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LoRa technology for Internet of Things(IoT):A brief Survey

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***Abstract*— IoT is one of the most emerging technologies for the growth of the research and development sector. This technology enables the connectivity of the devices so that they can talk to each other. A wide variety of communication techniques, standards and modules are available for data transmission and reception. In this work, the LoRaWAN techniques are being focused on sensor systems. The literature are being reviewed for finding possibilities of LoRaWAN for applying to different applications. This will be beneficial for the researchers and designers to know the feasibility of LoRaWAN in their system design.**

Keywords—LoRa WAN, Sensor Networks, LoRa Module, LPWAN, LoRa classes, IoT system.

I. INTRODUCTION

One of the fastest growing sectors in the internet of things is wireless sensor networking. which allows the collection of environmental information by utilizing simple and basic sensor networks. Miniaturization of electronics equipment, development of different protocols and the falling price will enable the rise of wireless sensor networks based IoT systems. This survey focuses on LoRaWAN WAN in Low Power Wide Area Network technology - LPWAN [1]. Common LPWAN technology including LORA, SIGFOX, NB-IOT. figure.1 shows range and bandwidth comparison for LPWAN technology. The data from end nodes being collected and sent to the base station and then to cloud service, where the client can collect data from cloud sources. The new trends in this technology[2] are to incorporate the LoRa with other sensor networks technology and transfer information from end nodes to base stations.

By this survey, the new trends in LoRa technology also is wished to resolve. This paper is mainly based on a technical overview of LoRa WAN [3]. LPWAN technology will provide low power wide area connectivity at a low bit rate. LoRa can handle a large number of sensor nodes and will cover kilometers. Range of a LoRa Module only depends on the environmental obstacles.

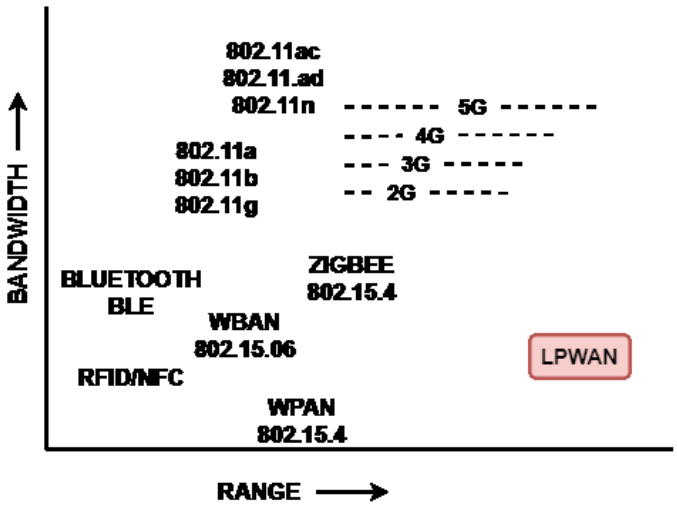

Figure1: Range and bandwidth comparison for different techniques.

Figure 1. Shows range and bandwidth comparison for different techniques with LPWAN. Modulation technique is based on the chirp spread spectrum and it is incorporated with forward error correction techniques. It operates in ISM bandwidth. LoRa Modulation [4] can be used by different protocol architectures such as a star, mesh. Bandwidth used are (Europe: 433MHz,868 MHz, USA: 915 MHz) [5]. Figure 2 shows the communication protocol of the LoRa WAN. LoRa physical layer will allow long-range communication and LoRaWAN networks can transfer data to multiple base stations [6]. A standardized MAC protocol by LoRa alliance is called LoRa WAN 1st version of LoRa WAN was published by LoRa alliance in 2015 and second version 2017[7]. Figure 2. Shows an architecture of LoRa WAN. Data collected in the sensor nodes is sent to the client via gateway and base station with the help of internet service.

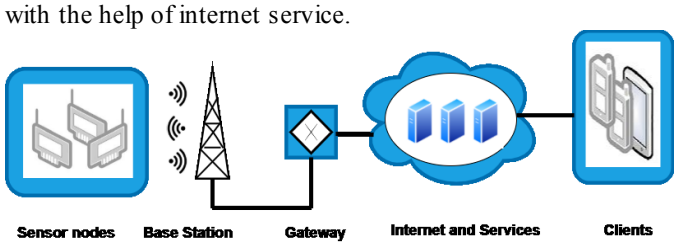

Fig 2. System architecture of LoRa WAN

The structure of this paper I. Literature survey II. Technical Analysis and benefits III. future research and Conclusion.

