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# Implementation and Analysis of LPWAN Technology using LoRa Architecture

**M.Srisivanandhini**
SSN College of engineering Kalavakkam,
Chennai

**Dr. S.Chithra**
SSN College of engineering Kalavakkam,
Chennai .

***ABSTRACT—:*** *The recently proposed LoRa low power wide area network (LPWAN) technology is discussed and analyzed. First of all, performance metrics of a single LoRaWAN end device has been analyzed, namely uplink throughput and data transmission time. Then illustrative application scenario with the maximum number of end devices which can be served by a single LoRaWAN base station has been analyzed and the spatial distribution of these devices is discussed. The LoRa endpoints are the elements of the LoRa network where the sensing or control is undertaken. They are normally located remotely and battery operated. They can be setup to communicate with a LoRa Gateway. The end node comprises of a sensor, microprocessor and a LoRa transceiver. The gateway can receive from any LoRa device and is designed to be fully customizable for a targeted application with post-processing features based on high-level languages. It receives the transmitted data from the end devices.*

***KEYWORDS: LoRa, LPWAN, LoRaWAN***

## I. INTRODUCTION:

The Internet of things plays a major role in the country the main aim is to communicate through the distance so the technique like **LoRa, LoRaWAN and LPWAN** has been used. **LoRa** is meant for wireless communication protocol which is designed for low power communication, long battery life. The Semtech industry provide different RF module recently they provide SX1276 transceiver to communicate in the distance 1-5km and operate in the frequency between 868MHZ- 900MHZ in NOS (Non line of sight) & LOS (Line of sight). One LoRa gateway takes care of thousands of nodes which reduces the infrastructure and construction cost. SX1276 will work on through SPI pins and the following should be considering power, bandwidth, frequency, spreading factor and data rate. LoRa which is connected to wide area network said to be **LoRaWAN is low power wide area network** is secure communication for bi-directional, mobility and location based service. LoRaWAN specify different tiers of geolocation services like network based and GPS based. The network based geolocation is a low cost because it works on any LoRa transceiver. The location based technology will work on time difference triangulation (TDoA) and receiving up to ~30m accuracy in rural areas and ~150m for urban areas these services to operate the network to offer "**receive macro - diversity**" which means there are multiple base station connected to number of end nodes. The base station is used to grab the signal from tracker device. These technologies are best for agriculture, park, shipping trader goods and forest surveillance. In the current scenario like health monitoring, underground communication system etc… has the long battery life and frequency range achieving is challenging task. Whereas the presently communication modules like Wi-Fi, Bluetooth, zigbee communicates to sensor data which gives range and battery life but it has some drawbacks. To overcome in some aspects so the long range (LoRa) has been used to reduce cost, battery life and long range communications. The main aim of the project is to increase the range of communication that to control and monitor the system in long range. This project developed for sensing the pulse rate. The sensed data is sent to a gateway using the Long Range (LoRa) communication technique. LoRa device is used to communicate to number of nodes through gateway. Lora transceivers transmit the sensed data to the gateway where it receives the pulse rate value. Gateway provides information about the spreading factor, bandwidth, and payload size. The main process is to check the maximum range of communication from gateway to the end node. At the gateway the data is analyzed and interpreted to allow administrators to monitor the pulse rate status. This helps the administrators of doctors to effectively monitor patient health conditions with less man-power and with better accuracy. LoRa is a new spread spectrum modulation technique that operates in the 860-900 MHz ISM bands and enables low-data rata communication (100-500bps) over long distances (30-50 km in rural areas and 3-10 km in urban areas) by sensors for IoT applications. A LoRa Network can be setup using multiple LoRa gateways. These gateways are connected to the network server using either Ethernet, cellular or any other telecommunication link on wired or wireless mode. In order to implement this, a new protocol called LoRaMAC has been proposed by IBM, Semtech, Actility and Microchip. This protocol is an open source MAC protocol which is secure and uses advanced encryption standards. The LoRa technology has been deployed by SIGFOX in few areas across the world. The SIGFOX's network enables the communication between different IoT nodes. Currently, this has been implemented in applications such as smart environment, smart metering, tracking, agriculture and smart home. The challenges faced by using Wi-Fi, zigbee, Bluetooth technologies are:

•The support of limited number of nodes.

•The limited range offered by these devices and their low tolerance to interference.

• Limited interoperability between nodes.

