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A survey of LPWAN technology: LORA and IOT

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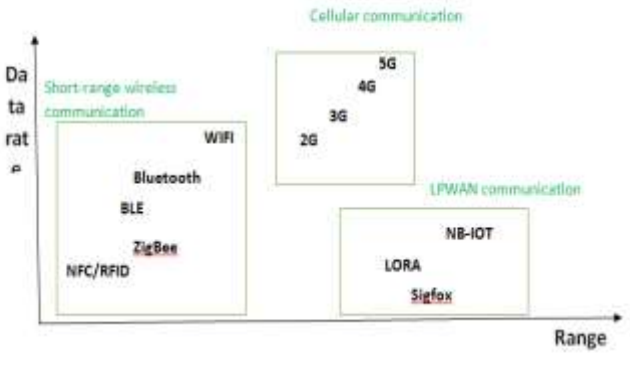
Abstract: LPWAN is a low power wide area network technology design for IOT and smart sensor application. IOT device connect with LPWAN enabled Gateways that forward information to a Network Server. Network server can in turn provide that information to User Application Servers. One main features of the system is long range and low power. In this paper we discuss the IOT success factors of these LPWAN technologies and we consider application scenarios and explain LPWAN modulation, Classes, Message formats & Protocols. It also provides as efficient solutions to connect smart, autonomous, and heterogeneous devices.

Introduction:

The Internet of Things (IOT) is a network of physical devices that are connected to the Internet and are able to "talk" to each other. There are many wireless technologies you can use to connect these devices to the Internet, such as:

- Short-range wireless communication
- Cellular communication
- LPWAN communication



LPWAN stands for Low Power Wide Area Network and this type of wireless communication is designed for sending small data packages over long distances, operating on a battery. There are a number of competing technologies in the LPWAN space such as: Narrowband IoT (NB-IoT), Sigfox, LoRa and others. LORA is one of them. LoRa (short for long range) is a spread spectrum modulation technique derived from chirp spread spectrum (CSS) technology. Semtech's LoRa devices and wireless radio frequency technology (LoRa Technology) is a long range, low power wireless platform.

IOT

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

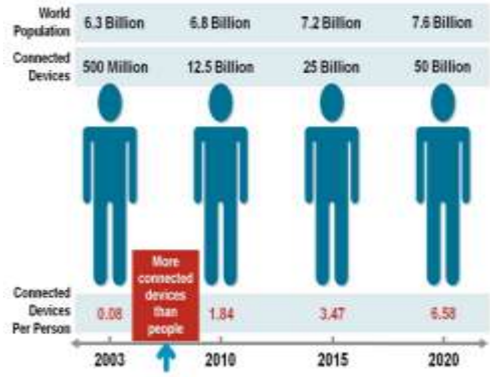


Figure-01: Growth of connected objects.

In this Figure-01, every year we can found more devices connected to the network and IoT still has a long way to go and grow. This rise of devices, systems and services connected and exchanging data between them, need a powerful and strong wireless technology to support them. Cellular and satellite machine-to-machine (M2M) technologies have traditionally filled the gap, but cost, power and scalability concerns make these choices less appealing for the future.

Low Power Wide Area Network (LPWAN) has arisen to solve this problem. To compare the protocols of LPWAN we keep in mind some of the most important characteristics of the LPWAN and some others important features like: Range, Band and spectrum, Data Rate, Over-the-air-updates, Handover.

	LoRa	Sigfox	NB-IoT
Range [km]	15-20	30-50	10
Band	Sub-Ghz	Sub-Ghz	Sub-Ghz
Modulation	Speed Spectrum	Ultra-Narrow Band	Ultra-Narrow Band
Data Rate	.3-22	0,1 – 0,6	0,1
Handover	No	Yes	No

LORA

The range between LoRa sender and receiver depends on the environment the equipment operates in. Indoor coverage largely depends on the type of building material used.

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Environment	Range
Urban Areas (towns & cities)	2-5
Rural Areas (countrysides)	5-15
Direct line of sight	>15

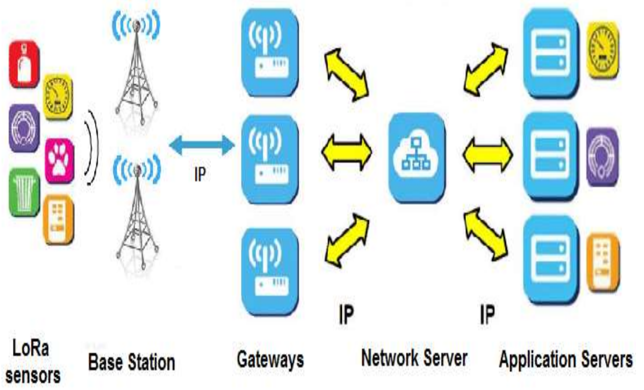
LoRa operates in the unlicensed ISM (Industrial, Scientific and Medical) radio band that are available worldwide.

