. This decoding is done with the help of the Arduino Uno board and then the information is shared with the ESP8266 module which in turn is connected with a wireless network and uploads the sensed values in the cloud server. The cloud server that we use here is nothing but ThingSpeak API which allows the user to see the real time changes in the temperature, the sensed environment parameters are shown to the users in a graphical format and the user can also download the report in JSON, XML and CSV formats.

3.1 Block Diagram:

- The block diagram is illustrated with the help of two blocks one is the Transmitter part and the other is the receiver part.
- The transmitter part consists of DTH11, MQ2, MQ135 sensors interfaced with the Arduino Uno board and the Arduino Uno board is connected to the LoRa module.
- The receiver part consists of a LoRa module to receive the data and Arduino Uno board and ESP8266 module.
- Both the transmitter and receiver blocks are each connected with a rechargeable 12V battery along with the Voltage protector circuit.

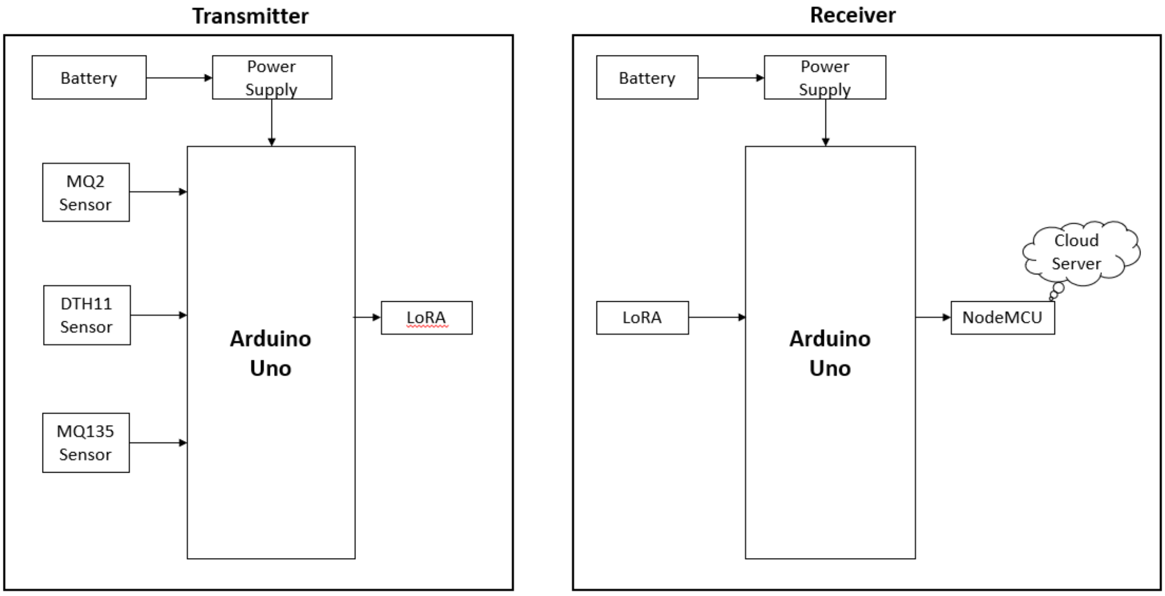

Fig 3.1: Block diagram of Proposed System

3.2 Connection Diagram:

Connection diagram also play an important role while assembling all the components together, a good engineer knows to setup components in the suitable place which in turn reduces the complexity and also solve the wiring issues.A pictorial diagram would show more detail of the physical appearance.The below figure shows the connection diagram of the transmitter part in which all the components are arranged in good manner, in the transmitter part we had used Arduino Uno, DTH 11 sensor, MQ 2 sensor, MQ135 sensor as the main components.