II. LITERATURE SURVEY

LoRa is a wireless Modulation or the physical layer. Most of the wireless system follows frequency shift keying [FSK] which is used to achieve low power. For creating a long-range communication and a low power most of the military and long-distance communication sector will follow the chirp spread spectrum [8]. For effective and robust modulation LoRa is also following the chirp spread spectrum. The long-range communication capability is the most important advantage of LoRa technology. By the help of base stations and gateway, LoRa technology can cover kilometers in a smart city area. Link budget [9] which is expressed in (dB) is the primary factor for measuring range in given environmental conditions. Compared to other technology LoRa has a greater link budget. For determining the range of LoRa in a particular environment, it mainly depends on the obstacles and constructions in the same area.

LoRa WAN is the communication protocol and LoRa is the physical layer which ensures long-range communication. The protocol determines security, network capacity and quality of service [10]. LoRaWAN WAN is technically not suitable for high bandwidth, like transmission of real-time video and images and is only suitable for sending data of 0.3kbps to 50 kbps. LoRa technology has long battery life. Which sends sensor data in IoT based systems and industrial applications[11].

1) LoRa classes

IEEE 802.15.4 is the protocol security of LoRa WAN. Every LoRaWAN node has its own App Key [12]. Three different classes of LoRaWAN are Class A, Class B, Class C.

- Class A devices need more Latency time and LoRa class A devices are more energy efficient which is used in many low powered sensor networks.
- Class B has time Synchronization with a beacon. It is also associated with low power devices but beacons will allow the end nodes about the listening period.
- Class C has low latency time but has maximum reception slots. These are bidirectional but need an external power supply.
- LoRa classification.

TABLE I. LORA CLASSIFICATION.

Class A [13]	Class B	Class C
Battery powered	Low latency	Low latency
End devices initiate communication	Ping slots	Server can initiate communication
At a predetermined response window, the server can communicate with the end device.	At a fixed interval of time, the server can initiate communication.	End devices are constantly receiving
Bidirectional	Bidirectional with receive slots.	Bidirectional
Small payload	Small payload	Small payload
Unicast	Unicast and multicast	Unicast and multicast

2) Analysis

The main aim of this section is to collect the significance and benefits of LoRa technology via many different applications shown in different papers[16]. The analysis of the comparative study shows LoRa technology has a large influence in IoT [19]. The outdoor range of LoRa is almost 10 to 15 km. Battery consumption is very less compared to other technologies but data throughput is low compared to Wi-Fi, GSM [20 22]. LoRa base station can handle thousands of end nodes at the same time but it has several security issues. Different research and surveys show that LoRa technology practically matches certain real-time requirements. Most of the work shows real field implementation of LoRa for monitoring environmental changes. All these techniques are IoT based works. Most of the smart city related papers show the implementation of LoRa technology in various sectors. Few papers show the sustainability of LoRa WAN technology and performance of LoRa devices outdoors [21] to measure different environmental conditions.

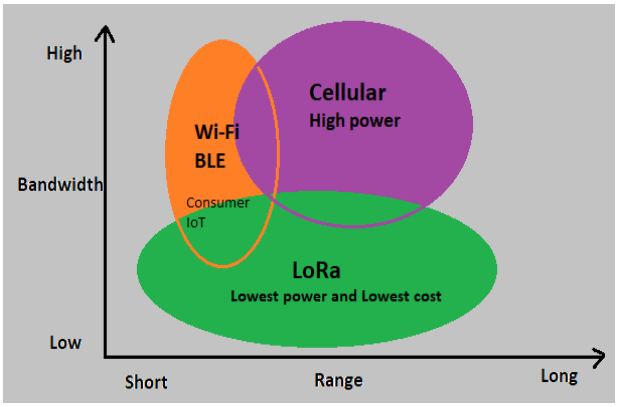

Fig.3 Comparative representation of Lora with other technologies.

Most of the studies in different papers show a comparative survey, paper [23-24] shows a comparative study between different classes of LoRa. Figure 3. Shows representation of LoRa with other technologies. When comparing other technologies such as sigfox, NB-IoT with LoRaWAN such as its architecture, security, LoRaWAN technology is a good choice[25]. A comparative analysis [26] shows that unlicensed LoRa has better performance in terms of capacity and battery lifetime but licensed NB- IoT shows advantages in terms of range and reliability. Compared to other technologies both LoRa and NB IoT could offer better performance. Security issues are discussed in [23,25] different studies. LoRa offers two layers of security.one for application and other for the network layer. But there are many security vulnerabilities in LoRa technology due to similar spread factor and frequency.

