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Design of Air Quality Analysis Monitoring Using LoRaMOTE Developing Module

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Abstract: ***Recent researches on LoRa Technology which provide the low power and long range over 20km have been very attractive. LoRa Technology is one of the most developing technology in modern communication link. The overall LoRa network comprises of the gateways, network servers and end nodes. The LoRa network that can be used for either star or mesh topology. The gateways are called as base station or concentrators and end devices are also called as motes in LoRa. LoRaWAN is a protocol specification which is only top of LoRa technology. It uses unlicensed radio spectrum in ISM band. However, the feasibility of LoraWAN for smart city application need to be investigated. Now a day air pollution is a major problem in every cities. Air pollution is not only an environmental problem but also a social problem. This paper provides the analysis of LoRaMOTE and developing module for air quality monitoring. The old method of monitoring air quality is time consuming, low precision and costly. Therefore, there is a need for continuous monitoring of air quality parameters in real time. Air quality parameters are measured by different sensors such as pH, humidity, temperature, PM sensor. The device has been tested in the city and the measurement was compared with the output of the pollution control authority stations.***

Keywords: LoRa (Long Range), LoRaMOTE board, Lo- RaWAN, Sensors, Smart City

1. Introduction

Monitoring is a practice to measure the ambient levels of air pollution in an area. The results of which indicate the status of quality of air we breathe. Each person needs approximately 13,000 litres of clean air per day. Monitoring data over a long time is useful to find out patterns that helpand support air pollution control policy. Air pollution monitoring itself does not reduce air pollution, it gives us ideas as to where the pollution is coming from and what is its level. Air Quality Monitoring using LoRa (Long Range) has become a very popular upcoming technology in the modern wire- less communication link. Any systems which provide fewer amounts of data over long range of several kilometres employ this technology. LoRa is generally based on Chirp Spread Spectrum Modulation technique which uses linear wideband frequency modulated chirp pulses to encode the information. The architecture designed for LoRa technology incorporates the Nodes and Gateways which communicate with network server. Various topologies are employed for Communication which includes Star, Mesh etc. In LoRa a single gateway or base station can cover entire cities or even hundreds of square kilometers of which the range depends on the environment or obstacles in the given area. LoRa and LoRaWAN have superior advantage of link budget greater than any other standardized communication technology. The key features of LoRa include its capability to enable GPS-free location, low power tracking technology, long range. AlsoLoRa technology operates in unlicensed ISM band which portrays low spectrum cost.

The Communication Technology where there is more num- ber of connected nodes employs Security. Security can be achieved at different levels. In specicLoRa achieves Security at two different layers. One is the Security for the network layer and for the application layer. In network Layer security is achieved by the reliability of the node in the network. In application layer the operator does not have access to endusers application data. Generally the architecture of Lora comprises of the devices which are connected to the Gateways further to the network server and then to the applicationserver.

Air pollution is a major environmental issue in Coimbatore. Coimbatore is the second largest city (by area and popula- tion) in the state. Air pollution is increased day by day in Coimbatore due to rapid growth in vehicles and industries. So monitoring air quality is important.

LoRaWAN Device to device communication is established using the scheme based on LoRaWAN Mac command which uses two MAC command list such as Secure D2D Req, Secure D2DAns to enable security between nodes in Communication. The energy consumption in the proposed scheme increases by 4-5 % which has little effect on the lifetime of the end node [1]. Monitoring of Large-Area IoT sensors using a LoRa shows good performance for long range transmission in the country side. Design of LoRa wireless mesh network system for collecting data from IoT sensors distributed across a large geographical area. Wireless Mesh Networking is a solution for increasing communication range and Packet DeliveryRatio without the need of additional Gateways. LoRa Mesh Network achieved an average 0f 88.49 %PDR whereas star topology achieved 58.7 %under the same settings was reported in [2]. Low Power Wide Area networks are making fantastic progress from design, standardization and commercialization. The effects of interference have been investigated via single

gateway with LPWA technology. Unlike other wireless networks, LoRa employs an adaptive Chirp Spectrum modulation scheme. This extends the communication range in the absence of any interference was reported in [5].

