NB-IoT Report

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November 26, 2018

1 Introduction

The Narrow-Band Internet of Things(NB-IoT) is a massive Low Power Wide Area(LPWA) technology proposed by 3GPP for data perception and acquisition intended for intelligent low-data-rate applications. Enable a wide range of cellular devices and services.
The NB-IoT supports massive connections, ultra-low power consumption, wide area coverage and bidirectional triggering between signaling plane and data plane.

2 Usage and Application

NB-IoT applications can cross many service categories. These include:

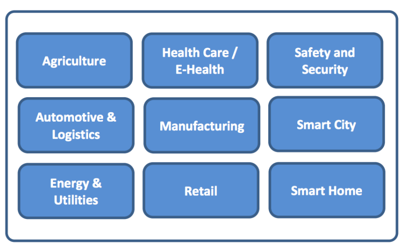

Figure 1: Target Industries for NB-IoT Services

1. Smart metering (electricity, gas and water)
2. Facility management services
3. Intruder alarms & fire alarms for homes & commercial properties
4. Connected personal appliances measuring health parameters
5. Tracking of persons, animals or objects

6. Smart city infrastructure such as street lamps or dustbins
7. Connected industrial appliances such as welding machines or air compressors.

3 Physical Layer

The NB-IoT specification was frozen in Release 13 of the 3GPP specification in June 2016. Release 13 define 14 frequency bands for NB-IoT. In release 14, 4 more frequency were added. And in release 15, 3GPP added 7 futher bands.

E-UTRA Operating Band	Uplink (UL) operating band BS receive UE transmit			Downlink (DL) operating band BS transmit UE receive			Duplex Mode
	F_{UL_low}	–	F_{UL_high}	F_{DL_low}	–	F_{DL_high}	
1	1920 MHz	–	1980 MHz	2110 MHz	–	2170 MHz	HD-FDD
2	1850 MHz	–	1910 MHz	1930 MHz	–	1990 MHz	HD-FDD
3	1710 MHz	–	1785 MHz	1805 MHz	–	1880 MHz	HD-FDD
5	824 MHz	–	849 MHz	869 MHz	–	894MHz	HD-FDD
8	880 MHz	–	915 MHz	925 MHz	–	960 MHz	HD-FDD
11	1427.9 MHz	–	1447.9 MHz	1475.9 MHz	–	1495.9 MHz	HD-FDD
12	699 MHz	–	716 MHz	729 MHz	–	746 MHz	HD-FDD
13	777 MHz	–	787 MHz	746 MHz	–	756 MHz	HD-FDD
17	704 MHz	–	716 MHz	734 MHz	–	746 MHz	HD-FDD
18	815 MHz	–	830 MHz	860 MHz	–	875 MHz	HD-FDD
19	830 MHz	–	845 MHz	875 MHz	–	890 MHz	HD-FDD
20	832 MHz	–	862 MHz	791 MHz	–	821 MHz	HD-FDD
25	1850 MHz	–	1915 MHz	1930 MHz	–	1995 MHz	HD-FDD
26	814 MHz	–	849 MHz	859 MHz	–	894 MHz	HD-FDD
28	703 MHz	–	748 MHz	758 MHz	–	803 MHz	HD-FDD
31	452.5 MHz	–	457.5 MHz	462.5 MHz	–	467.5 MHz	HD-FDD
66	1710 MHz	–	1780 MHz	2110 MHz	–	2200 MHz	HD-FDD
70	1695 MHz	–	1710 MHz	1995 MHz	–	2020 MHz	HD-FDD

Figure 2: NB-IoT frequency bands until release 14

The bandwidth of NB-IoT is 200kHz for both downlink and uplink. The modulation used for NB-IoT is essentially the QPSK modulation for downlink and uplink with multi-tone transmission. Also, it uses the $\pi/2$-BPSK or the $\pi/4$-QPSK modulation for uplink single-tone transmission.

4 Power Consumption

Low power wide area networks mainly require wide coverage, low power consumption and massive connections. There are several inherent characteristics of the NB-IoT technology that makes it the best for LPWA deployment.
When we compare inherent capabilities of NB-IoT with other LPWA technologies like e-MTC, SigFox and Lora, NB-IoT offers better performance. Furthermore, when we look at all the technologies in terms of network investment,

coverage scenario, uplink and downlink traffic and network reliability we realize that NB-IoT is the most suitable technology.
Additionally from a performance point of view, NB-IoT guarantees more than 20 dB coverage, up to 10 years using only 200 KHz bandwidth.