3) Technical details

Real deployment of LoRa in a test environment, for testing some technical features such as scalability and QoS [35 27 36 37 38] explained in a large number of papers. The testing of LoRa technology, especially LoRa technology is tested indoors and outdoors [39 40 41 42 27]. By measuring the packet delivery ratio LoRa can be tested. More studies can be discussed in the licence free ISM bands signals [43 36 44]. A number of LoRa devices were tested with the help of programming. some were modeled by software without any implementation, research studies shows the same.

III. TECHNICAL ANALYSIS

B. Network Architecture

Star architecture [15] is more suitable for LoRa than mesh network architecture. For long-range application star architecture preserve battery life. Mesh network architecture is deployed in many existing networks. While increasing range It adds more complexity to the system and it reduces battery lifetime.

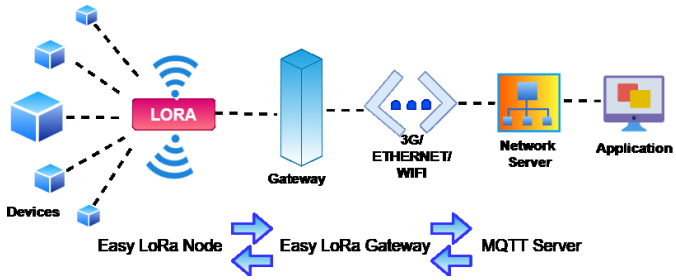

Fig.4 System architecture.

In a LoRaWAN network end nodes will send data to multiple gateways and by cellular, Wi-Fi or any other medium gateway will forward data from the end node to distant cloud-based network server [17]. The network server will perform all other activities like security check, acknowledgement of the received packets. Figure 4 shows the overall the system architecture.

D.Network Capacity

Data rate changes with the spreading factor. A gateway can receive multiple data rates on the same channel. Battery lifetime can be increased by proper use of data rate. All these make LoRaWAN a higher capacity network than other LPWAN networks. Compared to other LPWAN techniques LoRaWAN is a more scalable network. With minimal infrastructure, LoRaWAN can add more gateways and shift data rates. The high network capacity [18] in LoRaWAN is achieved by multichannel in the gateway and thereby simultaneous message transfer is possible. The main parameters depend on the network capacity are the number of channels, data rate and spreading factors which will change with data rate.

A. Security

The LoRaWAN has 2 layers of security, one for the application layer and the other for the network layer. Authenticity [14] of a node assured by the network layer. application layer offers security to the application data of the end-user.

C. Battery Lifetime

LoRaWAN networks are asynchronous; it will transfer data whenever it has data ready. This type of protocol is referred to as aloha. Unlike the synchronous network nodes frequently wake-up to check messages and the same will reduce battery lifetime compared to LoRaWAN.

E. Applications

In many applications for real-time monitoring, LoRa is selected for long-range communication. Health care services like blood transfusion services [45] and some other health care services [40]. Monitoring road conditions by sensor nodes [46]. For cost-effective air conditioning, temperature difference and humidity changes in different rooms had to be monitored by different sensor units [47]. At the same time, air quality can be measured by various gas sensors [48]. LoRa modules are also used to monitor environmental information in the sea such as sailing of sea boats [30]. Reference [32] shows various geolocation tracking applications for livestock management. Tracking devices communicate with the gateway by LoRa [29]. For safety driving vehicles tracking is also possible by LoRa and gateway [49]. LoRa has been used effectively indoors and outdoors, health monitoring, environmental, tracking.

H. Limitations and Benefits

Limitations

- Small packets of data [52] in the kbps range can only be supported
- Sending video files better to go with Wi-Fi compared to LoRa
- Bluetooth or ZigBee is better for indoor home automation compared to LoRa
- Compared to LoRa, LTE/GPRS can be better for phone calls

Benefits

TABLE II. BENEFITS OF LORA WAN.

Benefits	Explanations
Security[50]	Network layer and application layer security is defined.
Network capacity[51]	Simultaneous messages can be received on multiple channels. It is achieved by adaptive data rates[54].
Battery lifetime	Nodes communicate when it has to send data[52].
Classes	Three classes A, B, C has chosen depending on the device lifetime.

IV. FUTURE SCOPE AND CONCLUSION

This Survey includes the research area in the performance and deployment of LoRa. Which is one of the major networking elements in many IoT applications. Paper mainly based on comparative analysis and trends in LoRa based communication in IoT. LoRa has many applications and future relevance in the field of IoT. As compared to other LPWAN techniques LoRa WAN has so many advantages like long battery life, long-range and low cost. One of the main limitations of LoRa is its low data rate. Technical details and analysis are briefly explained in this paper.

V. ACKNOWLEDGMENT

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