Comparative analysis of the application of different Low Power Wide Area Network technologies in power grid

Hao Wang1*, Hong Sui1, Xing Liao1, Junhao Li1
1Guangzhou Power Supply Co.Ltd., Guangzhou, China

*Corresponding author e-mail: wanghao_hust@sina.com

Abstract. Low Power Wide Area Network (LPWAN) technologies developed rapidly in recent years, but the application principle of different LPWAN technologies in power grid is still not clear. This paper gives a comparative analysis of two mainstream LPWAN technologies including NB-IoT and LoRa, and gives an application suggestion of these two LPWAN technologies, which can guide the planning and construction of LPWAN in power grid.

1. Introduction
At present, telecom operators have built mobile cellular networks covering all over the world. In recent years, the demand of M2M(machine-to-machine) communication in power grid enterprises increased rapidly. Although the 2G/3G/4G cellular networks already have wide coverage, the cellular networks have the problem of not supporting mass connection, insufficient coverage of typical M2M scenes and high cost of terminal power consumption[1]. These disadvantages make the 2G/3G/4G cellular networks don’t match the demand of IoT(Internet of things) application of power grid.

To solve the problems above, LPWAN (Low Power Wide Area Network) is designed for the low bandwidth, low power consumption, long distance, mass connection IoT applications, which is suitable for the M2M communication in power grid. The LPWA communication modules acquire the data from different types of sensors and transmit the data to the software platform through LPWAN. The low power consumption characteristic of LPWAN can make the battery of a communication module support its normal functioning for several years[2]. The software platform can be custom-developed to adapt to a variety of application scenarios of power grid.
LPWAN technologies can be divided into two main types, one type works in unlicensed spectrum (such as LoRa, SigFox), and the other type is based on 2G/3G/4G cellular network under the licensed spectrum supported by 3GPP (such as NB-IoT, eMTC). LoRa and NB-IoT are the most mainstream technologies of these two types of LPWAN. This paper will give a comparative analysis of NB-IoT and LoRa, and gives an application suggestion of these two technologies in power grid.

2. Network structure of LoRa in power grid
LoRa is a proprietary LPWAN technology based on chirp spread spectrum (CSS) radio modulation. Power grid enterprises can deploy LoRa networks using license-free sub-gigahertz radio frequency bands. LoRa networks for the power grid consist of LoRa communication modules, LoRa gateways, LoRa network servers and the application server for power grid. The LoRa communication modules acquire the data from different service terminals (such as distribution automation terminals, electricity meters and street lights) and transmit the data to the LoRa gateways (data transmitted by a LoRa communication module can be received by multiple gateways). The LoRa gateways can be deployed on the roofs of the transformer substations or office buildings which are the property of the power grid enterprises. Through the power grid backhaul communication network (such as the SDH network of power grid), the LoRa gateways will forward the received packets from the LoRa communication modules to the cloud-based network server[3]. The network server can accomplish filtering redundant data packets, adaptive rate selection, gateway management and selection, process validation and safety management [4]. The application servers analyze and utilize the data of service terminals obtained from the network server, and accomplish data encryption and decryption. Power grid enterprises can develop proprietary LoRa application systems based on their service demands.
3. Network structure of NB-IoT in power grid

NB-IoT (Narrow Band Internet of Things) uses licensed frequency bands (only about 200 kHz bandwidth), and can be deployed in the 2G/3G/4G public cellular networks of the telecom operators through smooth upgrade. NB-IoT network can be deployed to several modes including stand alone, guard band and in-band [5]. Compared with eMTC (enhanced Machine-Type Communication), NB-IoT has lower cost and wider coverage performance but worse mobility and data transmission rate performance [6]. The M2M services in the power grid like distribution automation, intelligent electric meters and intelligent street lights are usually static and demand low bit rate. So NB-IoT is more suitable for the IoT solution for power grid.