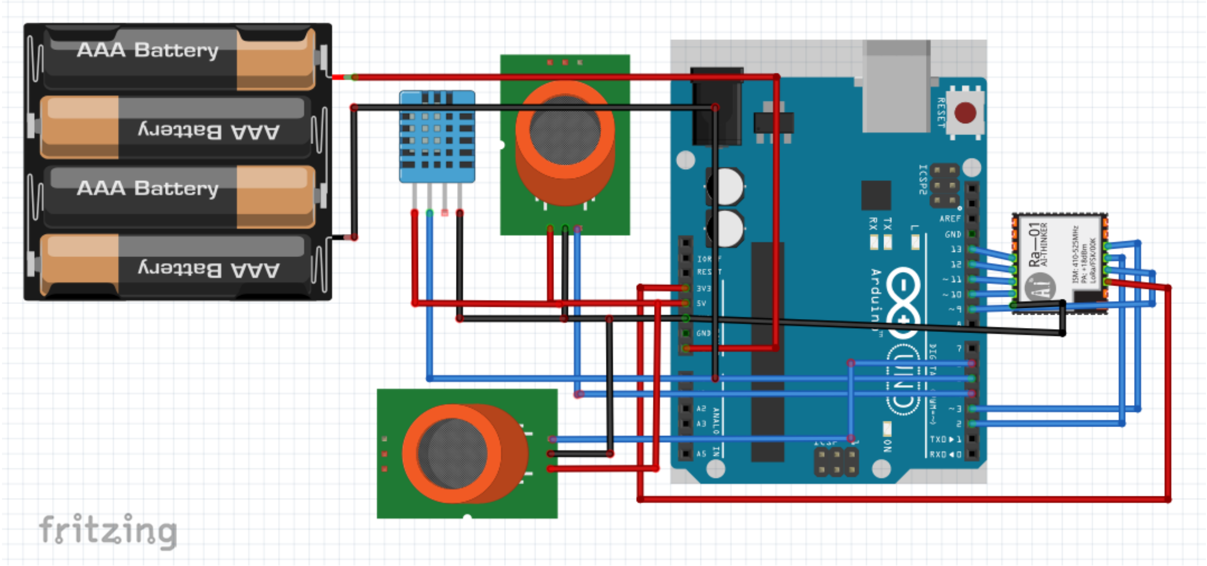

Fig 3.2: Connection diagram of Transmitter Part

The below diagram shows the connection diagram of the Receiver part where the main components used are Arduino Uno, ESP 8266 or Node MCU.

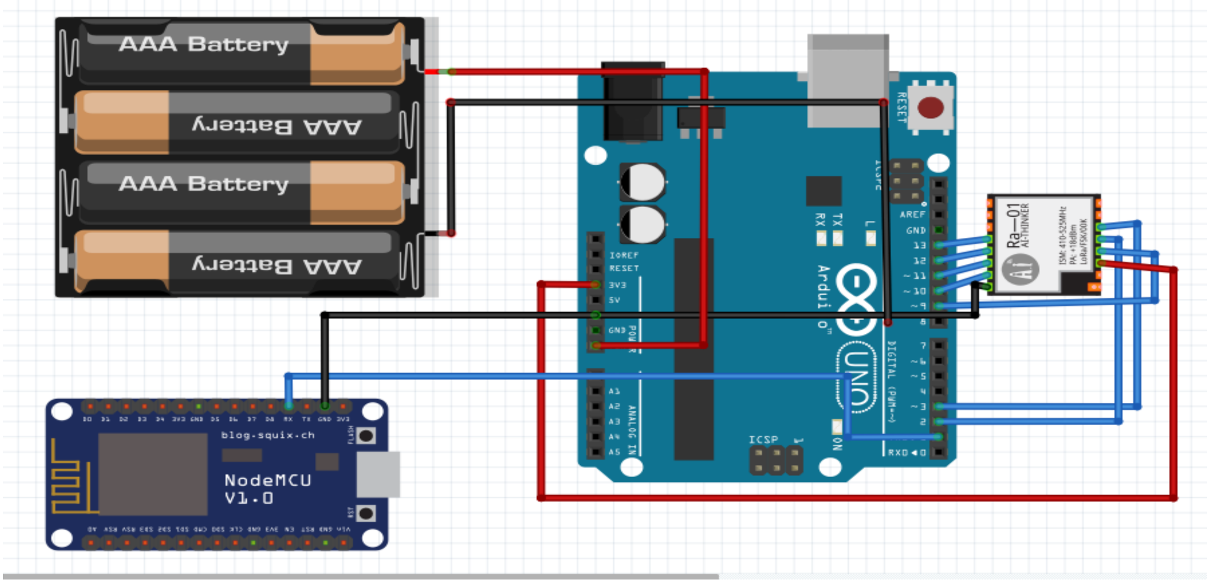

Fig 3.3: Connection diagram of Receiver Part

3.3 working Principle:

