SJIF Impact Factor 2021: 8.013| ISI I.F.Value:1.241| Journal DOI: 10.36713/epra2016 ISSN: 2455-7838(Online)
EPRA International Journal of Research and Development (IJRD)
Volume: 6 | Issue: 7 | July 2021 - Peer Reviewed Journal

LoRaWAN: AN EVOLUTION OF WI-FI FROM SHORT RANGE TO LONG RANGE

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ABSTRACT

Long-range, low-power networks are quickly gaining traction in the Internet of Things (IoT) due to their potential to handle long-range sensing and control applications at a reasonable cost. Wireless communications have now spread throughout the universe. Wireless sensors and Internet of Things (IoT) applications can result in useful applications. In IoT applications, traditional wireless solutions such as mobile signals and data transmission play a vital role. Bluetooth, ZigBee, Wi-Fi, and a slew of other application-specific wireless protocols are currently available. This article examines the most recent wireless technology for IoT, namely LoRaWAN, an application-specific wireless protocol. The LoRaWAN Network is a low-power radio network for IoT devices. In the realm of industrial automation, there is an IoT strategy that is paving the way for novel services to improve the efficiency, dependability, and availability of industrial processes and goods. The LoRaWAN technology is discussed in this study, thanks to its widespread adoption in both the industrial and academic spheres. This paper also discusses a few LoRaWAN applications.

INDEX TERMS - *LPWAN, LoRa, LoRaWAN, Bluetooth, ZigBee, Wi-Fi, Application.*

1. INTRODUCTION

During this time, a lot of effort is being put into studying, analysing, and discovering new ideas about sensor networks, which are employed as part of IoT (Internet of Things) concepts.It pioneers the study of LoRa (Great Range), which is a modulation technology that permits the transmission of data across long distances at a low rate. The number of IoT application areas and deployments continues to expand as the Internet of Things grows at a rapid pace. The number of linked IoT devices is expected to continue to expand at a 32 percent annual rate, reaching 20.8 billion IoT end points by the end of this decade. This wireless protocol is required for the implementation of any type of automation. These wireless protocols are used to transmit the different parameter signals observed by the sensor as well as reverse the control signals generated by the controller in a wireless sensor network.

LoRaWAN is a Low Power Wide Area Network (LPWAN) standard for battery-operated wireless devices in regional, national, and worldwide networks. LoRaWAN focuses on important internet of things requirements including secure bi-directional communication, mobility, and location services.

Low-rate, long-range, and delay-tolerant wireless communication with very low energy consumption and cost are required for IoT applications. Traditional Machine to Machine technologies, such as cellular or WPAN, struggle to meet these needs. As a result, LoRa and LoRaWAN technologies are employed. LoRaWAN offers a unique value proposition by sacrificing speed for larger ranges.

The yet-to-be-released 5G network is built from the ground up to link a huge number of devices across a broad geographic area, but it is currently experiencing difficulties. Meanwhile, Low Power Wide Area Network (LPWAN) technologies have been offered as a viable option for creating private cellular-like networks with minimal infrastructure expenditures. Due to the availability of modules from a variety of vendors and an open alliance driving the creation of standard documents, LoRaWAN has gained traction.

For many years to come, LoRa is expected to remain an attractive technological area for smart cities. The Internet of Things (IoT) is a collection of interconnected devices. The

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network is usually represented as an IP network, and the objects are devices having a telecommunication (wireless) interface as well as processing and storage units, such as sensors and/or actuators. The wireless IoT access system should, in particular, provide better indoor coverage, support for a large number of low-throughput devices, low delay sensitivity, and extremely low device power consumption.

2. WHY LORAWAN?

It is mainly used due to following advantages,

- It has bit rate of 300kbps
- -40°F to +85°F is the operating temperature range
- 860-1020MHz is its frequency range.
- Bandwidth is around 125-500KHz
- It has sensitivity of -117 to -137dBm
- Integrated synthesizer with resolution of 61Hz

3. AVAILABLE WIRELESS COMMUNICATION SYSTEMS

Few other types of wireless communication systems include Bluetooth, ZigBee, Wi-Fi and Sigfox.

