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Comparative Analysis of Internet of Things (IoT) based Low Power Wireless Technologies

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Abstract **— Internet of Things (IoT) marketplace is swiftly expanding as companies across multiple vertical industries recognize the need for connectivity and the potential transformation enabled through connectivity. In short, the Internet of Things refers to the rapidly growing network of connected objects that are able to collect and exchange data using embedded sensors. NB-IOT (Narrowband - Internet of Things), LoRa, and Sigfox wireless technologies have been getting a good deal of attention globally as the market for wireless matures in light of the prospects for billions of connections. The goal of the LoRa Alliance, LoRaWAN adopters, and SigFox is that mobile network operators adopt their technology for IoT deployments over both city and nationwide low power, wide-area networks (LPWANs). But there are some prominent differences between how each technology plans to achieve this goal and which applications the technology is best suited for.**

Keywords—LoRaWAN; SigFox; RPMA; NB-IoT; LPWAN

I. INTRODUCTION

A Low-Power Wide-Area-Network i.e LPWAN is one type of wireless communication WAN which is designed to allow communications with long range at a lower bit rate among sensors or connected objects(Things) that operate on battery[1]. Such networks due to their low power, lower bit rates and their use are distinguished from wireless WAN that connect more businesses or users, carry large data, require high power. A LPWAN may be an infrastructure or service provided by a third party, used to create a wireless private sensor network, letting the sensor owners to deploy them in field.

LP-WAN Essentials

The attributes of LP WAN wish list are:

Cost: LPWAN is used for IoT networks or sensor networks. While working with IoT or sensor networks we need to deploy sensors or things[1]. Therefore it is very essential to consider unit price for determining application's Return of Investment (ROI).

Low energy consumption: In IoT and wireless sensor network we work with sensors that may be remotely deployed. Now it is essential that the battery life of nodes (sensors) be such long that we do not need to replace it for long years[1]. Also it is necessary that the energy consumption must be as less as possible.

Extended range: Range is the coverage area of the application. In order to lower the cost of infrastructure the range should be longer. The range of the application is inversely proportional to the cost of infrastructure.

Scalability: If the frequency is openly available then it is quite possible that the number of users may increase with time. It is possible that the application is installed by multiple users. If the installation is done using the common access point like shared tower, cellphones, it is possible the number of devices the access point can support may get limited and a requirement for new infrastructure may arise. If they are not using access point and working with frequencies even then it is quite possible that the available channel may go down preventing further installations.

Let us see the technologies concerned with LPWAN:

LoRaWAN: LoRa Alliance maintains the LoRaWAN which is a MAC layer protocol that manages communication between end-node devices and LPWAN gateways. First version of LoRaWAN 1.0 was released in the year 2015[6].

LoRa is a physical layer chip that enables long range communication link, while LoRaWAN is a system architecture and communication protocol for network. LoRaWAN holds responsibility for managing data rate, power and frequencies for devices[3]. Devices in such network transmit only when data is available to send. Multiple gateways receive data that is transmitted by the end-node and forwards it to the network server which is centralised. The responsibility of network server is to perform security checks, manage the network and filter duplicate packets. Later the data is carried to the application server. The technology is highly reliable for moderate load, but it shows some performance issues while sending acknowledgements.
It targets IoT basic needs like mobility, localization services and secure bidirectional communication [6].

RPMA: For Internet of Thing's Machine to Machine communication, Random Phase Multiple Access is a method that is low power wide area channel. RPMA employs Direct Sequence Spread Spectrum for multiple access. In order to find clear signal at both device and network level, RPMA self modulates[8]. This technology enables battery efficiency and maximum coverage unlike cellular. There is a special

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connection protocol deployed which pings the device, checks the status of device, data is received and then connection is closed to save battery life. Most of the IoT and M2M connections require high battery life and low data throughput connectivity.

Narrowband – Internet of Things (NB-IoT): Narrowband Internet of Things is a latest way of communication that allows the transmission of small chunks of data for long periods to remote places.

NB-IoT technology falls into the category of Low Power WAN that is developed to handle wide range of services and devices of IoT[12]. In deep coverage areas NB-IoT helps to significantly improve system capacity, power consumption of end-devices and spectrum capacity. It supports a longer battery life of around 10 years for a variety of use cases. This technology is specially designed to meet increasing demand for extended coverage like rural or indoor areas with ultra low device complexity. The cost of NB-IoT s comparable to GPRS/GSM. It is expected that the cost may decrease with increase in demand of the technology. Also that it is very simple than GPRS and GSM. It can be said that NB-IoT may co-exist with 2G, 3G and $g networks of mobile if it is supported with all major equipment and chipset[11]. All the mobiles network privacy and security features like authentication, integrity, confidentiality, device identification is advantageous to NB-IoT as well[10]. The launch of NB-IoT is completed and it may globally available in 2017 or 2018.