The changes in the temperature and concentration of various gases are sensed using MQ2, MQ135 and DTH11 sensors and then these sensors values are sent to the Arduino Uno board in digital form. The Arduino Uno converts this information into a single string and this information is transmitted with the help of LoRa module. The information or the data received by the Receiver LoRa module is in encoded format and the single string is divideinto substring using the coding techniques and the respected parameter values are then communicated with the ESP8266 module which in turn is connected with a wireless network and uploads the corresponding values to the Thing Speak API. The Thing Speak API stores these values in several fields and display it to the user in a graphical format and even the changes in the environment can be communicated with the user using MQTT protocol.

4. Applications

1. Used in Agriculture for better Crop yielding:

The proposed model can be used in the Agricultural sector for monitoring the changes in the humidity levels which is also known as the water vapour content and we can water the crop accordingly. So, we can get a better yield.

Fig 4.1: Crop Yielding

2. Used in Green Houses for monitoring the temperature levels:

The plants and herbs which had been growing in the green houses had to be monitored constantly regarding the temperature and humidity levels because the plants had to be grown at particular conditions. So we can use the LoRa communication feature in the large gardens and nurseries and can send the data over the wide area.

Fig 4.2: Green House

3. Used in Pharmaceutical Industries for measuring air quality:

LoRa based Smart communication network model can be used pharmaceutical industries to detects the traces of any toxic gases leaked during the manufacturing process and the necessary actions can be taken to control the situation and the corresponding timestamp values can also be obtained when we can download the entries from the Thing Speak site.

Fig 4.3: Pharmaceutical Industries or Companies

4. Can be used in the Industrial Areas:

This system can be used to measure the levels of toxic gases and their concentrations in the atmosphere in nearby industrial areas. So, the concerned authorities can take care of the problem and can come up with any remedies. If added with some extra features the precise quantity of gases concentration can also be determined in this model.

Fig 4.4: Industrial areas

5. For display of temperature and Air quality levels in Metropolitan cities:

We can use this model and integrate it with the Large Led screens across the vicinity to display the sensed values by the network. So, the people can know the environment around them.

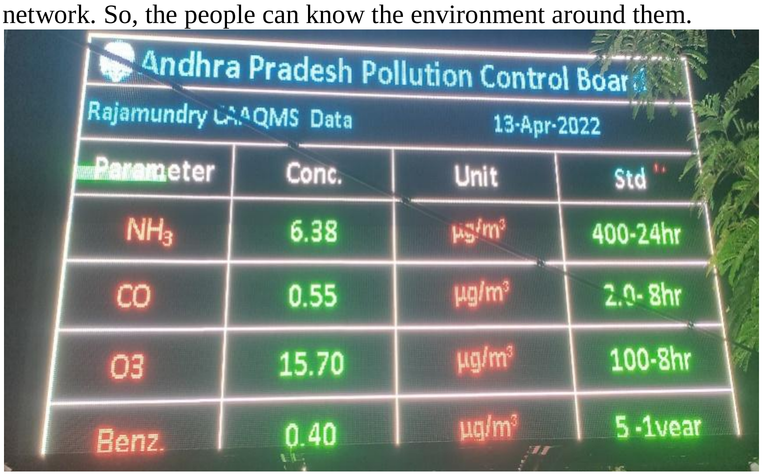

Fig 4.5: Air Quality Index Screens

5. Results And Discussion

The values from the temperature, MQ2, MQ135 sensors are updated to the Thing Speak API and the users can see the changes in the values in the graphical format from time to time and the user can also download the report which consists the values of sensed parameters in JSON, XML and CSV file formats.The below figure shows the outputs of various sensors caught in the serial monitor, when we run the code in the Arduino IDE Software:

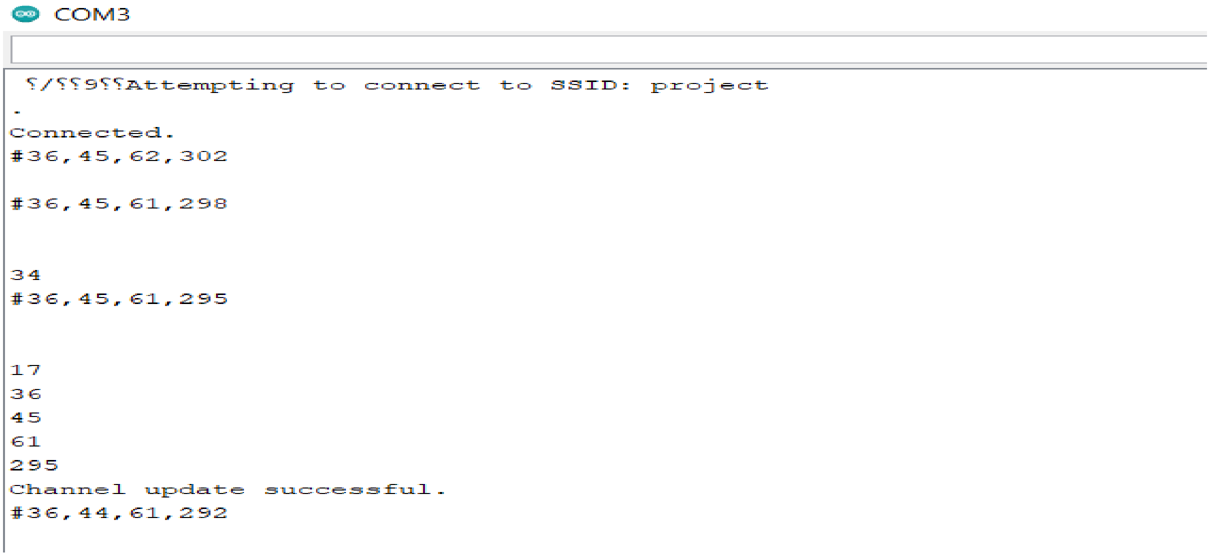

Fig 5.1: Output shown in the Serial Monitor section of the Arduino IDE

The output mentioned in the figure 5.1 will be obtained when we run the code in the Arduino IDE software and the output of the corresponding code will be displayed in the Serial Monitor part of the Arduino IDE. The figure shows the output in graphical format from the values sensed by various sensors:

