Technology Reports

5G | High Speed & Large Capacity/Low Latency/Massive Connectivity | Service Commercialization

Overview of 5G Commercial Service

R&D Strategy Department Yu Kojo Taisei Kato
Takahiro Kawada Suguru Okuyama Aki Ohashi

NTT DOCOMO launched its 5G commercial service in March 2020. Featuring advanced communication specifications of high speed and large capacity, low latency, and massive connectivity, there are high expectations that 5G will provide a means of solving social problems, and from the industrial world, that it will be a force for creating new industries. This article describes 5G technical features and presents a system overview.

1. Introduction

NTT DOCOMO launched its fifth-generation mobile communications system (5G) in March 2020. Up to now, NTT DOCOMO has been unrolling its network in increasingly advanced versions, from its third-generation mobile communications system (3G) to its fourth-generation mobile communications system (4G), and within 4G, from LTE to LTE-Advanced, as data traffic increased with the spread of video content. We can expect this trend toward higher volumes of data traffic to continue into the future as large-capacity plans become popular and content like video and other services becomes enriched.

In addition, the 5G features of high speed and large capacity, low latency, and massive connectivity when combined with AI should make it possible to solve heretofore difficult social problems and create new industries thereby generating even higher expectations of mobile communications (**Figure 1**).

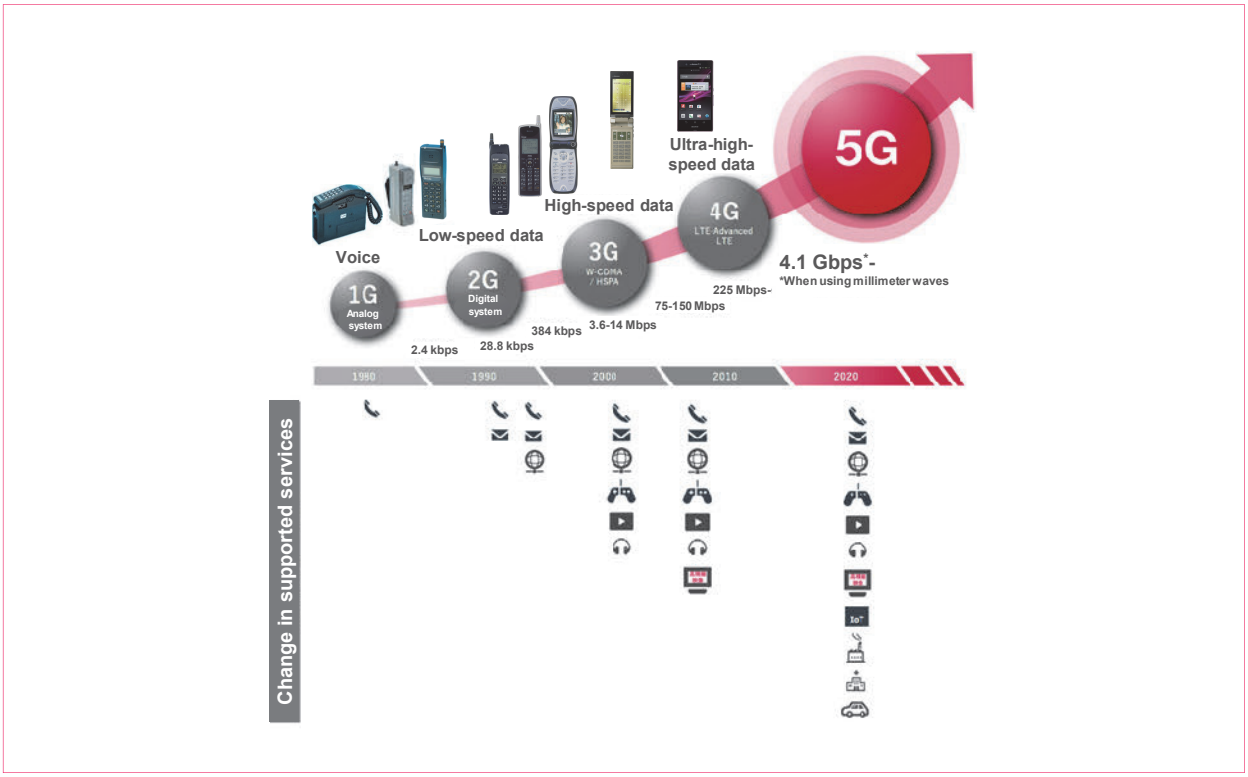

Figure 1 Evolution of mobile communications system

Prior to launching its 5G commercial service, NTT DOCOMO began basic 5G studies in 2010 and commenced high-frequency-band trials in 2014. Then, after contributing to early formulation of 3GPP standards for 5G in collaboration with major global mobile enterprises, NTT DOCOMO launched its 5G pre-commercial service in September 2019 creating many solutions together with co-creation partners.

