Technology Reports (Special Articles) 5G Evolution Standardization 3GPP Release 16
Special Articles on 3GPP Release 16 Standardization Activities

5G Evolution Directions and Standardization Trends

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5G services have begun in many countries around the world, and in Japan, 5G commercial services began in March 2020. Furthermore, in the area of research and development, steady progress is being made in studying technologies and drafting standards to drive the evolution (enhancement) of 5G. This article describes the directions of 5G evolution and standardization trends toward 5G evolution in 3GPP Rel-16 specifications.

1. Introduction

Nippon Telegraph and Telephone Public Corporation (forerunner to NTT) began mobile communication services with the world's first cellular system on December 3, 1979. Since then, mobile communications technology has been evolving and expanding to next-generation systems every 10 years. Services too have been evolving together with technical developments, and while mainly limited to voice calls and simple e-mail in the beginning, they now enable anyone to exchange multimedia information such as photographs, music, and video. Recent years, moreover, have seen an explosive growth in the use of smartphones and an even greater diversity of multimedia communication services thanks to high-speed communications technology beyond 100 Mbps under the Long Term Evolution (LTE) system. For its part, NTT DOCOMO launched commercial fifth-generation mobile communications

system (5G) services in March 2020 as another milestone in the evolution of its mobile communications technology.

Owing to technical features such as high-speed and large-capacity transmission, low latency, and massive connectivity, 5G is expected to enhance multimedia communication services provided up to 4G and to provide new value as basic technology supporting industry and society together with advanced technologies such as Artificial Intelligence (AI) and Internet of Things (IoT). As shown in **Figure 1**, mobile communications technology has been evolving in 10-year intervals while mobile communication services have been changing greatly in roughly 20-year cycles. We can therefore expect the next big change driven by 5G evolution (5G enhancement) and the next-generation sixth-generation mobile communications system (6G) to support industry and society in the 2030s [1].

In this article, we describe the main directions of 5G evolution with an eye to 2030 and the schedule for drafting standards toward 5G evolution in 3rd Generation Partnership Project (3GPP) Release 16 (hereinafter referred to as "Rel-16") specifications.

2. Main Directions in 5G Evolution

On the road toward 5G evolution, a number of technical issues have been uncovered based on 5G pre-commercial and commercial services launched in various countries around the world. The 5G system is the first generation of a mobile communications system to support high frequency bands in excess of 10 GHz. It features technology that can achieve ultra-high-speed wireless data communications of the several Gbps class using frequency bandwidths of the several 100 MHz class that are dramatically wider than previous technology. At