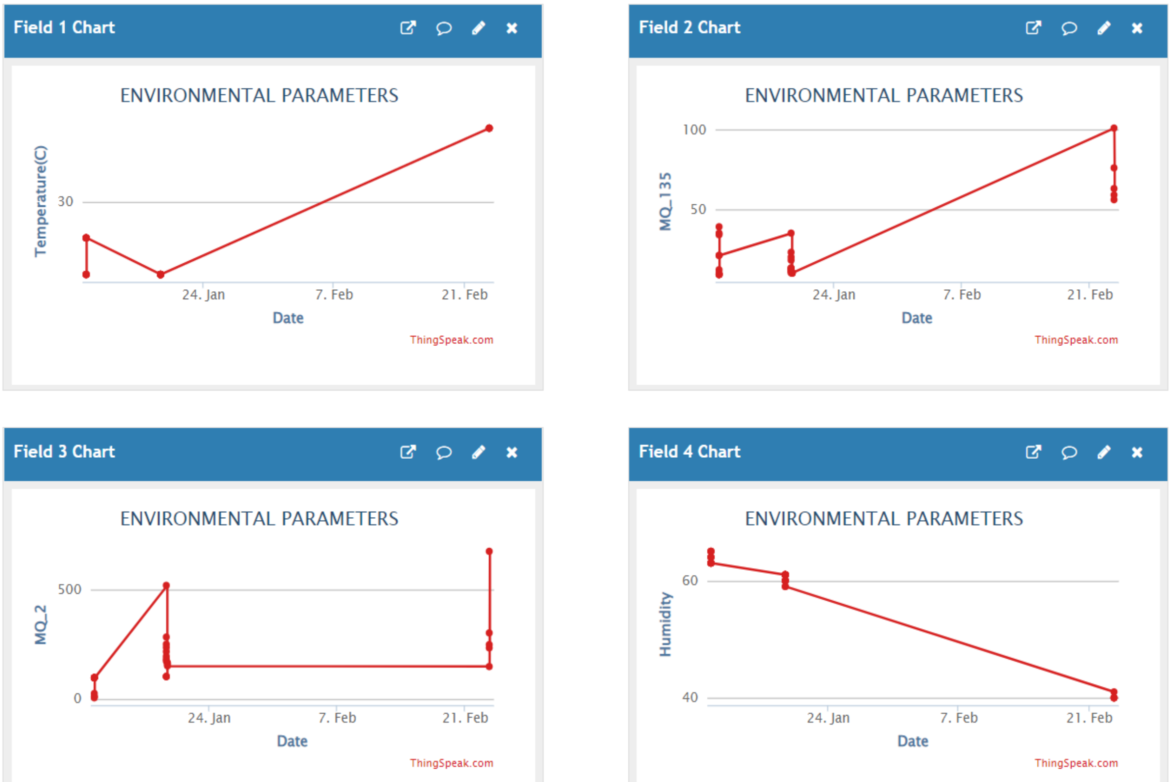

Fig 5.2: Output shown in the Thing Speak API in graphical format

The output of the above figure 5.2 will be obtained when all the outputs from the sensors are measured and only when the receiver part gets connected to a network then the outputs measured from these sensors will be directly updated to the Channel id as mentioned in the code part and we can see the data in the Graphical format.

We have tested the prototype kit in the real time environment at different locations, the locations are as mentioned below:

1. We had placed the transmitter kit at the location: JCWF+6CW Tirupati, Andhra Pradesh (13.6456125, 79.4235781) and the receiver kit at the location: JCWF+5RTirupati, Andhra Pradesh (13.6454375, 79.4245625) with both the distance between the kits as 110 meters and the values got updated to the Think Speak server with the entry id 120.

