RESEARCH ARTICLE

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Collation of NBIOT with Other LPWAN Legacy Technologies

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ABSTRACT

A few years back The Internet of Things - IoT which is like fiction for us has moved to realism. In a queue of low power wide area network (LPWAN) technology, one more novel technology is now added known as Narrowband Internet of thing (NB-IoT). The reason behind to developed this technology is to provide long battery life for distant devices, accomplished communication, and lower costs and cover a large geographical area and very useful in urban infrastructure. As the growing demand for IoT devices, we can see in the coming few years it increases promptly, and all the devices are connected to each other wirelessly. This paper provides as an inclusive overview of NB-IoT, different types of deployment options and Narrowband IOT (NB-IOT) Collation with the other LPWAN Technology like SigFox and LoRaWAN. NB-IOT is utilized where the requirement is to only transmit a small amount of data if we talk about the conventional cellular options they are not fit well with such applications because 4G and LTE networks put away too much power. Cellular NB-IoT is developed to meet the necessities of long-range, deep penetration, long battery life applications.

Keywords: LPWAN, NB-IOT, IOT, Long Range, Long Term Evolution.

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INTRODUCTION

Over the past few decades, humans are busy in innovating something new in the field of wireless technology to change the world from wired to wireless. By the year 2020, this wireless technology has to support more than 50 billion connected devices. To find out the solution, 3GPP (3RD generation partnership project) in its Release-13, a new narrowband technology emerged, named as Narrowband Internet of Things (NB-IoT). If we compare it with other legacy technologies it provides low-power, low-cost, wide-area connectivity, deep penetration for IoT devices. Distant devices face the problem of more power consumption, NB-IoT comes up with lots of improved features like it requires less power consumption of user devices, system capacity is high and utilization of spectrum efficiency is more, especially if we talk about deep coverage. The 5th generation provides all the above solutions and connects all the devices to the internet with low cost and less power consumption. Now we can see with an increase in IoT devices the wireless sensor industry market loaded with such devices. When there is massive numbers of devices want to connect then the technology like Zig-Bee and Bluetooth will not work and we need something new. IoT provides a better solution to connect the enormous number of devices at the

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same time. To fulfill the demand of the user like extended coverage area – rural coverage and deep indoors penetration – and complexity of the device should be reduced, for all this, we have to make lots of changes in the physical layer signals and channels. Globally, the first NB-IoT commercial launch is expected to be at the end of year 2019/20. LPWAN technologies work into two groups, in an unauthorized spectrum (Sigfox and Lora) and another one that works in the authorized spectrum (NB-IoT) [1], [2]. If we compare the novel NB-IOT technology with an existing GSM/GPRS then we analyze that in the near future with the increase in the demand the cost of the devices will drop rapidly.

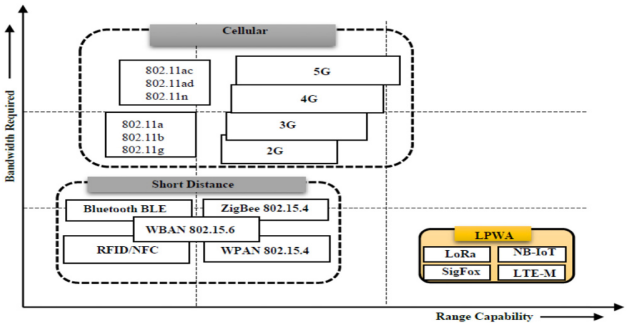

Figure 1: Bandwidth and Range capability for cellular and short distance [6]

The authorized group is comprised of 2G/3G cellular communication technologies, and LTE technology supports different categories of terminals [3]. NB-IoT is a gigantic Low Power Wide Area (LPWA) technology proposed by 3GPP [4], [5]. The relationship between 5G and IoT is very close and significant.

NB-IOT DEPLOYMENT OPTION

As the demand for the upcoming LPWAN technology that is NB-IoT seems to be increased in the near future. For this new spectrum options are required and to be used as efficiently as possible. The type of choice of deployment option will have a direct impact on network dimensioning, Quality of service (QoS) and also affect the total cost. To achieve spectral efficiency, NB-IoT is designed to exist in one of three ways:

1. In-band Operation using one PRB of an LTE carrier [6] [7].
2. Guard band Operation utilizes new Resource Blocks within the existing LTE carrier Guard Band [6].
3. Standalone Operation by using a GSM 200 KHz carrier [8]

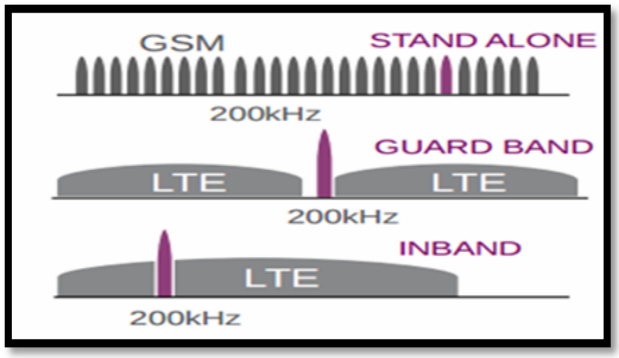

Figure 2: NB-IoT Deployment option [8]