To overcome this challenges by Lpwan technology using LoRa is implemented. The motivation for this project is to exploit the new communication technology called LoRa (Long Range) which offers high resistance to interference, and high penetration power. These properties of LoRa enable for the long range communication of up to 2Kms in Non Line Of Sight conditions and up to 5Kms in Line Of Sight conditions. Deploying this technology in the field of e-health monitoring has an added advantage as the sensors that are attached to the human body that will be able to transmit data due to high penetration power offered by LoRa to gateways that are located far from the hospital building. This otherwise is not possible using the existing technologies such as Wi-Fi, Zigbee and Bluetooth. The proposed system is expected to increase the range and efficiency of the communication and reduce the delay gap between the devices. Through the deployment of this project it is expected to ensure higher communication for low data rate, low cost, low battery consumption.

## II. RELATED WORK:

In this concept the LoRa architecture is explained in LPWAN technology. The chronic patient is monitored using bio sensors with Lpwan technology with development of efficient communication between concerned doctors and patient using LoRa. The patient health is monitored at long distance and intimate immediately to the doctor if there any critical in patient health. This is particularly beneficial to the medical field for providing interoperability to patient connected medical devices [1]. In [2] specifies the long range, low bit rate communications this analysis the performance of LoRa using single hop communicates to end devices through gateways. The gateway acts as a transparent bridge to send and receive the data to the nodes. The smart cities scenarios using LoRa [4],[15] the two main approaches to provide data access to the things based on multi-hop mesh networks using short range communication technologies in the unlicensed spectrum, or on long-range, legacy cellular technologies, mainly 2G/GSM, operating in the corresponding licensed frequency bands. The advantages based on efficiency, performance, durability. The interconnection of body area network communication in the infrastructure how internet of things play the major role in health care applications which provides low power and low cost for a wide range of communications. Internet of things is used to communicate wearable body area network to establish the electronic health care management and also focus on the drawback of the IoT adoption to satisfy the solution [5]. A Study of Efficient Power Consumption in wireless communication is carried out in different protocols like LPWA ZigBee, Low Power Wi-Fi, and 6LowPAN. The protocols are classified based on range connectivity between different sensor nodes. The payload, data rate are shown in figures [6]. For short range connectivity these protocol like ZigBee, Low Power Wi-Fi, and 6LowPAN is used and for long range LoRaWAN is used [11] , [16]. Battery life plays a vital role in choosing a different protocol/module. The power consumption is based on candidate choosing the application. Here [7] they focus on the low bandwidth frequency to overcome this problem the cognitive radio communication technique is used. The purpose is to find out efficiency of presence and absence of licensed frequency of channel detection so the wasp mote sensor has been introduce for effective usage of internet, TX &RX transceiver antenna, storing the data files and can scan the channel resources

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within the range. In [8] the technology so far established is not purely cover the requirements of industrial applications [14] so LPWAN has discussed the promising solution for reliability, efficiency, data rate. In [9] this paper explains about the existing performance of solar street lights by adding the wasp mote devices v1.1 and the performance is examine by monitoring the remote system of power 120 watt and uses zigbee, GSM protocol attached with wasp mote device and implement in the MAT LAB software to view the collective data for the betterment. This article [10] is to understand the LoRaWAN limitations to avoid the expectation of developer. The network is suitable for many applications like geolocation, streetlights [18], [19], island, rural and urban areas although it supports these communications there are some limitation of some parameters like spreading factor, bandwidth, scalability and payload. These parameters will vary according to the applications used by the developer [21].

## III. COMPARITIVE STUDY OF WIRELESS COMMUNICATION:

The comparative study is based on the range, spectrum and standards

**ETSILTN [EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE LOW THROUGHPUT NETWORKS**] **-** its ranges about 40km in open field and spectrum specifies any unlicensed spectrum such as ISM (433MHz, 868MHz, 2.4GHz)

This standards and specification is (ETSI GS LTN 001 -003)

**LoRaWAN –** its ranges about 2-5km in urban areas and its increases to 15km in suburban areas and generates any unlicensed spectrum 868MHz(Eu),915MHz(Us),433MHz(Asia)

**WEIGHTLESS-N** – the specification has Weightless SIG it has greater than 5km in urban areas and 20-30km in rural areas this frequency is 800MHz-1GHz(ISM)

**RPMA [RANDOM PHASE MULTIPLE ACCESS]** – this specification define the proprietary planned to become an IEEE standard it has greater than <65km line of sight <20km non line of sight its spectrum efficiency is 2.4GHz

**LoRaWAN** has taken in this paper it has a media access control (MAC) protocol for wide area networks. It is designed to allow low-powered devices to communicate with Internet-connected applications over long range wireless connections. The **LoRaWAN [16]** protocols are explained by the LoRa Alliance and specified for the different applications.