Infrastructure aging, vehicular mobility, energy consuming, individual safety are some of the problem that place serious issues on the economic sustainability of human activities as well as the life in urban areas. As afact, the survey in last decades the livability of every cities has been worsening significantly and it is expected to get worse in future. The percentage of population in urban areas is expected to reach 66 % in 2050 as compared with 54 % in 2014[6].

The research on low power wireless networks with the massive number of devices has been very attractive. Multi-hop shortrangecommunicationtechnologiessuchasBluetoothand Zigbee have been implemented by IoT. These technologies provide low power consumption and very limited coverage. Wireless networks which are able to provide transparent coverage which play a vital role in spread of IoT. Howeverthe current wireless network technology were not able to provide the services to the more number of devices. Therefore the development of Low Power Wide Area Network (LPWAN) using LoRa technology is needed [7].

Technological developments in embedded systems and new gas sensors provide a low cost air quality monitoring systems to emerge. These sensors are widely accepted and implemented because of the development of emerging electronic technologies. The number of devices increased in the last five years but the data generation which they provide is still questionable [8].

A small and portable ozone measurement system Gas Mobile is proposed in [9]. It uses a particular sensor and it is connected with the transmitter board. This allows the easy connection between the sensor and the users smartphone through the USB port. It is very compact and upload the accurate data to the server. But it has refer only single gas and the readings are very limited [9].

2. System Architecture

a) LoRa

The LoRa architecture comprises of three namely End Devices, Gateways and the Network Server as shown in Fig.1.

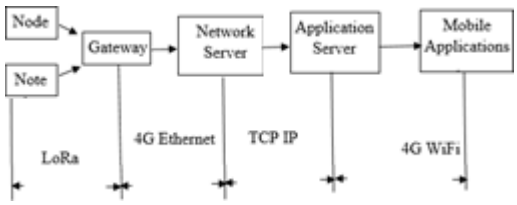

Figure 1: Block Diagram of LoRa

1) *End Nodes:* End-Nodes transmit directly to all gateways within the range, using LoRa. The End Nodes are LoRa embedded sensors. The nodes typically have, i) Sensors (used to detect the changing parameter e.g. temperature, humidity, accelerometer, GPS), ii) LoRa transponder to transmit signals over LoRa patented radio transmission method, iii) Optionally a Micro-Controller (with on board Memory)
2) *Gateway:* The LoRa sensors transmit data to the LoRa gateways. The LoRa gateways connect to the internet via the standard IP protocol and transmit the data received from the LoRa embedded sensors to the Internet i.e. a network, server or cloud. The Gateways devices are always connected to a power source. The Gateways connect to the network server via standard IP connections and act as a transparent bridge, simply converting RF packets to IP packets and viceversa.
3) *Network Layer:* The network server connect to the Gateways and de-duplicate data packets, and then routes it to the relevant applications. The network server can be used for both Uplink (i.e.Sensor to Application) and Downlink (i.e. Application to Sensor) Communication.
4) *Application Layer:* Network Server forwards received uplink frames and Acknowledgements to Application Server. It can be any LoRa App server or any Application server developed on ourown.

b) LoRaMOTE Description

LoRaMOTE consists of four section namely GPIO (General Purpose Input Output), Communication Section, Power Selection, Power Section as shown in Fig. 2.

Figure 2: LoRaMOTE

The LoRaMOTE Module comprises of 14 General Purpose Input Output Pins. These pins are restricted to sink and source capabilities. The pins can be of logic inputs or outputs. Some pins have analogue input capability that can be accessed via module firmware. These lines can be connected to switches, LEDs, and relay outputs. The Communication section is designed with transceiver module such as RN2483 which is a module based on 434 MHz, 868MHz frequency range. The Host interface is UART and the total pin count is about 47. The LoRaMOTE internal circuitry is powered at 3.3 V. It can also be supplied with 9V alkaline battery through the USB connector. The power switch is used to select whether the board is powered from the USB or from the battery. The LoRaMOTE is active when both a battery and USB connector are power supplied and also the switch is rendereduseless.

c) RN2483

The RN2483 Transceiver module features LoRa technology RF modulation which provides long range communication with high interference immunity. This RN2483 module delivers exceptional phase noise, selectivity and receiver linearity.