Its features include:

- Ultra low power consumption
- Secure and reliable network
- Low cost of component
- Easy deployment with current cellular network architecture
- Excellent extended range for underground and remote areas.

SigFox: SigFox is a French company, which was found in 2009. SigFox, due to its triumphant marketing in Europe, has achieved most traction in space of LPWAN[2]. It has a rich ecosystem vendors that include Silicon Labs, Axom and Texas Instruments.

In order to achieve longer range a proprietary technology is used by SigFox that uses slow modulation rate. SigFox turns out to be an excellent option for application in which there is requirement of sending infrequent, small data bursts.

Applications of SigFox includes smart dustbins, water meters, parking sensors, etc[4]. It has a drawback that its downlink (i.e. replying back to devices/sensors) is severely limited and there may arise an issue with signal interference. Let us see the comparison of the above LPWAN technologies in the following section.

II. COMPARISON

Here we are making comparison between LPWAN technologies as LoRaWAN, SigFox, RPMA and NB-IoT respectively. The attributes that are taken into consideration are namely Year of introduction, technology which is used, application of the technologies, its advantages and disadvantages, uplink, downlink, frequency, channel width, range and packet size, deployment status and the governing body.

Attributes	LoRaWAN	SigFox	RPMA	NB-IoT
Year	2015	2009	2008	2016
Technology	LoRa is a physical layer chip, LoRaWAN is the software that enables networking using this chip.	To achieve longer range, SigFox uses slow modulation rate.	RPMA uses key innovations and silicon technology.	Used with LTE network
Applications	Applications that require low cost battery solutions and less frequent requirement for communication.	Better for water meters, smart dustbins or parking sensors.	host of applications like environmental monitoring, pedestrian traffic, air quality and parking, etc.	Suitable for applications that require minimal latency and communicate more frequently. Industrial IoT(IIoT)
Advantages	Increased in Gateway capacity as messages may collide and interfere.	Advantageous to send small data bursts, for large area coverage, reachable to underground objects.	Operates in globally available spectrum 2.4GHz, have better scheduling, interference robustness and Doppler.	Battery life up to 10 years, ubiquitous network coverage, faster network up gradation, plug and play, high network security, low cost.
Disadvantages	Not suitable for applications that require bounded jitter and low latency[7].	Downlink capability is limited and may have issue with signal interference	-	Challenge with the network to cope up with attached devices, Challenge with diverse frequencies and interference with other LTE traffic.
Uplink	300bps to 50kbps (EU)[6]	100bps to 140 message/day [2]	per Sector 625 kbps[8]	for multi tone 50 kbps, for single tone 20kbps[13]

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Downlink	300bps to 50kbps (EU)[6]	Maximum of messages 4, 8bytes/day[2]	per Sector 156 kbps[8]	50 kbps[13]
Frequency Band	915/780/868/433 MHz ISM[5]	902 MHz/868 MHz ISM[4]	2.4 GHz ISM[4]	180 KHz[4]
Channel Width	Modulation: (CSS)Chirp Spread Spectrum[9]	Ultra Narrow width[4]	1 MHz (40 channels available) [4]	1.4 Mhz[13]
Range	2-5km - urban, 15km - rural[4]	30-50 km - rural, 3-10km - urban, 1000km LoS[4]	more than 500km LoS[4]	more than 35 km[4]
Packet size	Defined by user[4]	12 bytes[4]	Flexible 6 bytes to 10kbytes[4]	1500 bytes[4]
Status	In deployment, Spec was released in June 2015.	In deployment	In deployment	Not available yet, and will likely not be until the end of 2017.
Governing body	SigFox	LoRa Alliance	Ingenu(formerly OnRamp)	3GPP

From the above table we can say that each of the LPWA technology is best suitable for a specific application. LoRaWAN is most suitable for applications like agriculture; SigFox is most suited for smart garbage can, parking sensors; while RPMA is applicable for environmental analysis and NB-IoT is most suited for applications falling in Industrial IoT (IoT) category.

III.CONCLUSION

In this paper we have discussed different LPWAN (Low Power Wide Area Network) technologies which are presently ruling the Internet of Things (IoT) world. We have compared four technologies LoRaWAN, SigFox, RPMA and NB-IoT respectively with different parameters like features, applications, range, bandwidth etc. Each technology is running at its best with their own applications. It will be very tough to go with any one technology for all the IoT related applications. Our future work will be concentrated on to overcome the limitations of these technologies in their area, so that we can provide a better solution to the IoT world.

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