**LPWAN REQUIREMENT AND CHARACTERISTICS:**

**Table 1:** ***Characteristics of LPWAN***

| CHARACTERISTIC | TARGETED VALUE FOR LPWAN TECHNOLOGIES |
|---|---|
| Long range | 5-40km in the open field |
| Ultra low power | Battery lifetime of 10years |
| Throughput | Depends on the application, but typically a few hundred bit/s or less |
| Radio chipset cost | $2 or less |
| Radio subscription cost | $1 per device and year |
| Transmission latency | Not a primary requirement for LPWAN. IOT applications are typically insensitive to latency. |
| Required number of base stations for coverage | Very low. LPWAN base stations are able to serve thousands of devices. |
| Geographic coverage penetration | Excellent coverage also in remote and rural areas. Good in-building and in-ground penetration (e.g. for reading power meters). |

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## IV. SYSTEM MODEL:

LoRa is a long range that is used to control and monitor the communication in long distance with less battery power. The Bluetooth,WiFi,Zigbee are the technologies which is used for wireless communication. The problem in these technologies are range,power consuption and cost to overcome the analysis of LoRa technology has been carried out in terms of distance and delay parameters. LPWAN network has been constructed for IoT application for human pulse rate measurement. It is proved to be better compared to WiFi, Zigbee and Bluetooth. LoRa can be incorporated as one of the best LPWAN technology.

### BLOCK DIAGRAM

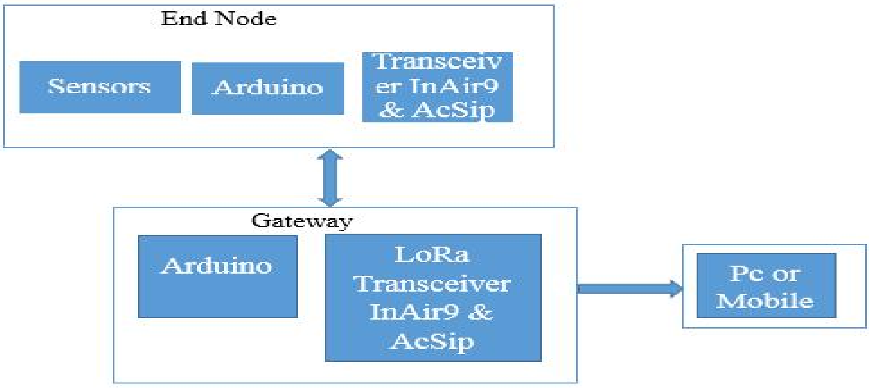


***Figure 1: Block diagram***

The block diagram explains the end node and the gateway. The end node is meant for sensing and transmitting the sensor data to the gateway devices the received data will be monitor in the serial monitor of Arduino software.

This are the four components helps to develop the technology

1. End nodes
2. Gateway
3. Network server
4. Application server

The main aim of the project is to increase the range of communication to control and monitor the system in long range. This project helps in sensing the character or sensor data. The sensed data is sent to a gateway using the Long Range (LoRa) communication technique. At the gateway the data is analyzed and interpreted to allow administrators to monitor the sensing process. This helps the user to communicate at long distance with less man-power and with better accuracy.

### A. END NODE

The LoRa endpoints are of the LoRa network where the sensing or control is undertaken. They are normally located remotely and battery operated. They can be setup to communicate with a LoRa Gateway. The end node comprises of a sensor, microcontroller and a LoRa transceiver.

### B. GATEWAY

The LoRa gateways are designed to be used in long range star network architectures. They are multi-channel, multi-modem transceivers and can demodulate on multiple channels simultaneously and even demodulate multiple signals on the same channel simultaneously due to the properties of LoRa. The gateways use different RF modules where the end-point to enables the high capacity and act as a transparent bridge hope on messages between end-devices and a central network server in the backend. The end-devices use single-hop wireless communication to one or many gateways through standard IP connections where gateway is connected. Generally all end-point communication is bi-directional, but also supports operations like multicast enabling. The gateway comprises of the microcontroller (Arduino Mega 2560) and a LoRa transceiver that are connected similar to that of an end node.