Power grid enterprises can deploy the NB-IoT communication modules on different types of M2M service terminals. The NB-IoT modules access the NB-IoT network of telecom operators through base stations and the core network to the cloud platform, and the power grid enterprises pay network rental fee to the telecom operators. Dedicated NB-IoT cloud platforms for power grid can be developed to accomplish the refined management on the power grid M2M service terminals which access to the NB-IoT network.

![Figure 2. Network structure of LoRa in power grid.](image1)

![Figure 3. Network structure of NB-IoT in power grid.](image2)
4. Comparative analysis of LoRa and NB-IoT

This chapter will give a comparative analysis of the application of LoRa and NB-IoT in power grid in multiple aspects.

4.1. Deployment cost

Power grid enterprises can deploy LoRa as private network. Power grid enterprises should purchase and deploy LoRa communication modules, LoRa gateways, LoRa servers, and the holding poles for the gateways on the building roofs. The deployment costs include equipment purchasing cost, construction and installation cost and operating maintenance cost after the LoRa network putted into operation.

NB-IoT is public network. Power grid enterprises only need to purchase and deploy NB-IoT communication modules and pay the rental fee to the telecom operators to access the NB-IoT network. So the investment of LoRa for power grid is mainly nonrecurring expenditure. The investment of NB-IoT is mainly long-term network lease cost.

4.2. Signal coverage

The LoRa gateways can only be deployed on the roofs of the transformer substations or office buildings which are the property of the power grid enterprises. The LoRa signal coverage is restricted in the area near the power grid LoRa gateways. The coverage area of LoRa cannot accomplish large-scale continuous coverage area because the locations of deploying the LoRa gateways are restricted in the buildings of the power grid enterprises.

The signal coverage of NB-IoT depends on the network deployment of the telecom operators. In the area where the telecom operators have not deploy the base stations or the base stations haven’t update to have the NB-IoT function, the service terminals of power grid cannot access the NB-IoT network. However, the service terminals of power grid like distribution automation terminals and electricity meters always installed in buildings sheltered electric environment, telecom operators must make some signal enhancement measures(indoor distribution system or signal relay equipment) to guarantee the signal coverage for power grid.

4.3. Frequency usage

The LoRa networks using license-free radio frequency bands, in China the frequency can be 470MHz~510MHz. Besides power grid enterprises, other industries can also use this unlicensed frequency band. So the LoRa networks of power grid are likely to be interfered by other industries when the network scale is large, which will affect the communication reliability. And the usage policy of 470MHz~510MHz frequency band is still not clear, the frequency policy is likely to restrict the development of LoRa in power grid.

NB-IoT uses licensed frequency bands of 2G/3G/4G cellular networks, so it cannot be interfered by other industries when making large-scale applications in power grid.

4.4. Communication performance

NB-IoT has better system capacity and spectrum efficiency performance than LoRa. But the basic performance parameters (network capacity, bitrate, time delay, signal receive sensitivity and power consumption) of these two technologies can both meet the communication demand of low-bitrate M2M power grid services.

4.5. Evolution route

NB-IoT has a clearer evolution route, it can accomplish the evolution to 5G mMTC(Massive Machine Type Communication) based on the evolution plan of 3GPP. LoRa doesn’t have explicit evolution after the latest version right now.

5. Conclusion

LoRa is more suitable for the application scenarios that service terminals of power grid are in centralized distribution. For example, LoRa gateways can be deployed on the roof of a transformer
substation to achieve on-line monitoring of the equipment in the substation outfield when the sensors of the monitored equipment are connected to the LoRa modules. NB-IoT is more suitable for the M2M service terminals in decentralized distribution like electricity meters or street lights, which need to deploy a large number of base stations to ensure the signal coverage.

In the area that the telecom operators haven’t deployed the NB-IoT network, power grid enterprises can deploy private LoRa networks to meet the pressing needs of the M2M communication in that area.

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