Analysis on the Development of Radio and Television 5G IoT

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Abstract. This paper introduces the technical characteristics and end-to-end typical application systems of NB-IoT, puts forward the overall network architecture of NB-IoT. Based on the development status of the industry, the network deployment scheme and relevant development suggestions are proposed, providing reference for the innovative development and commercial implementation of 5G IoT in radio and television industry.

1. Introduction

With the rapid development of 5G, artificial intelligence, big data, block-chain and other new generation information technologies, the information industry represented by the Internet of Things has ushered in the third wave. Driven by both supply-side and demand-side, the global Internet of Things has entered a new stage of "cross-border integration, integrated innovation and large-scale development", facilitating a new round of technological revolution and industrial transformation.

NB-IoT (Narrow Band Internet of Things) is a kind of low-power wide-area technology, characterized by low power consumption, low cost, wide coverage and large connection, etc. As the formal completion of the core part of the first version of NB-IoT standard protocol in June 2016, NB-IoT has rapidly become the common focus of the industry and academia, exerting its end-to-end industry chain capability from chip, module, wireless access, core network to IoT platform within a short period of time. In July 2019, NB-IoT was officially confirmed as a 5G candidate technology to meet the technical requirements of mMTC scenario (Massive Machine Type Communication). At the same time, 5G's enhanced broadband, massive connectivity, low latency and high reliability will greatly promote the realization of the vision of the Internet of Everything, supporting for cross-border integration and cross-industry applications.

2. NB-IoT

NB-IoT works in the authorized frequency band and relies on cellular network to achieve smooth evolution through software upgrade. In particular, compared to unlicensed technologies such as LoRa, NB-IoT has significant advantages in guaranteeing the security and reliability of data transmission. With the continuous innovation and popularization of advanced technologies, NB-IoT has been deployed nationwide in order to support smart cities (such as utility meters), shared bikes and smart agriculture and other applications.

2.1. Technical characteristics of NB-IoT

Low power consumption: NB-IoT has introduced power-saving modes such as eDRX and PSM to reduce power consumption by limiting unnecessary commands, using longer paging cycles, and simplifying protocols and optimizing modular chip manufacturing processes, enabling a theoretical battery life of up to 10 years.
**Low cost:** NB-IoT achieves low cost by reducing storage capacity and processing speed, and improving terminal integration. The cost of NB-IoT terminal modules will further decrease with the scale effect.

**Wide coverage:** NB-IoT achieves coverage enhancement by increasing the transmit power spectral density and repeated transmission. The MCL (i.e., Maximum Coupling Loss) of NB-IoT can reach up to 164dB. It optimizes the network depth coverage capability, which can better achieve the whole area coverage and improve the network coverage in locations where signals are difficult to reach, such as subways, basements, and tunnels.

**Large connection:** Compared to the traditional cellular IoT, NB-IoT has a hundredfold increase in the number of connections, theoretically supporting 50,000 connections/cell.

**High security:** Based on authorized spectrum, air interface two-way authentication and strict encryption mechanism, NB-IoT provides telecommunication-level security and reliability to ensure the security of user data.[1]

### 2.2. End-to-end application system of NB-IoT

Typical NB-IoT end-to-end application systems consist of five major parts: terminal, wireless access network, core network, IoT platform, and application server.

![Figure 1. End-to-end application system of NB-IoT](image)

**Terminal:** connects to the base station through the air interface to realize the docking with the wireless access network.

**Wireless access network:** it undertakes the functions of air access processing and cell management, realizes the connection of user terminal to the network, and forwards the data of non-access layer to the core network element.

**Core network:** it is responsible for mobility, security and connection management, interacts with the terminal non-access layer, and forwards data to the IoT platform.

**IoT platform:** the IoT connection management platform, gathers data and forwards it to the application server.

**Application server:** completes operations such as data processing and storage, and provide front-end and back-end programs for client access.