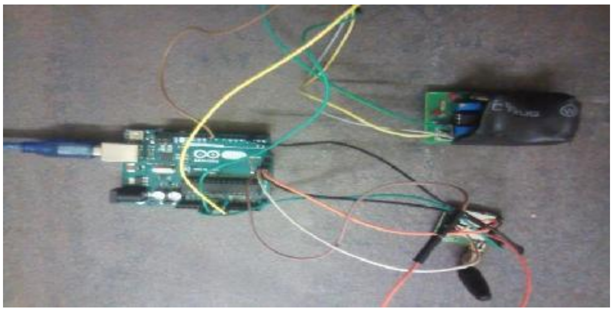

***Figure2 End node connecting with sensor***

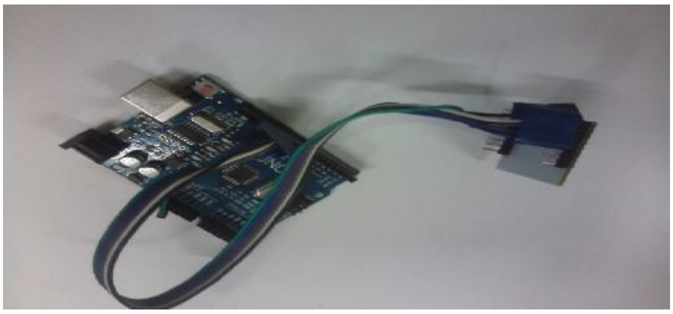

***Figure3 End node connection***

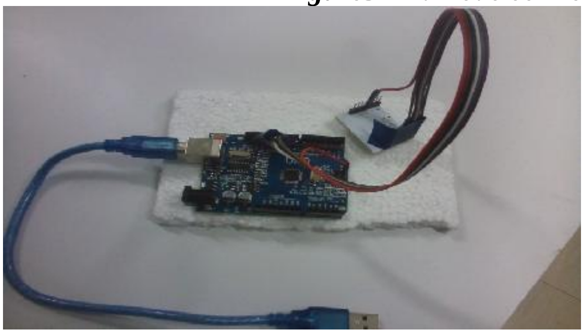

***Figure4 Gateway Connections***

The application used here is heart beat pulse rate sensor where the pulse rate is read and sensed using Lora transceiver (SX1272/SX1276, AcSip). One node is acts as transmitter (end node) and another node acts as receiver (gateway) it communicates up to 200m in line of sight.

## V. IMPLEMENTATION:

The implementation requires construction of an affordable, easy-to-use, e-health information system based on IoT. The prototype of IoT based human health information system is developed with following functions:

(1) Sensing real time pulse rate value of the patients;

(2) Transmitting the sensed data from the end node to the gateway.

(3) Transmitting data is received by the gateway to the destination end node.

To build the system, an end node is required to have connection with the board in which the sensors are interfaced. An Arduino Uno board with a LoRa module is used for transmission. The data sensed by the end node is sent to the gateway. The gateway consists of an Arduino board and a LoRa module for data reception. Implementation of the system involves setting up of pulse rate sensor in the thumb finger of human body from which pulse rate can be measured. Other sensors for measuring health parameters can be used like body temperature sensor. After fixing of many such sensor nodes into the human body, a central gateway has to be set up. The gateway is able to receive data simultaneously from many sensor nodes

The system architecture has of two parts

(1) End node

(2) Gateway

**EXPERIMENTAL SETUP**:

The end node and gateway is connected in wired mode and wireless mode. In wired mode the gateway and end devices are connected in one PC for testing short distance whereas for testing long distance the gateway and end node are connected in different PC. In wireless gateway is connected to PC to monitor the

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communication where the end node is uploaded in the Arduino LoRa module board which is battery operated. The more number of end device can take care by single gateway. According to this setup the single end node and gateway is connected for communication. Here the end node transmit the sensed heart beat sensor value and also the character data whereas gateway helps to control and monitor the data from the end devices. . It receives the transmitted data from the end devices and prints the source address, the sequence number, the payload length, the SNR and the RSSI on Arduino serial monitor.