- **Bluetooth:**

Bluetooth is an IEEE standard-based wireless personal area network technology. Ericsson introduced it in 1994. It operates on the 2.4 GHz frequency spectrum, with a channel frequency band of up to 1MHz. The frequency hopping spread spectrum (FHSS) transmission method used by Bluetooth allows for a maximum data throughput of 1 megabit per second. With seven slave nodes and one master node, conventional Bluetooth can link eight nodes to each other. The distance between transmitter and receiver nodes, the ideal power to be kept by the signal, and, most significantly, the type of data being transferred all influence the power consumption of any communication network. Bluetooth-based networks may communicate almost any sort of data, including video and text.

After Bluetooth 1.0, 2.0, and 3.0, a new version called Bluetooth 4.0, commonly known as Bluetooth Low Energy (BLE), was suggested. It was created as a low-power alternative to traditional Bluetooth. Traditional Bluetooth can handle nearly all types of data, but it uses more power and costs more money. BLE is used for low-data-rate applications and hence has a longer battery life.

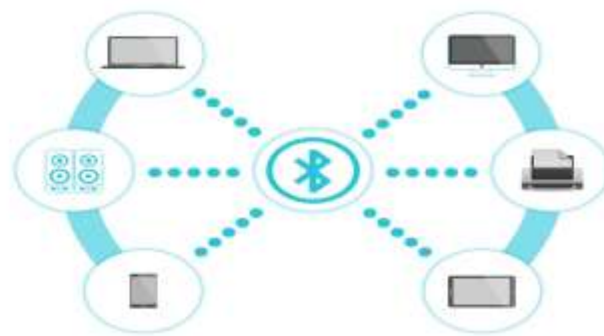

Figure 1: Bluetooth

- **ZigBee:**

In Low Rate Wireless Personal Area Networks and Wireless Sensor Networks (WSNs), IEEE standard 802.15.4, often known as ZigBee, is the most preferred choice. The network layer and application layer standards have been defined by ZigBee. The MAC layer enables for fast access to the wireless physical medium, wireless node relationships, data frame validation, and security services in wireless networks. ZigBee-based networks can be centralised or decentralised, depending on the application needs.

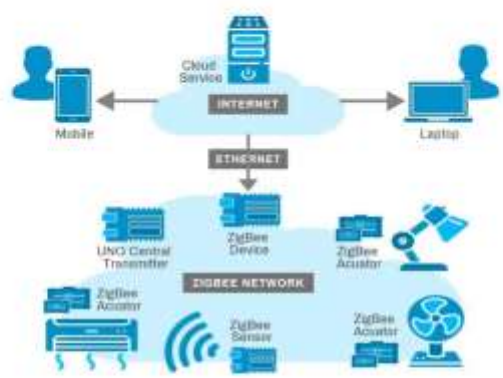

Figure 2: ZigBee

A wireless network based on ZigBee may adapt to a star topology. To its member nodes, the star topology provides both contention-based and contention-free wireless media access. In a peer-to-peer architecture, nodes within their radio range can interact with one other. Contention-based un-slotted carrier sense multiple access with collision avoidance CSMA/CA wireless MAC protocol is supported by a decentralised or peer-to-peer topology based wireless network. Nodes in the CSMA/CA protocol compete for access to the shared wireless medium. In ZigBee, more than 64000 nodes may be connected, and each one just has to assign a role. In the 2.4 GHz frequency range, ZigBee employs the direct

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spread spectrum sequence (DSSS) transmission method and delivers a data rate of up to 250 kbps. To expand the signal bandwidth, spreading methods are used (BW). With chips, DSSS adjusts the phase of a sine wave pseudo-randomly. The pseudo-noise (PN) code symbols or PN-sequence are the names given to these continuous chips. This phenomena aids in increasing signal power, reducing interference effects on received signals, allowing many users to share spectrum, and providing resistance to intentional or unintentional signal jamming. The PN-sequence is known at both the transmitter and the receiver. ZigBee is a low-power, low-cost wireless technology that is ideal for WSNs.