### 3. 5G IoT network architecture based on NB-IoT

In view of the current status of 5G network construction and future business development plans, a differentiated NB-IoT Internet of Things network architecture is proposed, which mainly includes three parts: terminal, wireless access and core network.
Figure 2. 5G IoT network architecture based on NB-IoT

**Terminal:** Terminals are the underlying business entities in the entire network architecture, including smart terminals with built-in NB-IoT transmission modules, such as smart home appliances, smart door locks, and wearable devices. These terminals connect with the wireless access network through the air interface, and undertake data acquisition, preliminary processing, encryption and transmission, etc. Through smart TV, mobile phone or various control panels, users can achieve the management and control of terminal devices.

**Wireless access network:** Base station is the basic unit of wireless access network, which mainly completes the communication and management between terminal and access network, including wireless resource management, dynamic resource allocation and scheduling, data stream encryption and so on. [1] On the one hand, the base station is connected downward to the terminal through the air interface to realize the terminal access to the network. On the other hand, the base station is connected upward to the functional units of the core network to realize the connection between the wireless access network and the core network. Moreover, the interconnection between base stations enables the terminal to switch between different base stations. For the radio and television industry, due to the limited resources of 5G frequency band, it is inevitable that NB-IoT and 5G NR will coexist in the same frequency band. In order to ensure the normal operation of both systems, the way of resource reservation is essential to be fully considered. In terms of downlink, ensure that the synchronization channel, broadcast channel and public channel of the two systems are free from interference, and the anchor and non-anchor carriers of NB-IoT do not overlap with the synchronous signal block (SSB) of NR. For the uplink, NR’s detection reference signal (SRS) should be protected from NB-IoT interference, so as to avoid resource overlap between NR SRS and NB-IoT.

**Core network:** Taking into account the later maintenance and scalability, network function virtualization technology (NFV) can be used to construct a virtual core network, where the required function of IoT is separated from the core network elements to form a new virtual IoT service gateway node. [2] The radio and television industry directly adopts 5G architecture in the construction of the core network, but the existing NB-IoT terminals can only access the LTE core network, no way for 5GC. Therefore, in addition to the replacement and iteration of terminals, it is also necessary to introduce NB-IoT network elements in the access and mobility management functions of the 5G core network to achieve end-to-end business processes.
4. The development plan of 5G IoT based on NB-IoT

4.1. Network planning and deployment

Scale Estimation: Based on the network structure and traffic model to estimate the scale of different areas by comprehensively considering the uplink and downlink rate, interference margin and penetration loss, etc. The scale estimation mainly includes coverage planning and capacity planning. Coverage planning focuses on network structure, strictly controls overlap coverage between cells to meet the requirements of the strength and rate of the edge signal, realizing effective coverage in each area. Capacity planning should be combined with the former one, and make an overall analysis of various factors such as wireless air outlet resources and service capacity, so as to meet the performance indexes of coverage and capacity simultaneously. For example, in cases where capacity cannot be accurately estimated, the coverage level should be designed as high as possible to ensure a sufficiently large capacity.[2]

Site planning: Before construction, the site must first be surveyed, collect the key information including the supported frequency band, antenna gain, azimuth angle, height, etc., confirm whether the transmission resources can meet the bandwidth allocation requirements, and check the power supply, access terminal and other supporting equipment. In terms of configuration, 2T2R (2 transmit and 2 receive antennas) is preferred, which is currently the most economical and easy to implement. For supplementary scenarios with weak coverage, 4 receive antenna will be adopted, and gradually introduce 4 transmit antenna with the maturity of the industrial chain.

4.2. Security system construction

In the massive data processing and business operation, security issues such as IoT terminal management, access authentication, information security and privacy protection are particularly prominent.[3] Therefore, the construction of IoT needs to improve the security management system and mechanism, continuously promote the network security level protection, risk assessment, commercial password application and so on, enhancing the ability of business systems, transmission networks and terminals to resist security risks.