In the gateway, LoRa parameters can be configured remotely with ASCII control sequences. We use prefix '/@' to indicate a remote control packet. The command should be terminated with an '#'. For example, the commands can be given as follows

/@M1#:set LoRa mode 1
/@C12#: use channel 12 (868MHz)
/@PL/H/M/x/X#: set power to Low, High, Max, extreme (PA_BOOST), extreme (+20dBm) if available
/@A9#: set node addr to 6

***Figure5 End node connection***

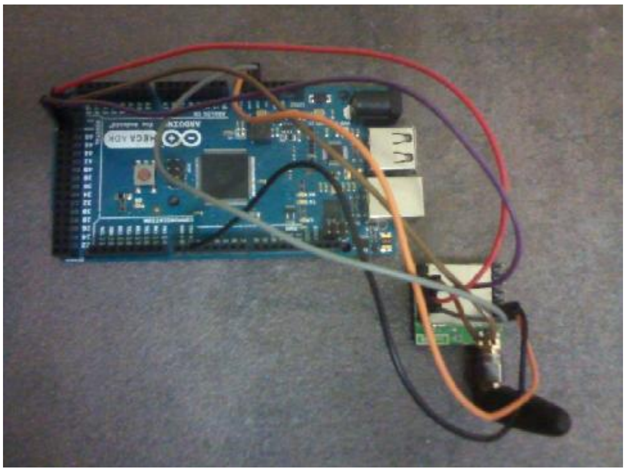

***Figure6 Gateway Connections***

## VI. RESULT AND PERFORMANCE EVALUATION:

This project monitors the data in monitoring system for e-health was tested using pulse rate sensors. The data from the sensors has been successfully acquired and transmitted to the gateway. The gateway has been placed at a distance of 200 meters from the end node in line of sight conditions. The performance of LoRa nodes are tested by changing the parameters like distance coverage, bandwidth, code rate and spreading factor. The experimental setup is tested by varying it to operate in different modes of LoRa. The observations of the experimental setup has revealed that the maximum distance coverage range has been attained when the gateway has been configured in mode 1 and when the gateway is configured in mode 4, higher penetration power has been achieved but the range in this case, has been reduced to 600 m.

***TABLE 2: Observed data***

| Distance measured(range) | Time to receive | Delay |
|---|---|---|
| 50 cm range | 1 sec | 0 |
| 1 meter | 1 sec | 0 |
| 2 meter | 1sec | 0 |
| 3 meter | 50 sec | 15 sec |
| 4 meter | 53 sec | 20 sec |
| 5 meter | 55 sec | 25 sec |
| 100 meter | 120 sec | 30 sec |
| 200 meter | 240 sec | 40 sec |

*TABLE 3: Technologies compared to LoRa*

| PARAMETERS | LoRa |
|---|---|
| BANDWIDTH | 125,250,500MHz |
| FREQUENCY | 868MHZ,900MHz |
| RANGE | Claimed (1-5km) Received in few meters |
| COST | Low |
| NODES PER NETWORK | 1000 nodes in single gateway |

**RESULTS**

The LoRa module communication is initially tested with message transfer from end node to the gateway. The figures 2,3,4,5,6 shows the successful implementation of LoRa module and the message transfer process to the gateway in wired and wireless mode. The pulse rate sensor value is read from the arduino board and the data is viewed in Arduino serial monitor. The pulse rate sensor data is sensed and transmitted to the gateway in wired mode.

This is shown in the figure 7.

