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Applications of LoRa and NB-IoT in Internet of Things

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Abstract

There are many wireless communication technologies in the Internet of Things, which are mainly divided into two categories: one is Zigbee, WiFi, Bluetooth, Z-wave and other short-distance communication technologies; the other is LPWAN (low-power Wide-Area Network), namely WAN communication technology. LPWA can be divided into two categories: one is the technology of LoRa and SigFox working in unauthorized spectrum; the other is the technology of 2/3/4 G cellular communication supported by 3GPP working in authorized spectrum, such as EC-GSM, LTE Cat-m, NB-IoT. LoRa works in an unauthorized frequency band below 1GHz, so there is no additional charge for its application. It uses free unauthorized frequency bands and is an asynchronous communication protocol, which is the best choice for battery power supply and low cost. NB-IoT has become an important branch of the Internet of Things. NB-IoT is built in cellular network and needs a narrow bandwidth about 180 KHz, which can be directly deployed in GSM network, UMTS network or LTE network to reduce deployment cost and achieve smooth upgrade. From the point of view of NB-IoT and LoRa chip products, many products are integrated with MCU or processor, which makes signal and data processing and communication protocol management more convenient. Both NB-IoT and LoRa are still at the initial stage of development, requiring input from all parties and common development.

Keywords

IoT, LoRa, NB-IoT

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1. Standards and Progress of NB-IoT

1.1. RAN Aspect

In May 2014, Huawei acquired Nuel Company and began to research the narrowband honeycomb interconnection technology with Vodafone, and proposed the narrowband technology NB M2M. In May 2015, Huawei, Vodafone and Qualcomm jointly formulated relevant downlink and downlink technical standards, and formed NB-CIoT by integrating NB OFDMA.

NB-CIoT has proposed a new technology of empty port, which has changed a lot in the existing LTE network [1-3]. But NB-CIoT is the only one of the six Clean Slate technologies that meets the five goals proposed in TSG GERAN_conference (improving indoor coverage performance, supporting large-scale equipment connection, reducing equipment complexity, reducing power consumption and delay), especially NB-CIoT. The cost of oT communication module is lower than that of GSM module and NB-LTE module.

At this time, Ericsson and Nokia jointly launched the narrowband cellular technology NB-LTE, which is similar to the location of NB-CIoT, but NB-LTE is more inclined to be compatible with the existing LTE, and its main advantage is

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easy to deploy. In July 2015, Ericsson and Huawei submitted standard proposals to 3GPP respectively. Finally, after intensive discussion at the RAN #69 meeting in September 2015, the NB-IoT standard was formed by the integration of the two technologies in the Rel-13 version of 3GPP.

NB-IoT has evolved from narrowband technology to the formal standard of 3GPP [4]. The active promotion of relevant manufacturers and operators and the real demand of the market are two factors that can not be ignored.

The communication technology standard of 3GPP can be divided into Core Part (main function), performance standard and RF conformance test standard. Among them, the main function standard refers to the specific content of the protocol, including signaling protocol, network access and so on, which is mainly related to development; the performance standard mainly refers to the performance of various sub-technical areas, which is strongly related to testing; and the conformance test standard mainly includes some process and function testing standards.

1.2. SA/CT

From Rel-12 onwards, 3GPP is gradually studying the core network architecture of MTC communication enhancement. From Rel-13 onwards, it focuses on NB-IoT and DECOR/eDECOR related technologies.

The main standards related to NB-IoT on the core network side of 3GPP are mostly in stage 2 (business and system architecture), and the related work of stage 3 (core network and terminal) was launched from the second half of 2016 to the beginning of 2017. In order to meet the massive fragmentation, low cost, low speed, low power consumption of the NB-IoT Internet of Things applications, the core network mainly considers the following aspects [5].

1.2.1. Supporting Infrequent Packet Delivery Efficiently

For NB-IoT, the processing efficiency of infrequent packet transmission is further improved. Because the number of NB-IoT terminals may increase exponentially, but the data volume and communication cycle of each terminal are relatively low. To deal with such services with the existing EPS core network (based on S1 interface), its efficiency will be very low and there is a risk of overload. Therefore, it is necessary to minimize the communication overhead of the entire EPS system [6], especially the empty port part (e.g. the establishment and release of RRC connections). In addition, we need to strengthen the security process of EPS system (this part is from SA WG).

At present, there are two optimization directions, one is based on the control side, that is, to transmit packets through the NAS process; the other is based on the user side, that is, to cache the user's context at both UE and RAN nodes through RRC suspend state, so as to reduce signaling interaction [7]. The above two optimization schemes have been added in the version of TS23.401 Rel-14. The first one is the necessary one, and the second one is the optional one. At present, 3GPP tends to adopt control-based optimization scheme, and this part of the standard is still in progress in the main body of CT (core network and terminal).