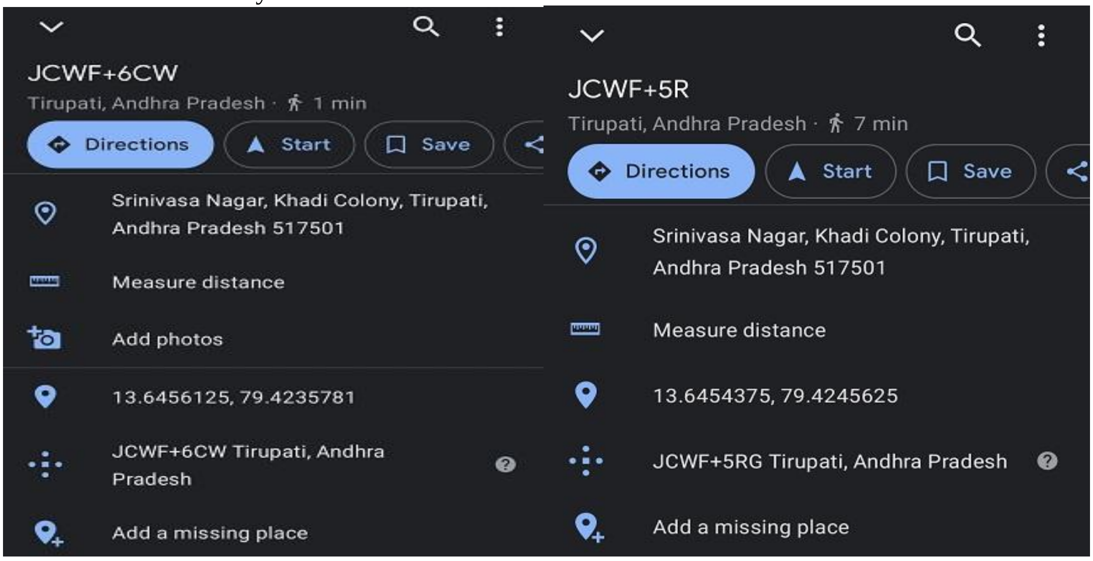

Fig 5.3: Test location coordinates for entry id 120.

2. We had placed the transmitter kit at the location: JCWF+5RTirupati,Andhra Pradesh (13.6454375, 79.4245625) and the receiver kit at the location: JCWG+2MW Tirupati, Andhra Pradesh (13.6451125, 79.4267031) with both the distance between the kits as 250 meters and the values got updated to the Think Speak server with the entry id 135.

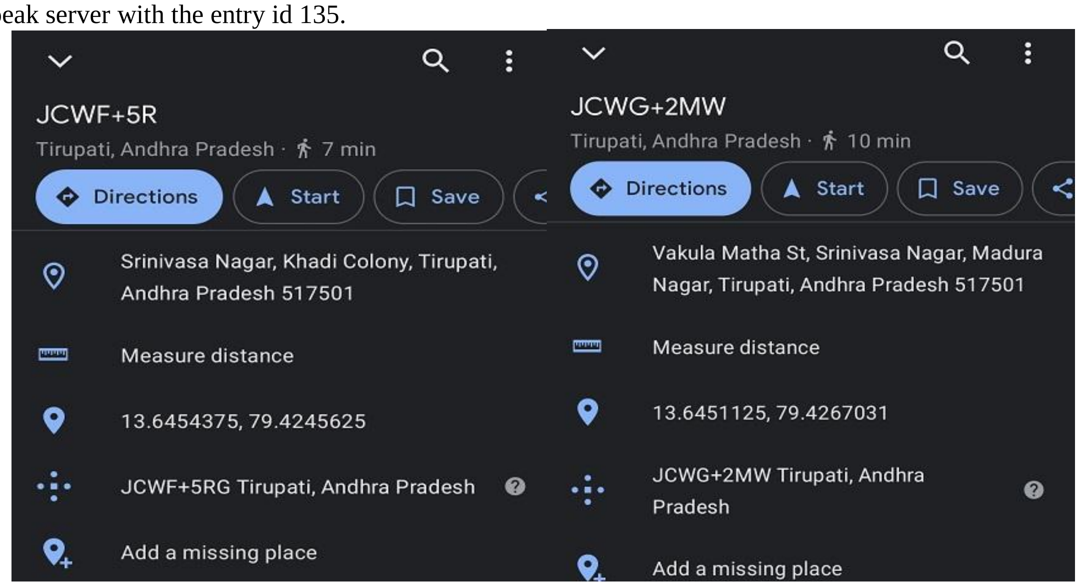

Fig 5.4: Test location Coordinates for entry id 135.

6. Conclusion

The Proposed system is used to measure the environment parameters such as temperature (ºC), humidity and it can also detect the traces of Carbon monoxide, Ammonia (NH3), Sulphur (S) and Carbon Dioxide (CO2) and these sensed values can be communicated to the user using LoRa WPAN which is a wide area network. The proposed system can be used in Agricultural and in Industrial sectors for measuring the environment parameters and the sensed data from various sensors in the model can be displayed in the graphical format in the ThingSpeak website.The proposed model can be utilized in a wide variety of projects in the future and the scope can be increased to a wide range. In the future we can add features to the proposed model like adding sensors like soil moisture module for detecting the moisture content in the soil and even we can add Light Dependent

Resistor (LDR) to measure the intensity or brightness of sunlight for agricultural purpose. We can also add MQ5 sensor to this model which can be used to detect LPG and Alcohol, so that it can be used both in households and even in Industries also.

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