The terminal should be able to defend against attacks to prevent illegal access, including hardware and software considerations such as hardware chip-level security, OS security, and terminal security reinforcement above the OS layer.

For the network layer, establish and improve the two-layer security mechanism of NB-IoT, that is, access layer security (integrity protection and encryption) and non-access layer security to prevent information leakage, content tampering and eavesdropping.

IoT platform needs to focus on building security capabilities including terminal secure access and management, data security, and the platform's own security protection.[2]

Establish a security isolation mechanism at the application layer, perform mandatory authentication and business permission control on cloud access, so as to achieve efficient, safe and reliable management of diversified business applications.

5. Suggestions on the development of 5G IoT

The Internet of Things is a whole industry chain that includes cloud, pipe, terminal and application, etc. the construction of 5G IoT, it is necessary to integrate all links of the industrial chain and information resources of various vertical industries, to create a multi-collaborative and multi-intelligent IoT service system, thus promoting the innovative development and commercial implementation of 5G IoT in radio and television industry.

5.1. Digital home terminal

Aiming at serving the masses and families, build a smart product ecosystem with the family as the core, to deeply explore the value-added value of terminal products, and guide the upstream and downstream technical standards of the terminal industry chain, the radio and television industry can cooperate with
manufacturers to develop NB-IoT chips and modules, focus on the field of digital homes and develop smart home business terminals, e.g., smart home appliances, smart cameras, smart sockets, etc., so as to provide refined digital life services for users.

5.2. Cloud service platform
Based on the collaborative "cloud + network" model so as to promote the linkage between cloud and network in radio industry. Integrate the application of cloud computing, big data, edge computing and other technologies to provide a unified delivery platform for the diversified IoT applications, which sink cloud data processing capabilities, simplify the application delivery process, reduce delivery costs, optimize service capabilities, and provide application services and intelligent solutions for urban infrastructure construction and social public utilities.

5.3. Business demand oriented
The typical market of IoT has the characteristics of fragmentation, with numerous vertical industries and diverse industry demands. Hence, to build the radio and television IoT, it should be oriented by business demand, focusing on the customized development of vertical industries and associated market segments in combination with the needs of specific industries and even specific government and enterprise customers, and providing personalized and differentiated IoT service.[4]

5.4. Explore data value
Build a smart broadcasting IoT big data application system with data as the key element, and with the help of cloud computing and big data technology to aggregate, mine, analyze and apply the massive IoT data generated by various vertical industries. Grasp the data dividend, dig deep into the value of data, and better serve government decision-making and management, economic and social development, the optimization and upgrading of broadcasting as well as high-quality development.

5.5. Strengthen safety capabilities
Combined with the block-chain technology, build a distributed intelligent radio and television IoT architecture, by taking advantage of its features of data unforgeability, value transmissibility and programmability. [4] Relying on the unique trust mechanism of the block-chain to realize penetrating supervision and level-by-level transmission of trust, so as to form a feasible data security protection scheme to ensure the security of data transmission and access, strengthening the data security protection capability.

5.6. Enhance public welfare attributes
Make full use of the public credibility advantages of radio and television, timely dock with the information resources of party and government organizations at all levels, make overall plans for public welfare services such as smart cities, smart elderly care and smart communities, and actively participate in the construction of public welfare projects (e.g., emergency broadcasting), so as to promote the standardization, equalization and quality of radio and television public services.

6. Conclusion
It is necessary to be oriented by business needs, focusing on the customized development of vertical industries and associated market segments, and providing personalized and differentiated service. In addition, making further efforts to grasp the data dividend, deeply explore the value of massive data, timely dock with the information resource management platform of party and government agencies at all levels, and actively participate in the construction of smart cities, smart communities and other public welfare projects, thus enhancing the dissemination, guidance, influence and credibility of radio and television.
Acknowledgments
Funding supported by Project of Academy of Broadcasting Science, Project No.:JBKY20210260.

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