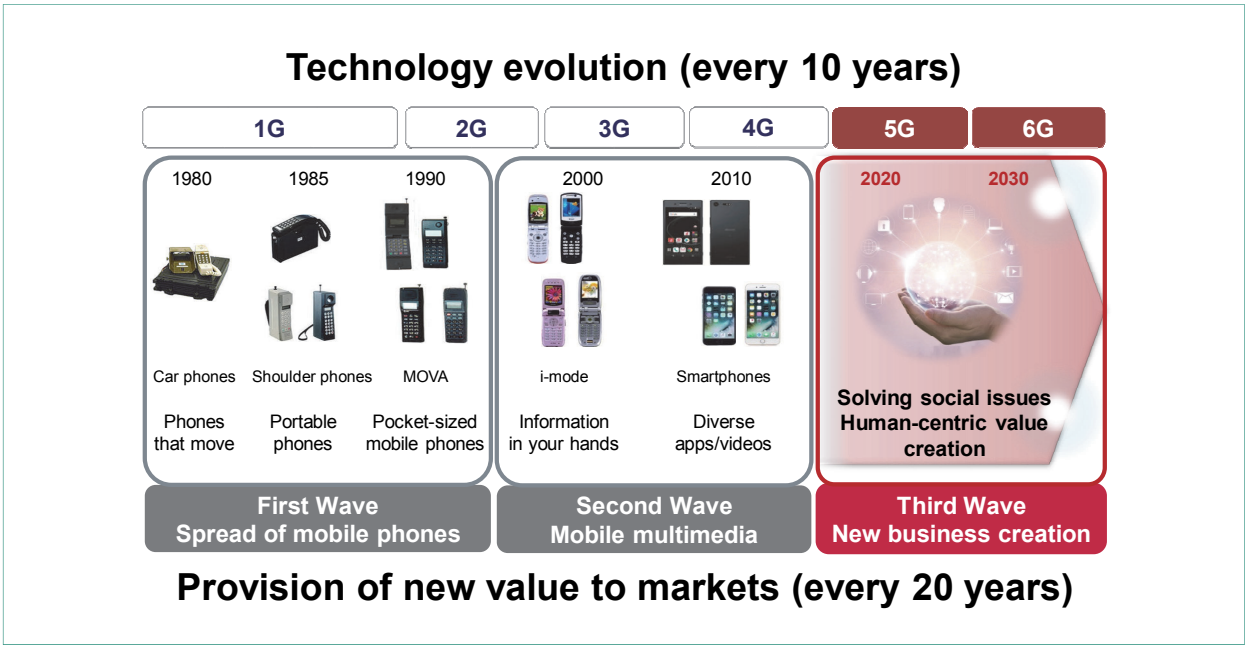

Figure 1 Evolution of technology and services in mobile communications

the same time, there is still much room for further development of high-frequency-band technology such as millimeter waves[*1] in mobile communications. In particular, the need for coverage improvement and uplink performance improvement in a Non-Line-Of-Sight (NLOS)[*2] environment and for mobility performance improvement are issues that have come to light through 5G-related trials. In addition, many expectations are being placed on 5G as technology that can support industry and society of the future, and industrial use cases in particular often have special requirements or require high radio performance. In Japan, discussions on "local 5G" specific to industrial use cases have been attracting the attention of the industrial world. There is therefore a need for further development of 5G technologies so that a wide range of industrial requirements can be satisfied in a flexible manner. The main directions in 5G evolution for addressing these issues and requirements are "exploiting new frequency bands," "improving system performance and efficiency," and "expanding use cases and services" as summarized below (**Figure 2**).

1) Exploiting New Frequency Bands

3GPP Rel-15 specifications support frequencies up to 52.6 GHz. With the aim of pioneering future usage scenarios using frequency bands in excess of 52.6 GHz, studies are being conducted at 3GPP on extending New Radio (NR)[*3] technology toward frequency bands up to 71 GHz as a global target toward International Mobile Telecommunications (IMT)[*4] as specified at the World Radiocommunication Conference (WRC)[*5]-19 [2] of the International Telecommunication Union (ITU) held in 2019.