Region	Frequency (MHz)
Asia	433
Europe, Russia, India, Africa	863-870
US	902-928
Australia	915-928
Canada	779-787

LoRa enables very-long-range transmissions with low power consumption. The technology is provided two parts – LoRa, the physical layer. The communication protocol built underlying LoRa physical layer. The communication layer may be LoRaWAN. Thus, LoRaWAN defines the communication protocol and system architecture for the network, while the LoRa® physical layer enables the long-range communication link. LoRa WAN communication protocol ensures reliable communication, secure communication and adds additional headers to the data packets. LoRaWAN defines the communication protocol and the system architecture, while LoRa defines the physical layer. Here is a typical system architecture of a LoRaWAN node.

LoRa Network Architecture

Most of the modern IoT LAN technologies use mesh network architecture. For using mesh network, the system can increases the communication range and cell size of the network. But nodes in a mesh network has additional responsibility of forwarding message to other nodes. This affect the device battery life significantly. LoRaWAN uses star topology as it increases battery lifetime when long-range connectivity is used.



LoRa network consists of several elements.

LoRa Nodes / End Points: LoRa end points are the sensors or application where sensing and control takes place. These nodes are often placed remotely. Examples, sensors, tracking devices, etc.

LoRa Gateways: Unlike cellular communication where mobile devices are associated with the serving base stations, in LoRaWAN nodes are associated with a specific gateway. Instead, any data transmitted by the node is sent to all gateways and each gateway which receives a signal transmits it to a cloud based network server. Typically the gateways and network servers are connected via some backhaul (cellular, Wi-Fi, ethernet or satellite).

Network Servers: The networks server has all the intelligence. It filters the duplicate packets from different gateways, does security check, send ACKs to the gateways. In the end if a packet is intended for an application server, the network server sends the packet to the specific application server.

Using this type of network where all gateways can send the same packet to the network server, the need of hand-off or handover is removed. This is useful for asset-tracking application where assets move from one location to another.

LoRa Device Class

There are three classes of LoRa technology. Each device class is a trade-off between network downlink communication latency verses battery life.

Class A is the most suitable for battery power sensors

- Most energy efficient and can have years of battery-life
- All devices in LORAWAN network support this device class
- Downlink available only after sensor transmit something

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Class B is end-devices with schedule receive slots

- Open extra receive slots at schedule time
- Receives time-synchronized beacon from gateway

Class C is end-device with maximal receive slots

- Continuously open receive window
- RX is closed only when device is transmitting

LORAWAN Message Formats

LoRa terminology distinguishes between uplink and downlink messages. Uplink messages are sent by end-devices to the network server relayed by one or many gateways, a downlink message is sent by the network server to only one end-device and is relayed by a single gateway.

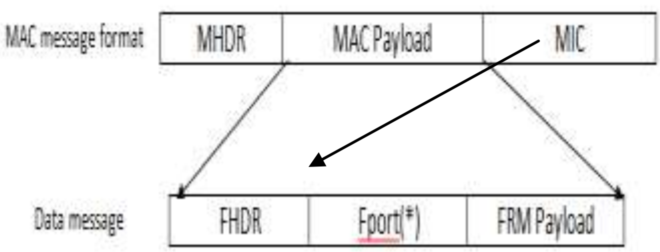
Radio PHY layer message structure

LoRaWANTM employs two types of packet format, explicit and implicit. The explicit packet includes a short header that contains information about the number of bytes, coding rate and whether a CRC is used in the packet. The packet format is shown in the following figure. The LoRaTM packet comprises three elements:

• Preamble.
• Optional header (depending on the selected mode, explicit/implicit).
• Data payload

Radio PHY Layer				
Preamble	PHDR	PHDR _CRC	PHYPay load	CRC (Optional)

Radio MAC layer message structure



This is LoRaWAN Medium Access Control message format. The Fport(*) field is present when the frame payload field contains data. The frame header (FHDR) field has a size of 7 bytes if it does not contain options, and up to 22 bytes when options are used (with an option size of up to 15 bytes). In this paper, we assume that options are not present in data messages.

Conclusion

In this survey paper, we demonstrate both LoRa and IoT features and interconnection among them. In the perspective of increasing the range of the system with a low power consumption a new protocol had been introduced. It is found that different classes of LoRa network and IoT architecture were analyzed. Both LoRa and IoT have their place in the IoT market. LoRa focuses on the low power, large range and low cost applications. IoT focuses on the use of network sensors in physical devices to allow for remote monitoring and control.

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