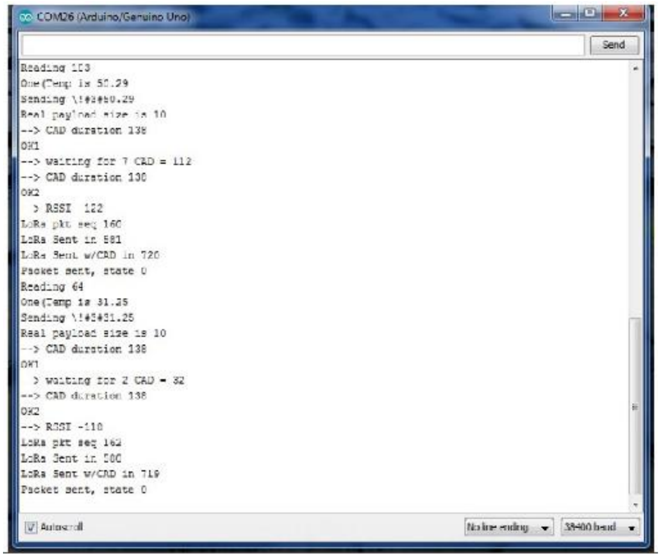


*Figure 7 End nodes transmitting the sensor value*

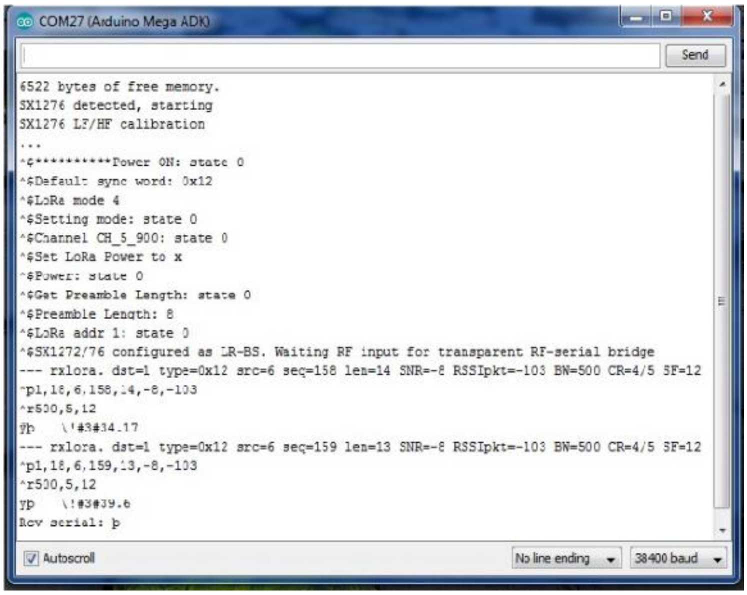


*Figure 8 Gateway Receiving sensor value*

The figure 8 shows the pulse rate value reception process in the gateway through wired mode.

The LoRa module has the advantage of wireless mode of transmission for longer distance. The LoRa module is set in the frequency (868Mhz or 900Mhz), bandwidth (125Mhz) and spreading factor.

The figure 9,10 explains the observed data in graph model

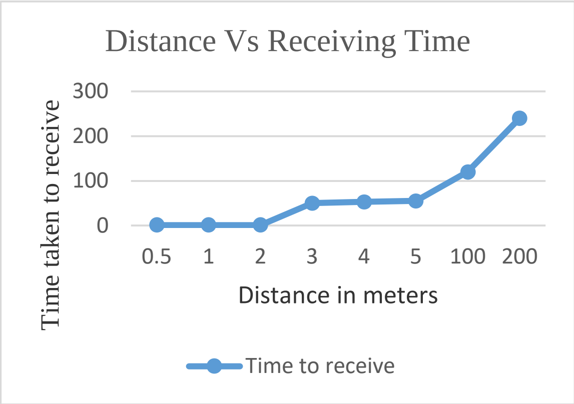


Figure 9: Distance Vs Receiving time

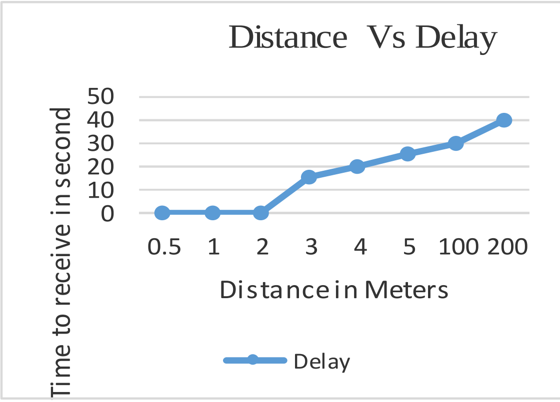


Figure 10: Distance Vs Delay

## *VII.* CONCLUSION:

LoRa is a technology for long range wireless communication. LoRa is a wireless communication module which is proprietary and claimed that it is able to cover few kilometers in distance. This project has been implemented using LoRa technology and the analysis of LoRa technology has been carried out in terms of distance and delay parameters. LPWAN network has been constructed for IoT application for human pulse rate measurement. It is proved to be better compared to WiFi, Zigbee and Bluetooth. LoRa is better in terms of distance coverage than ZigBee, Bluetooth and WiFi. It is better in power consumption than WiFi and GSM networks. It is also cheaper than all wireless networks. LoRa can be incorporated as one of the best LPWAN technology.

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