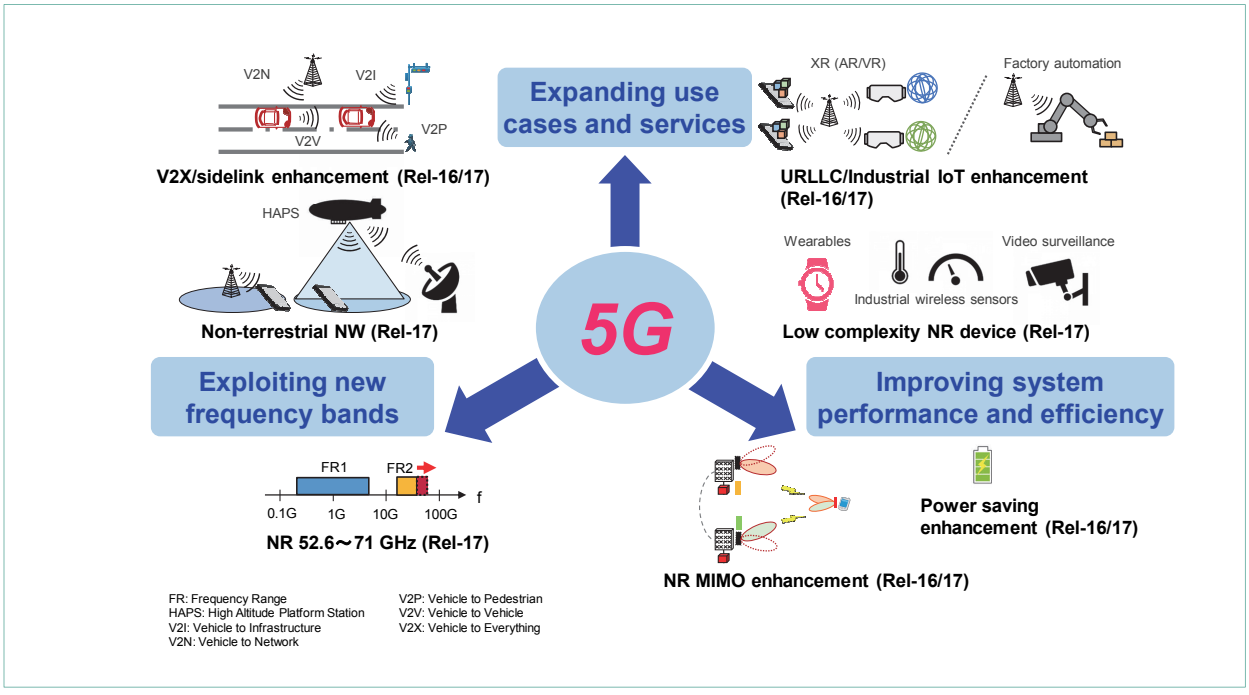

Figure 2 Directions in 5G evolution

*1 Millimeter waves: Radio signals in the frequency band from 30 GHz to 300 GHz as well as the 28 GHz band targeted by 5G that are customarily called "millimeter waves."

*2 NLOS: Describes an environment where there are obstacles between the transmitter and receiver. In this case, communication can only take place over waves that have been reflected, refracted, etc.

*3 NR: A new radio access system specified at 3GPP for 5G not compatible with LTE and LTE-Advanced.

*4 IMT: A generic term for international mobile communications systems standardized at ITU encompassing IMT-2000 (3G), IMT-Advanced (4G/LTE), IMT-2020 (5G), etc.

2) Improving System Performance and Efficiency

In NR under Rel-15, the plan was to improve performance and efficiency relative to LTE. However, optimization that takes into account new operation scenarios such as by making use of millimeter-wave characteristics was not taken up. For this reason, there are ongoing studies at 3GPP on reducing power consumption in terminals that use millimeter waves and on improving the performance of Multiple Input Multiple Output (MIMO)*6 technology and mobility. Some of these functional enhancements have been prescribed in Rel-16 specifications.

3) Expanding Use Cases and Services

In addition to services for existing smartphones and mobile phones, many studies are being conducted at 3GPP on the core network*7 and radio-extension technologies to satisfy requirements for a variety of use cases and services such as industrial automation, IoT, and Vehicle to X (V2X) communications through 5G. These studies are focusing on radio-extension technologies for achieving even higher reliability and lower latency, on network slicing*8, enhanced Quality of Service (QoS) control*9, enhanced security measures, AI applications, etc. for dealing with the evolution of diverse communication services, and on functional extensions to the 5G Core network (5GC) for achieving flexible and timely network construction and operation. Some of these functional enhancements have been prescribed in Rel-16 specifications.

The schedule for drafting standards toward 5G evolution at 3GPP is shown in **Figure 3**. Following the drafting of Rel-15, the initial 5G standard, the

