Anireekshith Narayana, et. al. International Journal of Engineering Research and Applications
www.ijera.com
ISSN: 2248-9622, Vol. 10, Issue 11, (Series-I) November 2020, pp. 53-57

RESEARCH ARTICLE OPEN ACCESS

Choice of effective LPWAN protocol for IoT System: Sigfox and LoRa

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ABSTRACT
LPWAN as the name indicates it stands for consumption of low power (LP) and long range communication (WAN). Since these devices are cheap in costs it suits well for IoT application. LPWAN technology can be based on licensed or open standard options
Low Power Wide Area Network (LPWAN) keeps Internet of Things active by providing solutions in unlicensed and licensed frequency bands. LPWAN devices known for long-distance, low cost battery or no battery and cheap end devices. LPWAN technologies based on two important concepts called, i) Ultra Narrow Band (UNB) ii) Spread Spectrum (SS). Selection of these technologies are considered based on parameters such as capacity, interference, co-existence and link budget etc.
In this paper, we will analyse Ultra Narrow Band LPWAN technology -Sigfox and Spread spectrum LPWAN technology - LoRa. Both UNB and SS are used for long distance coverage with extended battery life of IIOT (Industrial IoT).
KEYWORDS - LPWAN, Sigfox, LoRa, Ultra Narrow Band, Spread Spectrum, NB-IoT

Date of Submission: 31-10-2020 Date of Acceptance: 12-11-2020

I. INTRODUCTION

Devices which are actually sensors and actuators are used to monitor the physical and environmental conditions in Internet of Things (IoT) world rely on a internet of their communication

The IoT devices in general use cellular technology, Radio Access Technology (RAT), Low Power Wide Area Network (LPWAN) to connect to the Gateway server or Device Integration platform. The competitors for NB-IoT are Sigfox and LoRa. NB-IoT is becoming popular because of already established communication infrastructure with long distance sub-Ghz bands and reliable delivery of signals/data produced by end devices, which are applicable for IoT application. Base station configuration is split into cellular (NB-IoT and GPRS) and LPWAN (Sigfox and LoRa) tracks. LPWAN has wide distribution of technologies using which low power devices can connect in IoT world. These devices are mainly characterized by long-range up to several kilometeres, extended battery life up to several years and very low cost. LPWAN has 2 types of technologies i) UNB (Ultra Narrow Band) ii) SS (Spread Spectrum). UNB is basically used for transferring data with small bandwidth. SS is basically used for transferring data over a large frequency band. SS spreads the data signal over much larger bandwidth

II. LOW POWER WIDE AREA NETWORK

LPWAN is used by IoT devices for communication with Server/device integration platform, which operates on less battery power and for long-distance communication.

A typical IoT environment working on wireless sensor network which provides lower data rate as the sensors or actuators, emits measurements or events periodically which has less data, measurements or events should traverse to the long range with long battery life. LPWAN designed to best suit these requirements. LPWAN network characterized by sending smaller data over a long distance while maintaining the extended battery life, Long-distance communication, Less Power or No Power consumption, Small data rate, Cheap end devices and deployment, Simplified network topology and deployment

LPWAN is of 2 types based on License type:

1. Licensed LPWAN Technology
2. Unlicensed LPWAN Technology

UNB uses a narrow spectrum channel within 1Khz range to establish connection link between transmitter and receiver. Ultra Narrow band is used in Industrial IoT due to low in-band noise as it operates on the narrow frequency band. This makes it suitable for Industrial IoT. UNB uses the Differential Binary Phase Shift Keying (D-BPSK) for modulation. Usually a UNB network contains a payload of 12 bytes. With the necessary network

management information it may go up to 25 bytes [15]. In UNB, CRC encoding is used for error handling and each frame duration is around 2s [15].

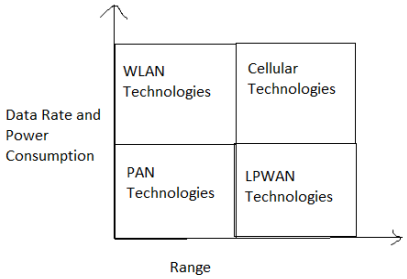

Fig. 1: Comparison of various Wireless Communication Technologies [1]

On the other hand, Spread Spectrum uses wideband to transmit the Signals. Spread spectrum works based on increasing the channel transmission bandwidth is the key to increase the performance. SS uses Chirp Spread Spectrum technique for the modulation. SS signal resembles like a noise, SS spread the data signal over a much larger bandwidth. Signals after the modulation appears as noise and hence SS signals resembles like a noise hence making hard to detect, interrupt, decode and jam.