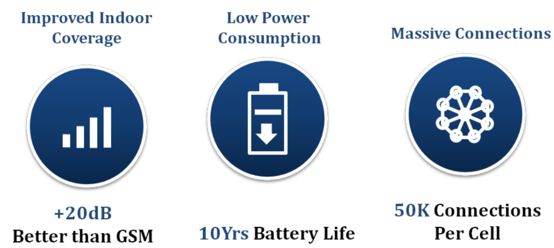

Figure 3: Inherent capabilities of NB-IoT

5 MAC Layer

NB-IoT reuses the LTE design extensively. For uplink, NB-IoT uses single-carrier frequency-division multiple-access (SC-FDMA). An NB-IoT carrier uses twelve 15 kHz sub-carriers for a total of 180 kHz. There are two types of transmission for NB-IoT, multi-tone and single-tone. Multi-tone transmission is based on SC-FDMA with the same 15 kHz sub-carrier spacing, 0.5 ms slot and 1 ms subframe as LTE. Single-tone transmission supports two numerologies, 15 kHz and 3.75 kHz. The 15 kHz numerology is identical to LTE and thus achieves the best coexistence performance with LTE in the uplink. The 3.75 kHz singletone numerology uses 2 ms slot duration. Like the downlink, an uplink NB-IoT carrier uses a total system bandwidth of 180 kHz. The following table illustrates the different types of NB-IoT :

Sub-carrier spacing	Number of tones	Number of SC-FDMA symbols	Transmission time
15 kHz	12	14	1 ms
15 kHz	6	28	2 ms
15 kHz	3	56	4 ms
15 kHz	1	112	8 ms
3.75 kHz	1	112	32 ms

Table 1: NB-IoT types of SC-FDMA

6 Security

The security requirements of NB-IoT are similar to those of traditional IoT. However, there are many differences, which mainly relate to IoT hardware equipment with low power consumption, network communication mode, and actual service requirements.

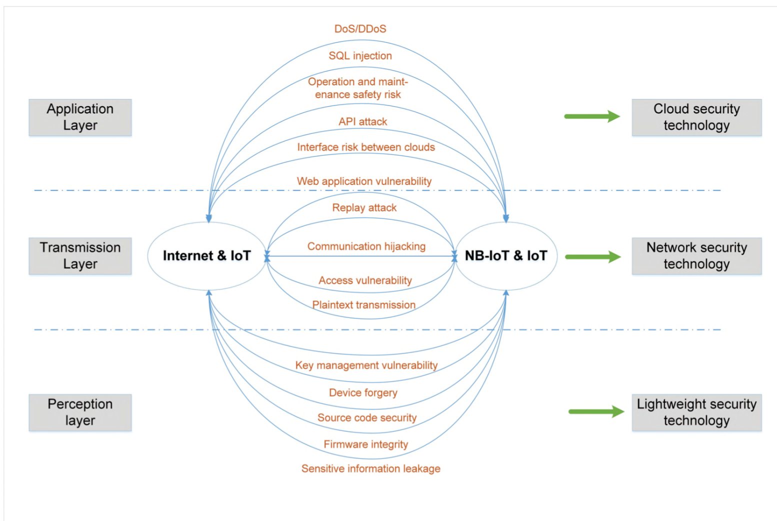

Figure 4: The similarity between NB-IoT and traditional IoT in terms of security requirements

The perception layer is the bottom layer of NB-IoT which represents the foundation of upper layers of architecture and services. The passive attack means that the attacker only steals the information without making any modification. Different from passive attacks, active attacks include integrity damage and falsification of information, therefore, the extent of injury brought by active attack to NB-IoT network is far larger than by passive attack.
In contrast to the transmission layer in traditional IoT, NB-IoT changes the complicated network deployment where in relay gateway collects information and then feeds back to base station. Therefore, many problems such as multi-network networking, high cost and high-capacity battery are solved. However, new security threats are also present:

- Access to high-capacity NB-IoT terminals
- Open network environment

The target of application layer of NB-IoT is to store, analyze and manage data effectively. After perception layer and transmission layer, a large amount of data converges in application layer. Then, massive resources are formed to provide data support for various applications. Compared with application layer of traditional IoT network, the application layer of NB-IoT carries larger amount of data. The main security requirements are as follows:

- Identification and processing of massive heterogeneous data
- Integrity and authentication of data
- Access control of data

7 Routing and IP

NB-IoT is based on the 4G network, profiting from its coverage and allowing an easy way to deploy. However, unlike LTE-M (another LPWA cellular technology) with which it is frequently compared, NB-IoT is not an IP-based communication protocol. It was made for simple IoT applications being more power efficient, whereas LTE-M is better suited for higher bandwidth or mobile and roaming applications.

8 Mobility

Due to its characteristics, the NB-IoT technology can meet requirements of low data transmission rate services with low power consumption, wide coverage and large capacity, but it is difficult to support high mobility. Thus, NB-IoT is better fit for static, low latency sensitivity, discontinuous movement or real-time data transmission services.

9 Conclusion

As a LPWAN technology, NB-IoT is especially designed for IoT communications, dedicated to long-range and low rate communication in order to ensure a low power consumption, up to 10 years. Also, the price is cheap because chips are simple to create and NB-IoT has a deep building penetration which allows to have a good coverage in location that are difficult to access (like underground parking for example).