1.2.2. Supporting Tracking Devices Efficiently by Using Packet Transmission

3GPP does not specifically define the business model of such services, and is still in the research state. It is expected to be solved in Rel-14 version [8]. Its business model belongs to the variant of MAR (mobile terminal periodic reporting) business model, which needs further enhancement and optimization in positioning, mobility, transmission efficiency and so on.

1.2.3. Efficient Paging Area Management

For mass static or mobile terminals, 3GPP SA2 is still discussing paging optimization due to the scarcity of empty port resources and limited core network interface resources. It is expected that this part of the function will be improved in Rel-14. The main idea of paging optimization is to consider paging only in the eNB or cell where the user last accessed, rather than the whole TA (preliminary assumption, the TA code of NB-IoT cell is different from the TA code of existing eNB cell), in order to save the related resources of the empty port and core network [9-11].

In the same coverage area, NB-IoT devices are massive, far more than traditional cellular terminals. Operators operating in narrowband spectrum may not be able to provide sufficient paging resources and UE identification (S-TMSI, IMSI). Compared with traditional cellular systems, the number of messages in a small packet is limited, so it is very limited to include the above identifiers in a single paging message [12]. On the other hand, coverage enhancement is mandatory in the standard, so paging messages may take longer time (the interval between repeating the same paging messages is longer).

Most NB-IoT devices are considered to be static or rarely mobile, so their paging range can be limited without paging the entire TA to which they belong, which can reduce the consumption of paging resources [13]. However, when UE enters IDLE mode, the last cell information reported by eNB to MME for NB-IoT UE service may be inaccurate (even for static users). This is because in the case of UE stationary, the change of user's main service cell may be caused by various reasons, such as radio frequency load.

2. Evolution of LTE-M, EC-GSM and NB-IoT

The interconnection of all things is a big trend and an inevitable trend of development. Various Internet of Things technologies are also in full swing.

Faced with various emerging Internet of Things technologies, 3GPP has three main standards: LTE-M, EC-GSM and NB-IoT, which are based on LTE evolution, GSM evolution and Clean Slate technology respectively.

LTE-M, or LTE-Machine-to-Machine, is based on LTE evolution of Internet of Things technology, called Low-Cost MTC in R12 and LTE enhanced MTC (eMTC) in R13. It aims to meet the requirements of Internet of Things equipment based on existing LTE carriers.

A friend who knows LTE UE categories is no stranger [14]. In order to adapt to the application scenario of the Internet of Things, 3GPP defines the lowest rate UE device in R1 1 as UE Cat-1, its upstream rate is 5 Mbps, and its downstream rate is 10 Mbps. In order to further adapt to the low power and low rate requirements of Internet of Things sensors, by R12, 3GPP also defines a lower cost and lower power consumption Cat-0, with up-and-down rate of 1 Mbps.

EC-GSM, namely Extended Coverage-GSM. With the rise of various LPWA technologies, the disadvantage of traditional GPRS application in the Internet of Things is highlighted. In March 2014, the research project of "Cellular System Support for Ultra Low Complexityand Low Throughput Internet of Things" at the meeting of 3GPP GERAN #62 proposed to migrate narrowband (200 kHz) Internet of Things technology to GSM, to seek a wider coverage of 20 dB higher than traditional GPRS, and put forward five goals: improving indoor coverage performance, supporting large-scale equipment connection, and reducing equipment replication. Hybridity, reduced power consumption and delay. In 2015, the report of the TSG GERAN conference indicated that EC-GSM has met five major goals.

GERAN (GSM EDGE Radio Access Network) is the abbreviation of GSM/EDGE Radio Access Network. GERAN is dominated by 3GPP and mainly formulates GSM standards [15]. Because the early technology of cellular Internet of Things was based on GSM, some projects of Internet of Things were carried out by GERAN.

With the development of technology, the communication of cellular Internet of Things needs to be redefined. Our image of "clean-slate" scheme is similar to "clean the house and treat it", which leads to the emergence of NB-IoT. Because NB-IoT technology is not based on GSM, it is a clean-slate scheme, so the work content of the cellular Internet of Things is transferred to the RAN group. GERAN will continue to study EC-GSM until the R13 NB-IoT standard freezes.

NB-IoT: In August 2015, 3GPP RAN began to study a new air port technology for narrowband wireless access, called Clean Slate CIoT, which covers NB-CIoT.

NB-CIoT was jointly proposed by Huawei, Qualcomm and Neul. NB-LTE was proposed by Ericsson, Nokia and other manufacturers.