- **Wi-Fi**

Despite the fact that Bluetooth and ZigBee are low-power, low-complexity wireless sensor technologies, they have significant disadvantages, such as low data rate, short range, and poor obstacle penetration. A variety of Wi-Fi based wireless sensors have been created for low power wireless sensor applications as wireless and system on chip (SoC) technologies have advanced. Wi-Fi is an IEEE standard-based wireless local area network (LAN) technology. The IEEE standard 802.11 and Wi-Fi are both utilised at the same time. IEEE standard 802.11 specifies the media access control (MAC) and physical layer (PHY) for wireless WLAN implementation in the 900 MHz, 2.4GHz, 3.6GHz, 5GHz, and 60 GHz frequency bands. Many extensions of IEEE standard 802.11 use the 2.4 GHz frequency operating band, which has 14 different channels. WSNs based on Wi-Fi might be network focused or data centred. Wi-Fi has a data throughput of 11Mbps to 54Mbps and a transmission range of 100 metres. The number of IP addresses determines the number of nodes in the network.

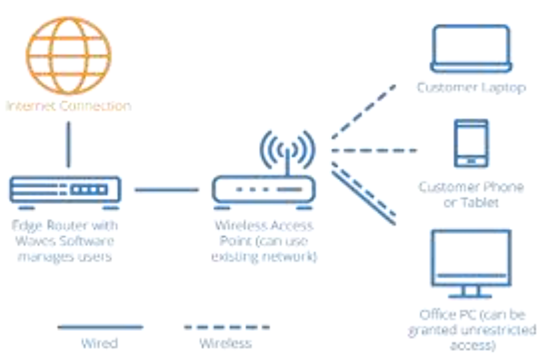

Figure 3: Wi-Fi

- **SigFox**

Sigfox is a specialist Internet of Things network operator (IoT). The Sigfox network employs the UNB (Ultra Narrow Band) technology, which allows devices to communicate over long distances with little power consumption. It supports narrowband technology and binary phase shift keying, a common radio transmission technique (BPSK). It lets the receiver to just listen in a limited portion of the spectrum, which reduces the influence of noise. To administer the network, a cheap endpoint radio and a more complex base station are required.

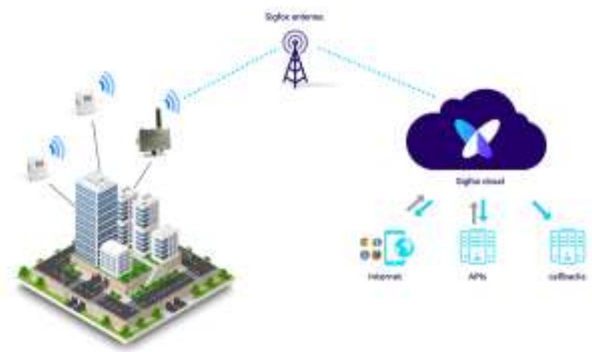

Figure 4: SigFox

5. Comparison between Different Wireless Communications.

	Range	Speed	Power Usage	Topology
Bluetooth	10m–1.5km	125 kbps-2 mbps	High	P2P, Star, Mesh
ZigBee	30m-100m	20 kbps-250 kbps	Low	Mesh
Wi-Fi	15m-100m	54 Mbps-1.3 Gbps	Medium	Star, Mesh
SigFox	3km-50km	100 bps	Low	Star

LoRaWAN

LoRaWAN networks, as a Low Power Wide Area Network technology, provide end devices with vast coverage areas and extended battery life. Unlike traditional network technologies (such as cellular and LAN), the trade-off between data throughput and range in LoRaWAN favours range. In addition, LoRaWAN networks use a patented physical modulation technology (dubbed LoRa) that was designed with long range and low power operation in mind.