1. Standalone Mode- In this deployment option when we use a separate NB-IoT channel which is launched outside LTE or inside GSM spectrum.
2. In-band Mode –In this NB-IoT channel goes within the LTE spectrum. The LTE in-band is the most cost-efficient deployment option of NB-IoT.
3. Guard Band Mode- The third alternative deployment options work at a very edge of GSM or LTE spectrum in so-called guard band frequency where useful information is not transmitted at all.

LPWAN

LPWAN technologies operate in the unlicensed sub 1GHz Industrial, Scientific and Medical (ISM) band, which is shared by all "Short Range" devices also called as ETSI [9].

Features	LORAWAN	SIGFOX	LTE Cat 1	LTE M	NB-IoT
Modulation	SS Chip	GPSK/BPSK	OFDMA	OFDMA	OFDMA
Rx Bandwidth	500-125 kHz	100 Hz	20 MHz	20-1.4 MHz	200 kHz
Data Rate	290bps-50Kbps	100bit/sec 12/8 bytes Max	10Mbit/sec	200kbps-1 Mbps	Average 20k bit/ sec
Max.# Msg/ Day	Unlimited	UL: 140 Msgs/day	Unlimited	Unlimited	Unlimited
Battery Life	105 months	90 months	-	18months	-
Interference Immunity	Very High	Low	Medium	Medium	Medium
Security	Yes	No	Yes	Yes	Yes
Mobility/Localization	Yes	Limited Mobility, No Localization	Mobility	Mobility	Limited mobility No localization

Figure 3: Comparison between different LPWAN Technologies

LPWA technologies are broadly divided into two parts either wideband or ultra-narrowband technologies, if we do the comparison between

two, the wideband utilize a larger bandwidth and use controlled frequency diversity to retrieve data, and ultra-narrow band techniques compress data into ultra narrow bands and use high stability RF crystals and digital signal processing techniques to recover the data. LPWAN focused on the characteristics like energy efficiency, scalability, and coverage. Applications that require sovereign battery-powered nodes with extended coverage, low throughput, are more inclined to LPWAN technologies. LPWA technologies features are suited for IoT applications and that's why the new technology is entered in the market called NB-IoT. The following sections will provide an overview of each of the key LPWAN technologies.

LoRa

LoRa (Long Range) is a digital wireless data communication technology, it's a spread spectrum modulation technique derived from chirp spread spectrum (CSS) technology [10]. It provides a wireless platform for Internet of Things (IoT) networks worldwide. LoRaWAN is rarely used for industrial application and it's a better option for the public services because all the channels are tuned to the same frequencies. LoRa Technology has no of use cases for smart cities, smart homes, smart agriculture, smart metering, smart supply chain and logistics, smart irrigation system and more. Fig. 4 shows how LoRa works.

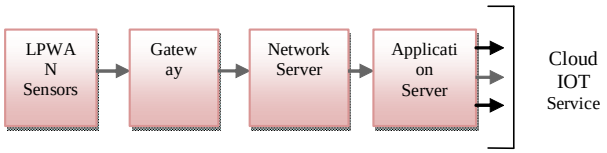

Figure 4: LoRa End to End Secured Payload

- LoRa Technology is embedded in end-nodes or sensor devices.
- Sensors or end nodes transmit data to gateways over distances with minimal power requirement.
- The data collected by LoRa-enabled devices are interpreted by cloud IoT service, by applying techniques like machine learning and artificial intelligence.
- The benefit of LoRa: - LoRa is a good option if the requirement of the consumer is bidirectionality, it is best for the devices in motion to collect the data. Long battery life in comparison to NB-IoT, best for single-building application and useful for setting up an own network.

SIGFOX

Sigfox is founded in 2009 and is a French global network operator. It is an excellent option where the target only has to send small (12 bytes) and infrequent bursts of data. It is also very slow (300 baud) using BPSK. The band 600 Hz is using Gaussian Frequency Shift Keying (GFSK) for the downlink and the band 100 Hz using Orthogonal Sequence Spread Spectrum (OSSS) for the uplink signal. Sending less data means less energy consumption, hence longer battery life. Use cases of SigFox are like parking sensors, water meters, or smart garbage bins. The device is not in a direct link of any particular base station just like cellular protocols. The message which is transmitted is received by any of the base stations in the range. It won't be able to handle a large number of use cases because it is not deployed everywhere. Mobility is difficult with sigfox devices in comparison to LoRa.