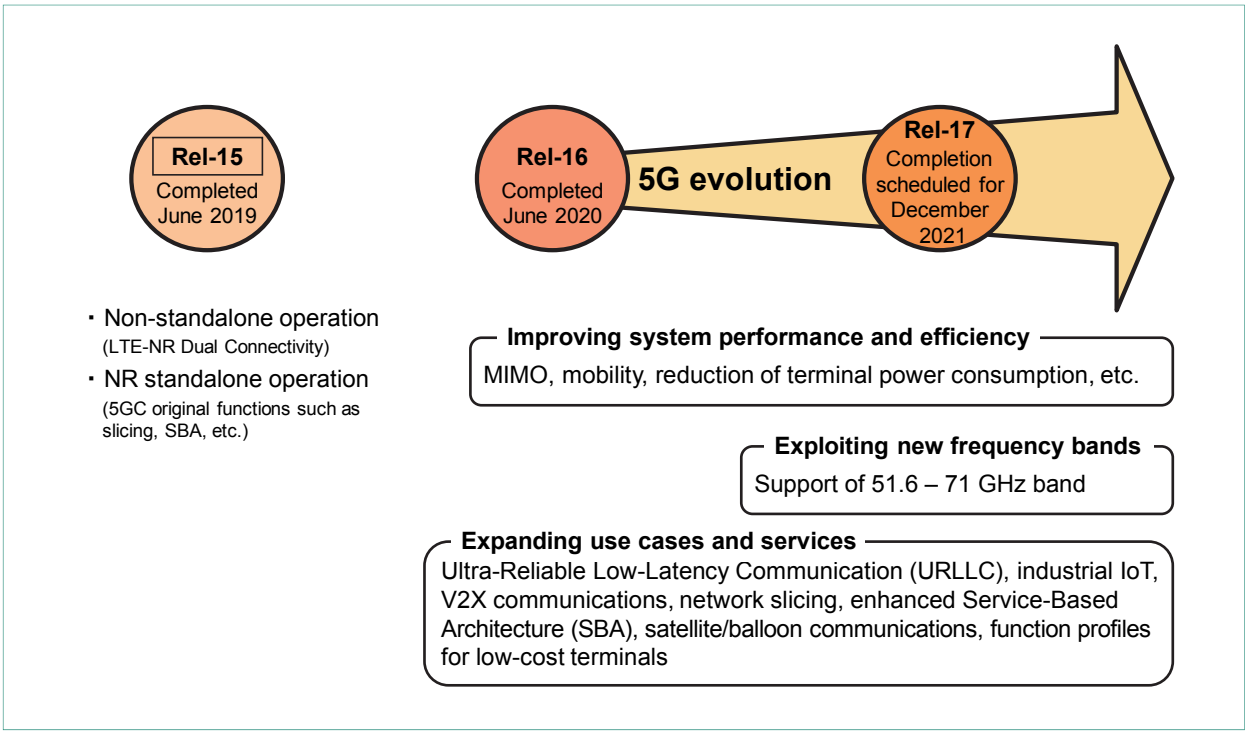

Figure 3 5G evolution at each 3GPP release

*5 WRC: A conference that reviews, and if necessary, revises Radio Regulations, the international treaty governing the use of radio-frequency spectrum, and the orbits of geostationary and non-geostationary satellites. The conference normally meets once every three to four years, and is attended by administrations, ITU registered corporations and related organizations.

*6 MIMO: A signal transmission technology that uses multiple antennas at both the transmitter and receiver to perform spatial multiplexing and improve communication quality and spectral efficiency.

drafting of Rel-16 as an expansion of Rel-15 was completed in June 2020. Discussions toward the drafting of Rel-17 specifications have already begun. At 3GPP, the plan is to draft standards and specifications toward 5G evolution, implement functional extensions across a wide range of fields, and respond to market demands in a time frame that straddles Rel-16 and Rel-17.

3. Conclusion

This article described technologies under study toward 5G evolution and the schedule for drafting associated standards at 3GPP. For details on the 5G core network and 5G radio extension technologies specified in 3GPP Rel-16, we ask the reader to refer to other Special Articles in this issue [3] [4].

REFERENCES

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*7 Core network: A network comprising switching equipment, subscriber information management equipment, etc. A mobile terminal communicates with the core network via a radio access network.
*8 Network slicing: One format for achieving next-generation networks in the 5G era. Architecture that optimally divides the core network in units of services corresponding to use cases, business models, etc.
*9 QoS control: Technology to control communication quality such as priority packet transfer.