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To accomplish long-range operation, LoRaWAN networks use the resilient LoRa modulation. The LoRaWAN alliance has specified medium access, frame formats, provisioning and management messages, security methods, device management, and other elements, and has standardised them. LoRaWAN networks build one-hop star topologies around gateways, which function as packet forwarders between end devices and a central network server. The network server is in charge of MAC layer processing and serves as a conduit between end-user applications and application servers. The LoRaWAN standard divides end devices into three categories (A, B, and C) to accommodate a variety of applications.

Figure 5: LoRaWAN

With AES encrypted connections enabled, LoRaWAN enables star topology with IP backhaul to the network server and application server. It's designed for battery-powered end-devices that can be portable or permanently installed. LoRaWAN has been chosen as the LPWAN solution in both regional and metropolitan regions to transmit sensor data back to the operation room to meet the fast-growing need for data from micro-grid. Connectivity testing are done with a gateway configuration in UNSW's Tyree Energy Technologies Building (TETB) with 4G connectivity as the backhaul by building a private LoRaWAN network as described above.

Conventional RF communication systems utilising AFSK and ASK, ZigBee, and Wi-Fi are the wireless technologies now in use. The data transfer rate for the aforementioned technologies is promising, and they can send data over great distances, but they require a considerable amount of transmission current, making them unsuitable for some battery-powered applications. The GSM module is another alternative for transferring the data parameter. The dependence on the network service provider and operator costs is a disadvantage of the GSM module. These disadvantages are incompatible with a data transfer application using low-power long-range wireless data transmission using battery-powered devices. LoRaWAN has demonstrated significant output in recent tests for preparing such low-power networks.

1. LITERATURE OVERVIEW

According to the literature assessment of all papers examined, LoRaWAN is a suitable low-power protocol for deploying a variety of applications on a wide scale. The following are the major features of LoRaWAN:

- Data transmission with low power consumption.
- Increased battery life for sensors.
- Data transmission over a long distance
- Wide range of applications.
- It is cost effective.
- Data transmission that is secure
- Control unit that is centralised.
- All network topologies are supported.
- Get around the drawbacks of alternative topologies.

When building a LoRaWAN system, there are a few more considerations to keep in mind.

- There is a slow data transfer rate.
- The complexity of the implementation in a complicated application is uncertain.
- Interface between the sensor and the LPWAN.
- Data signal interference
- Data transmission speed overall for rapid reaction circuits.

2. ARCHITECTURE OF LoRaWAN

The communication protocol and system architecture are defined by LoRaWAN, while the physical layer is defined by LoRa. Mesh network design is used by the majority of current IoT LAN technologies. The system may extend the communication range and cell size of the network by employing a mesh network. However, nodes in a mesh network are also responsible for passing messages to other nodes that are usually unrelated to them. This has a major impact on the device's battery life. When long-range connection is needed, LoRaWAN employs star topology to extend battery life.

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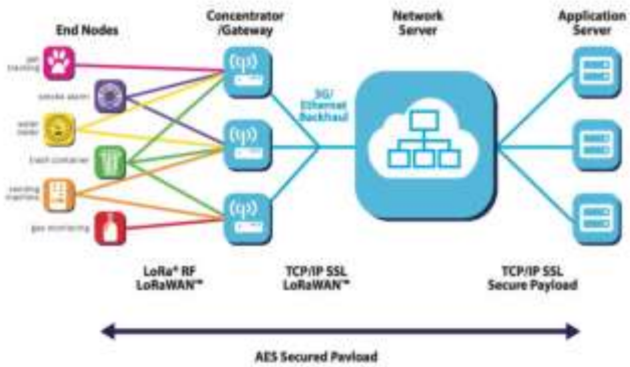