LTE-M

LTE-M is the abbreviation for LTE Cat-M1 or Long Term Evolution (4G), category. 3GPP in its release [11] introduced LTE in 3GPP Radio Access Network (RAN) and primarily focused on enhancement in the coverage area and low cost [12]. 3GPP in the release also introduced the first new user equipment (UE) category "Cat-0" for LTE-MTC [13]. The groundwork for Cat-M is all set by cat-0 protocol. It is ideal good for the M2M and IoT applications it provides speed of 10 Mb/s and 5 Mb/s for downlink and uplink respectively. In comparison to Cat-0, the cost and power consumption of Cat-1 is much reduced and Cat-M work for some particular applications like smart metering, smart building, Transportation and Connected health for this maximum system bandwidth is 1.4 MHz.

	Release/Category			
	Release 8	Release 12	Release 13	Release 13
	Cat-4	Cat-0	Cat-M	NB-IoT
Max. system bandwidth	20MHz	20MHz	1.4MHz	200kHz
Downlink peak rate	150 Mbit/s	1 Mbit/s	1 Mbit/s	~200kbit/s
Uplink peak rate	50 Mbit/s	1 Mbit/s	1 Mbit/s	~200kbit/s
Duplex	Full duplex	Half duplex	Half duplex	Half duplex
Number of antennas	2	1	1	1
Transmit power (UE)	23dBm	23dBm	20dBm	23dBm
Estimated modem complexity	100%	40%	20%	<15%

Figure 5: Release/ Category [11]

The existing LTE network is compatible with Cat-M which is also known as eMTC and LTE M. The design goals of LTE M for coming future, it provides variable data rates which is used to enhance the coverage, 10 years battery life, device cost comparable to GPRS and provides extended coverage greater than 156 dB MCL. LTM-M equipped with all the benefits of security, privacy which is already there in the existing mobile networks, also LTE M can accompany with 2G, 3G, and 4G networks and provides mobile equipment identification, entity authentication, data integrity, and confidentiality. Also, there is no need to spend money to build new antennas. LTE also easily accompanied with 5g and the backward-compatibility of Cat-M is a bonus for the upcoming technology.

NB-IOT

Narrow Band-Internet of Things (NB-IoT) is an LPWAN technology designed for new IoT devices and services. Three deployment options are there (stand alone, guard band and in-band) and 200 kHz of bandwidth is required for this technology and it works with the existing LTE technology. NB-IoT utilizes OFDM modulation technique for downlink communication and uses SC-FDMA technique for uplink communications [14]. To meet the demand for extended coverage, long battery life, deep penetration, and ultra-low device complexity, NB-IoT is designed with new physical layer signals and channels. It can co-exist with existing networks and if we compared it with the technologies like GSM/ GPRS it is simpler, cost-effective and demanding in the near future the demand of such devices will definitely going to be increased and will see the decrease in the cost. In terms of the business benefit, it provides Power efficient, cost-effective, Reliable, wider deployment and global reach. Complexity is there in NB-IoT, it deployed in a sideband, due to which the initial cost to develop operating software will be high. The problem also arises where little existing GSM spectrum, it further increases the cost of modem and antennas which lead to increase licensing fees. At the same time, it offers all features of existing LTE mobile networks including support for user identity confidentiality, entity authentication, data integrity, and mobile device identification. Narrowband IoT (NB-IoT) leverages DSSS modulation technology vs. LTE spread technology for connectivity.

Room for Improvement: The speed with which the IoT market is growing and the demand of such devices is increasing all this in the near future will provide numerous direct benefits to the IoT industry like we can examine the component and assets in real-time also the repair activity can be done before any failure occur [15]. In the near future, we can also see smart ventilation controller, radiation monitoring, air quality, and inventory measurement. The actual demand of the IoT devices depends on customer satisfaction and this provides us the real data for the IoT devices and how much consumption and manufacturing of the devices is needed [16].

CONCLUSION

We are growing towards the new LPWAN technology but still, we have to work on numbers of grey areas which are still left over. SigFox, LoRa is the technologies which are working in an unlicensed band and it is difficult to manage them because they only following the duty cycle limitations. If we compare LoRa devices and cellular IoT devices, Lora has no subscription cost, but the Cellular IoT devices will have a subscription charge. SigFox with the licensed model can be managed but the required number of the gateway in new network deployment. Other technologies working in the same band creates a physical interference problem which still remains the same [9]. Current solutions for the LPWAN focused on several coexistence and interference problems and also get the solutions like if we talk about the channel hopping it postpones the overutilization of the entire spectrum band [17]. In the conclusion we can say that till now the LPWAN are deployed and managed in uncoordinated manner, due to which we can't take all the benefit of these unlicensed technologies to make them more efficient we have to make lots of amendments in choosing the deployment option, architecture and operation so that in the upcoming 5g technology we can efficiently utilize the LPWAN technologies.

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