Going forward, NTT DOCOMO plans to construct and roll out 5G service areas successively starting with major train stations/airports and stadiums in urban and regional areas as well as various types of facilities with partner collaboration in mind.

In this article, we describe 5G technical features, present a system overview, and take a look at supported services and terminals.

Special articles in future issues will take up the radio systems and core network technologies making up 5G, 5G base stations and other types of equipment and terminals, and associated platform technologies.

2. 5G Technical Overview

2.1 Three Technical Features

NTT DOCOMO aims to leverage the 5G features of high speed and large capacity, low latency, and massive connectivity to create a new world that no one has experienced before while making

our lives more convenient and comfortable. Each of these technical features is summarized below.

1) High Speed and Large Capacity

The 5G system will provide much higher broadband data transmission compared with the existing system. It will realize high-definition video including Virtual Reality (VR)*1 and Augmented Reality (AR)*2 experiences while enabling users to enjoy high-presence video and services as a familiar part of life.

The maximum receive speed will be 3.4 Gbps achieved through the use of various technical advances such as high-order Multiple Input Multiple Output (MIMO)*3 technology and the combining of many frequency bands. This value corresponds to the maximum receive speed at the time of the 5G commercial service launch as shown in **Table 1**, but NTT DOCOMO will continuously improve transmission speed through a variety of technical approaches including higher spectral efficiency.

2) Low Latency

In 5G, low latency will enable high-real-time control. For example, it can contribute to even higher levels of automation by determining current running conditions of plant facilities and machines and controlling and operating them in real time.

Also in 5G, the radio transmission unit has been shortened to one-half to one-eighth that of 4G depending on the frequency band, and the timing for confirming delivery has been positioned immediately after data transmission. These technologies combined are expected to achieve low latency in the radio interval compared with 4G. In addition, the adoption of Multi-access Edge Computing (MEC)*4 is expected to achieve low latency on an end-to-end basis.

Table 1 Maximum transmission speeds

	Launch Period	Speed		
LTE commercial service	December 2010	Receive		75 Mbps
		Transmit		25 Mbps
5G pre-commercial service	September 2019	Sub-6 GHz	Receive	2.4 Gbps
			Transmit	107 Mbps
		Millimeter wave	Receive	3.2 Gbps
			Transmit	202 Mbps
5G commercial service	March 2020	Sub-6 GHz	Receive	3.4 Gbps
			Transmit	182 Mbps
	June 2020 or later (plan)	Millimeter wave	Receive	4.1 Gbps
			Transmit	480 Mbps

*Transmission speeds are maximum receive/transmit values as listed in technical standards.

*1 VR: Technology for producing "virtual reality" using a computer.

*2 AR: Technology for superposing digital information on real-world video in such a way that it appears to the user to be an actual part of that scene.

*3 MIMO: A spatial multiplexing method where signals are transmitted using multiple transmitting antennas and received using multiple receiving antennas for increased transmission speed and transmission capacity.

*4 MEC: A system that installs servers at locations near users. Standard servers are typically placed on the Internet, but MEC servers are installed within the carrier network to reduce latency. This scheme greatly improves response speeds.

3) Massive Connectivity

In 5G, simultaneous connection of smartphones and a wide variety of things such as sensors and electronic devices will become possible thereby furthering the penetration of IoT and enhancing the use of information helpful to life (for example, 5G will enable the collection of inventory data in automatic vending machines or meter data on electricity, water, and gas usage without human intervention for use in analysis and later use).

At present, two systems—LTE-M*5 and Narrow Band (NB)-IoT*6—are in widespread use for achieving massive connectivity.

2.2 Major 5G Radio Technologies

1) Technologies for Achieving High-speed and Large-capacity Transmission

These technologies include high-frequency/ultra-broadband transmission*7 and antenna techniques typified by Massive MIMO*8 as described below.

(a) High-frequency/ultra-broadband transmission

LTE has been using frequency bands up to 6 GHz, but 5G looks to supplement those frequency bands with high frequency bands up to 100 GHz to achieve ultra-broadband capabilities. In particular, the high-frequency bands that include the 28 GHz band used by NTT DOCOMO's 5G pre-commercial service feature signal propagation characteristics*9 different than those of existing frequency bands, so new specifications appropriate for using high frequency bands have been specified and a basic bandwidth of 400 MHz has been set.