Figure 6: Architecture of LoRaWAN

LoRa network consists of several elements. They are listed below,

- **LoRa End Nodes:** LoRa end nodes are sensors or apps that do sensing and control. These nodes are frequently installed in remote locations. They are generally placed at a great distance from the user and are controlled by him. Sensors, tracking devices, and other similar equipment are examples.
- **LoRaWAN Gateways:** Unlike cellular communication, where mobile devices are linked to the base stations that serve them, LoRaWAN nodes are linked to a single gateway. The data sent by the node is forwarded to all gateways, which then send it to a cloud-based network server.
- **Network Servers:** The network server filters duplicate packets from several gateways, does security checks, and sends acknowledgements to the gateways. Finally, if a packet is meant for an application server, the network server forwards it to that application server. Hand-off or handover is no longer required. This is helpful for applications that track assets as they travel from one location to another**.**

Different device types exist in the LoRaWAN network's end nodes. They are:

- **Class A -** Typically used in battery power sensors.
  - ➢ Are energy-efficient and offer a long battery life.
  - ➢ This device class is supported by all LoRaWAN devices.
  - ➢ Only once the sensor communicates anything the downlink will be available.
- **Class B –** These are end-devices that have received slots on scheduled time.
  - ➢ It will open an additional receive slot at scheduled time.
  - ➢ It receives time-synchronized data from gateway
- **Class C –** Are end-device with maximum number of receive slots
  - ➢ They frequently open the receive window
  - ➢ Receiver is closed only when device is transmitting

3. FEW POSSIBLE APPLICATIONS OF LORAWAN

Many studies based on LoRaWAN and its applications for smart cities have recently been proposed. This article proposes identifying a gap in current research and filling it with an appropriate remedy. Observation and comparison will be used to further build smart city applications.

- **Weather monitoring with LoRaWAN:** This system was proposed in 2018 to demonstrate the possibility of using LoRaWAN for weather monitoring in Malaysia's remote areas. All weather monitoring data was transferred up to 23km with a 7.3dBm speed using the suggested system. This system's battery usage was significantly improved.

- **LoRaWAN-based smart energy meter:** When the resent solution for consumer metering was proposed, it was discussed the construction of a smart energy meter using LoRaWAN. The suggested system was successfully employed on LoRaWAN for obtaining voltage, current, frequency, and other associated characteristics via the internet using IoT up to a 5km range. There was no mention of a battery utilization measure.

- **LoRaWAN-based water meter reading system:** It was proposed using multilevel relay and concentrator based on LoRaWAN for acquiring water meter readings. Water meter data has been accurately measured using the proposed approach. It has been able to transmit data up to the 7th storey of the building. This technology achieves a seven-fold reduction in battery use.

- **A health-monitoring system based on the Internet of Things:** Medical sensors are interconnected with

LoRaWAN via the internet of things in this suggested system. A human body's blood pressure, sugar level, and body temperature are all measured. This system has been able to send data over a 33-square-meter radius while using less than ten times the amount of battery power.

- **LoRaWAN-based vehicle tracking system.** The proposed technology was utilized to detect and monitor air pollution and climate change in metropolitan areas. The truck is used to collect data from various locations throughout the city. This system was used to monitor a variety of environmental characteristics such as ambient temperature and humidity, as well as air quality metrics such as PM2.5, NO_2, CO, and O_3. The vehicle's GPS position was provided by this system along with weather parameters in different areas, vehicle information, and air quality information.

CONCLUSION

The LoRaWAN protocol has a lot of potential for smart city applications. To develop viable solutions for smart city applications, more study in this field is required. According to the present comparison, LoRaWAN outperforms Wi-Fi and ZigBee. Other related technologies, such as DASH7, Sigfox, and weightless, will be evaluated further in order to choose the ideal LPWAN for smart city applications.

In this paper we have analyzed the few important features of LoRaWAN. We have also compared various available wireless communications and their comparison with LoRaWAN. The architecture of same is also discussed which is considered to be very important.

The future work will involve large scale applications of LoRaWAN for smart city application where the devices have to be connected and monitored continuously. This is better approach than using the traditional wireless communication systems.

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