Parameters for LPWAN:

Interference: Ultra narrow band technology in order to avoid the interference with neighbouring sub-carriers, uses orthogonal RF channels and also distributes the power with in sub-carriers to handle fading environment intelligently. UNB takes longer time for transmission of signals, due to lower data rate there are increased chances of interference with other LPWAN networks. UNB offers less data rate when compared to SS

Capacity: Capacity of LPWAN is defined as different operations that could be performed with less complex infrastructure and with efficient transmission of data. UNB supports better capacity with simple system as compared to the later.

Link budget: Link budget is one of the crucial factor in designing optimised IoT system. Most of the LPWAN techniques link budget in the range 156dB to 172 dB

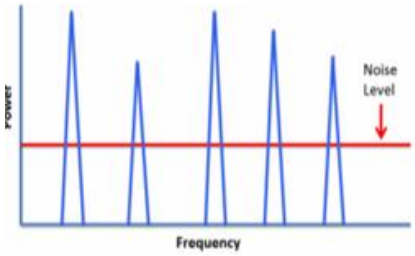

Fig 2: Power vs Frequency UNB Signals

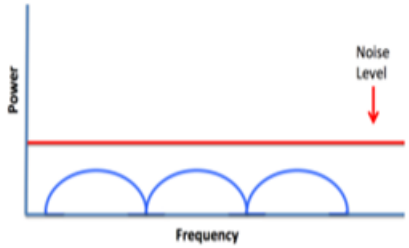

Fig 3: Power vs Frequency SS Signals

Sigfox technology is from Sigfox., a French company. Data rate of Sigfox is very low and Sigfox operates on the unlicensed spectrum. Sigfox is based on Ultra Narrow Band technology. Sigfox's performance is better than its counterpart for the uplink communication. However, Sigfox not very effective for vice-versa communication from base station to devices. As of today, Sigfox network has been fully deployed in 12 countries, with ongoing deployments in 26 other countries, giving in total a geography of 2 million square kilometers, containing 512 million people [12]

LoRa is from Semtech. LoRa networks consume more bandwidth compare to Ulta rnarrow band for transmission of data

LPWAN devices plays a key role in infrastructure monitoring, transportation, asset tracking, security, Healthcare. LPWAN technology becoming popular because of extended battery life, less expensive and low data rate. LPWAN technologies due to its low data rate it can achieve long distance communication and without the management of battery for several years.

Long range: In LPWAN network sensors or devices can connect to base station at a distance ranging from few kilometres of range. UNB squeeze each carrier signal as short as 100KHz further reducing the experienced noise and increasing the number of supported end-devices per unit bandwidth. Sigfox is an example for Ultra Narrow Band technology.

Spread spectrum technology sends a narrowband signal over a wider frequency band compare to its counterpart but with same power density. Actual signal resembles like a noise which makes more difficult for the attacker to understand and decode, more resistant to interference, robust to jamming attacks.

Ultra low power operation: In LPWAN technology, end devices are directly connected to base station, which avoids the high deployment cost and also avoids complex deployment topology. LPWAN use star topology. On need basis LPWAN end devices to turn off /turn on the transceiver which also saves the power

Low Cost: Low cost of LPWAN device enables to not only compete with well established short range wireless technologies and cellular networks but also suits for wide range of applications.

Reduction in Hardware complexity: LPWAN end devices has less complex and simple hardware as it needs to process the simple waveform compare to cellular and short-range wireless technologies

Minimum Infrastructure: Traditional cellular system has expensive infrastructure (Gateways, Powerlines, relay nodes etc). On the other hand, single LPWAN base station connects thousands of end devices across several kilometres, reducing cost of infrastructure

License free: Most of the LPWAN technologies are in the license exempt bands

Sigfox: Sigfox base station communicate with the server using internet. IoT devices/sensors communicate with the base station using Binary Phase Shift Keying (BPSK) modulation. With efficient use of bandwidth Sigfox produces high receiver sensitivity and consumption of low power. This is achieved with maximum throughput of 100bps. BPSK Modulation is conducted at an ultra narrow SUB GHz ISM band carrier. A single message from the device is transmitted multiple times over different frequency channels to achieve reliability, without acknowledgement

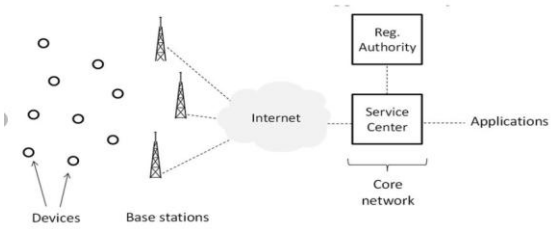

Fig 4: Sigfox Architecture

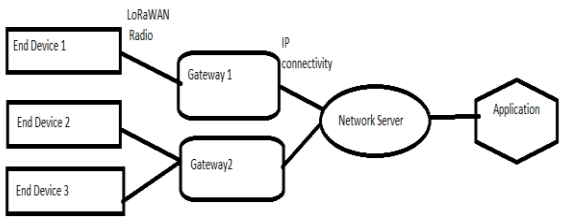

Fig 5: LoRa Architecture

LoRa: LoRa networks use star-of-star topology where in Gateway acts as interface between LoRa end devices and network servers. Gateways communicate with the network server via IP network and LoRa end devices communicate with the Gateways using single-hop LoRaWAN communication. LoRa performance is better with the uplink communication. However LoRa is favoured for bi-directional communication