LoRaWAN protocol connectivity is provided by the Mi-

crochip RN2483 module using UART interface. This module uses LoRaWAN class A protocol and provides an optimized text command/response interface to the host system. RN2483 consists of 14 GPIO pins that be configured through the UART interface. EEPROM is lowering the requirements for the host system while also increasing the system security. An end device consists of a host MCU which reads a sensor, commands the RN2483 to transmit the sensor reading over a LoRa network. The senor data are encrypted by RN2483 microchip and by using one or more gateways the radio packet is received which forward it through the network server. The network server sends the output data to the application server which has the key to decrypt the application server.

3. System Implementation

a) Coimbatore Smart City

Compared to the past five years of population in Coimbatore is significantly increased. The estimated population of Coimbat- ore in 2018 is 1.928 Million. Total area of Coimbatore district is 4.7232 square kilometer. In Coimbatore, the corporation installed the air quality monitoring device on a trial basis on Big Tank bund in Ukkadam and after finding it to be satisfactory, extended to 29 locations across the city. The areas it has installed include Puliakulam, Ukkadam bus stand, Gandhipuram Town Bus Stand, Selvapuram, Amma Canteen, Podanur, South Zone Office, Edayarpalayam, Ramanathapu- ram, Sungam and Flower Market.

Figure 3: Air Quality Monitoring Device

Figure 4: Air Quality Monitoring Device Setup

To monitor Coimbatores air quality approximately selected 50km x 50km domain. For our convenience this domain is further partitioned into 1 km grids. By using LoRa technology we can monitor carbon monoxide, nitrogen oxides, particulate matter and ozone. In Air Quality monitoring system Data generation is necessary because based on the data only we have to prepare the remedy for it. It will happen if the Corporation shares it with either the Traffic Police, Transport Department or the Tamil Nadu Pollution Control Board.

b) Gateway

Gateways form bridge between the End Devices and the Network Server as shown in Fig. 2. Devices use low power networks like LoRaWAN to connect to the Gateways, while the Gateway uses high bandwidth networks like Ethernet, WiFi to connect to the Network layer. All gateways receive the device messages and forward to the network layer. The Network layer will deduplicate the messages and select the suitable gateway to forward the any messages. A single gateway can use thousands of devices. The Gateway image as shown in Fig. 8.

Figure 5: Gateway

Gateways are called routers equipped with the LoRa concentrator which is used to receive the LoRa Packets. Generally two kinds of gateways are present. The first type of gateways running on a minimal firmware which has low-cost and easy to use. This type of gateway running only the packet forwarding software. The second type gateways running an operating system. Here the packet forwarding software is run as a background program. It gives more liberty to the gateway administrator to manage gateway and install their software.

c) TestingParameters

- AQI
- Sulphur Dioxide(SO2)
- Oxides of Nitrogen asNO2
- Particulate Matter (PM10) and Particulate Matter (PM2.5)
- Carbon Monoxide(CO)

4. Conclusion

With the rapid growth on industries and vehicles in every cities, making them smart become vital. This paper pro-posed an air quality monitoring using LoRa technology for Coimbatore city. The parameters like AQI, Sulphur Dioxide, Nitrogen Oxides, Particulate Matter 10, Particulate Matter 2.5 and Carban Monoxide are tested by using sensors. The data are shared with the Tamil Nadu Pollution Control Borador Coimbatore Corporation. Based on the data we have prepared the remedy to reduce the pollution. A LoRa technology making the system more comfortable, provide

long range can cover upto 20 km and low power consumption compared with the other wireless network technologies.

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