NB-CIoT has proposed a new technology of empty port, which has changed a lot in the existing LTE network. But NB-CIoT is the only one of the six CleanSlate technologies that meets the five goals proposed in TSG GERAN_Conference (improving indoor coverage performance, supporting large-scale equipment connection, reducing equipment complexity, reducing power consumption and delay), especially NB-CIoT. The cost of communication module is lower than that of GSM module and NB-LTE module.

NB-LTE is more compatible with existing LTE, and its main advantage is easy deployment. Ultimately, NB-IoT can be regarded as the integration of NB-CIoT and NB-LTE after intensive tearing and negotiation at the RAN #69 meeting in September 2015

3. Conclusion

NB-IoT works in the authorized frequency band, and the equipment needs access permission, so the interference is relatively less. LoRa works in the unauthorized frequency band. There are many kinds of devices in the unauthorized frequency band, which will inevitably be interfered by other wireless devices. The advantage of LoRa lies in its patented technology, which can maintain high acceptance sensitivity and anti-jamming ability even in complex environments.

The data rates of LoRa and NB-IoT are different. LoRa data rates can reach 50 Kbps and NB-IoT data rates can reach 200 kbps. In fact, different data rates of the two technologies also form different market segmentation applications, and suitable technologies can be selected according to actual project needs.

From the point of view of NB-IoT and LoRa chip products, many products are integrated with MCU or processor, which makes signal and data processing and communication protocol management more convenient.

NB-IoT and LoRa wireless networks are deployed in different environments and have different communication distances. In actual deployment, we need to consider the problem of "blind area". It can also combine other wireless technologies (such as FSK) to solve the "blind zone" problem of signals.

NB-IoT and LoRa have their own advantages. It is necessary to choose the appropriate technology according to the actual project demand and its own situation.

Both NB-IoT and LoRa are still at the initial stage of development, requiring input from all parties and common development. When large-scale deployment becomes a reality, the cost of NB-IoT and LoRa modules will naturally be further reduced. In this new wave of development of the Internet of Things, the first step is to land the project, in order to win the first step. NB-IoT and LoRa need not only product innovation, but also project application innovation.

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References

[1] Sinha R S, Wei Y, Hwang S H. A survey on LPWA technology: LoRa and NB-IoT [J]. Ict Express, 2017, 3 (1).

[2] Lin J, Shen Z, Miao C. Using Blockchain Technology to Build Trust in Sharing LoRaWAN IoT [C]// International Conference. 2017.

[3] Mekki K, Bajic E, Chaxel F, et al. A comparative study of LPWAN technologies for large-scale IoT deployment [J]. Ict Express, 2018.

[4] Bankov D, Khorov E, Lyakhov A. Mathematical model of LoRaWAN channel access [C]// IEEE International Symposium on A World of Wireless. 2017.

[5] Hejazi H, Rajab H, Cinkler T, et al. Survey of platforms for massive IoT [C]// IEEE International Conference on Future Iot Technologies. 2018.

[6] Beyene Y D, Jantti R, Ruttik K, et al. On the Performance of Narrow-Band Internet of Things (NB-IoT) [C]// Wireless Communications & Networking Conference. 2017.

[7] Lauridsen M, Kovacs I Z, Mogensen P, et al. Coverage and Capacity Analysis of LTE-M and NB-IoT in a Rural Area [C]// Vehicular Technology Conference. 2017.

[8] Harwahyu R, Cheng R G, Wei C H, et al. Optimization of Random Access Channel in NB-IoT [J]. IEEE Internet of Things Journal, 2017, PP (99): 1-1.

[9] Ayoub W, Mroue M, Nouvel F, et al. Towards IP over LPWANs technologies: LoRaWAN, DASH7, NB-IoT [C]// Sixth International Conference on Digital Information. 2018.

[10] Mekki K, Bajic E, Chaxel F, et al. A comparative study of LPWAN technologies for large-scale IoT deployment [J]. Ict Express, 2018.

[11] Vatcharatiansakul N, Tuwanut P, Pornavalai C. Experimental performance evaluation of LoRaWAN: A case study in Bangkok [C]// International Joint Conference on Computer Science & Software Engineering. 2017.

[12] Bardyn J P, Melly T, Seller O, et al. IoT: The era of LPWAN is starting now [C]// European Solid-state Circuits Conference. 2016.

[13] Harwahyu R, Cheng R G, Tsai W J, et al. Repetitions v.s. Retransmissions: Trade-off in Configuring NB-IoT Random Access Channels [J]. IEEE Internet of Things Journal, 2019, PP (99): 1-1.

[14] Chen J, Ota K, Lu W, et al. Guest Editorial Special Issue on Theories and Applications of NB-IoT [J]. IEEE Internet of Things Journal, 2018, 5 (3): 1435-1435.

[15] Martinez B, Adelantado F, Bartoli A, et al. Exploring the Performance Boundaries of NB-IoT [J]. 2018.