LoRa is based on spread spectrum technology and modulation of the signals done on Sub-Ghz ISM band. Though LoRa is effective for Uplink communication, bidirectional communication has been achieved with the help of special Chirp Spread Spectrum (CSS) technique. LoRa signal resembles like a noise, LoRa spread the data signal over a much larger bandwidth. In LoRa, modulated signal look like noise that makes eavesdropper harder to detect or jam. In LoRa data rate changes from 300bps to 37.5 kbps depending on spreading factor and channel bandwidth

	Sigfox	**LoRa**
Modulation	UNB DBPSK(UL), GFSK(DL)	CSS
Band	SUB-Ghz, ISM-EU(868MHz), US(902MHz)	Sub-GHz ISM-EU(433 MHz 868MHz), US (915MHz), Asia (430MHz)
Data Rate	100 bps(UL), 600 bps(UL)	0.3-37.5kbps
Range	10km (URBAN), 50km(RURAL)	5 km(URBAN), 15km (RURAL)
Num of Channels/Orthogonal Signals	360 channels	10 in EU, 64+8(UL) and 8 (DL) in US plus multiple SFs
Link symmetry	No	Yes
Forward Error Correction	No	Yes
MAC	Unslotted ALOHA	Unslotted ALOHA
Topology	star	star of stars
Adaptive Data Rate	No	Yes
Payload length	12B (UL), 8B(DL)	Up to 250B (depends on SF & region)
Handover	End devices do not join a single base station	End devices do not join a single base station
Authentication & encryption	Encryption not supported	AES 128b
Over the air updates	No	Yes
Localization	No	Yes

TABLE1: TECHNICAL SPECIFICATION OF SIGFOX AND LORA [2]

III. RELATED WORK

This section briefs about related work done in LPWAN. M. Anteur et al; [5] introduced the Ultra Narrow Band technology and explained requirements of LPWAN such as long distance, low energy consumption, and cost effectiveness. This paper details about Random access scheme performance at the MAC level, resistance to noise, interference along with long range communications,

advantages of Ultra narrow band which is suitable for the LPWAN networks.

Nitin Naik [1] explained the various parameters considered for the best performance of LPWAN network

X. Xiong et al ; conducted experiments with SDR prototypes to evaluate the field trial performance in urban environments. Experiments are conducted for outdoor and indoor environments with large coverage performance of 3 km and 1 km respectively.

In [15], authors have analyzed different solutions to address the LPWAN network. Licensed and unlicensed spectrums have been explained with examples of Ultra narrow band and Spread spectrum. Each solution has advantages and disadvantages. As per [15], NB-IoT would be good solution offering QoS for reasonable power while excluding coin cell batteries

IV. CONCLUSION

In this paper we mainly focused on 2 LPWAN technologies viz Sigfox and LoRa. There are few challenges while implementing these Ultra narrow band and Spread Spectrum technologies. UNB with the use of narrow RF channel provide long range connection with minimal data rates. UNB is simple and low cost. Complexity of decoding is implemented on base station making the LPWAN end devices simple.

Scalability: In a typical LWPAN environment, sometimes the number of devices in a particular region will be creating 'Hot-Spot' problem. This dense collection of end devices will results in degradation of performance. LPWAN devices working with cross technology will result in degrading the performance of LPWAN technologies. The MAC protocols used by LPWAN have issue with scalability [3]

Interference: In IoT system, where thousands of devices operating simultaneously all sharing the same channel is a key problem. As the number of devices increases there is a fair chance of interference of shared ISM bands in which devices operate. LPWAN technologies use simple ALOHA these not only deteriorate the performance but also generates high interference [3]

Low data rate: LPWAN technology sends extremely small payload. This limits the usecases to allow applications which needs high data rate to use LPWAN technologies devices.

Interoperability: There should be standards defined for interoperability of different LPWAN technologies. Intense competition among LPWAN technologies needs co-existence of LPWAN technologies

Security: Compared to other counter parts such as cellular networks or wifi LPWAN takes strong authentication, security and privacy. In order to avoid security breaches of the end devices and base station strong authentication and security policies should be defined [3]

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Anireekshith Narayana, et. al. "Choice of effective LPWAN protocol for IoT System: Sigfox and LoRa." *International Journal of Engineering Research and Applications (IJERA)*, vol.10 (11), 2020, pp 53-57.