In addition, NTT DOCOMO is achieving high speeds and large capacities not only by using new frequency bands marked for 5G but also by using various combinations of existing 4G frequency bands simultaneously in radio transmissions.

(b) Massive MIMO

Massive MIMO is a technology that uses many antenna elements to control the shape of transmit/receive beams (beam forming) and configure an optimal area according to the environment. It can be used to expand an area by combining individual antenna elements and concentrating energy in one direction and to achieve a high-capacity system by simultaneously generating multiple beams to increase the number of simultaneously connected users.

2) Technologies for Achieving Low Latency

New Radio (NR), a newly introduced radio access technology, achieves even shorter delays in the radio interval by shortening the smallest unit of radio transmission. However, to achieve low latency in the provision of services, it will be necessary to shorten total delay including delay in core equipment and transmissions, so it will be important to shorten delay in both the radio interval and fixed-line interval. Specifically, end-to-end low latency can be achieved by combining 5G with MEC that deploys computing resources at locations close to terminals. The docomo Open Innovation Cloud™*10 that NTT DOCOMO provides as one form of MEC will be used to promote the creation of 5G services and solutions that make the most of low-latency technologies.

*5 LTE-M: An LTE communication specification for terminals that communicate at low speed using narrow bandwidth, for IoT devices (sensors, etc.).

*6 NB-IoT: An LTE communication specification for terminals that communicate at even lower speed and narrow bandwidth than LTE-M, for IoT devices (sensors, etc.).

*7 Ultra broadband: Bandwidth of 100 MHz or greater. In Japan, 400 MHz of bandwidth has been assigned in the 28 GHz band for 5G radio communications.

*8 Massive MIMO: A generic term for MIMO transmission technologies using very large numbers of antennas. MIMO is a signal technology that improves communications quality and spectral efficiency by using multiple transmitter and receiver antennas to transmit signals at the same time and same frequency.

3) Technologies for Achieving Massive Connectivity

These are IoT technologies that fall under the enhanced LTE (eLTE)*11 standard as part of the continuous evolution of LTE/LTE-Advanced. Here, the use of technologies such as LTE-M and NB-IoT introduced to simplify signal processing can achieve massive connectivity of IoT terminals (environmental sensors, meters, etc.) installed in a certain area where each terminal transmits small amounts of data with low frequency.

These technologies are specified in 3GPP Rel. 13 – 15. The IoT system in 5G NR is now under discussion for specification in Rel. 17. This system is expected to achieve low costs and low power consumption required of IoT by making use of NR features.

3. System Overview

3.1 Concept of 5G Deployment

NTT DOCOMO is moving forward with the deployment of 5G by combining NR, which achieves dramatic improvement in transmission speed and capacity performance using a wide range of frequency bands, and eLTE, which enables basic area coverage and services such as broadcast.

3.2 5G System Configuration

NTT DOCOMO has achieved its 5G service through a non-standalone*12 format in which terminals connect to the mobile network through both the NR and eLTE radio access systems. Specifically, it has leveraged the know-how obtained in deploying an Advanced Centralized Radio Access Network (Advanced C-RAN)*13 in LTE to provide high-speed communications through Dual Connectivity (DC)*14, which uses two radio access systems in an area in which both NR and eLTE can be used. A system configuration diagram of the 5G service is shown in **Figure 2**.

3.3 Multi-vendor Connections between Base Station Equipment

Up to now, specifications for interconnecting

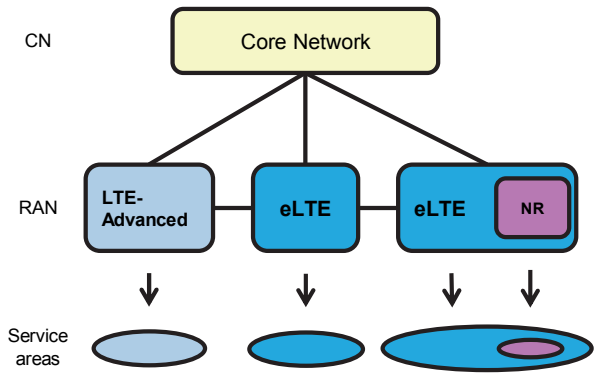

Figure 2 System configuration diagram

*9 Signal propagation characteristics: Refers to characteristics such as propagation losses, power and delay profiles, and angular profiles.

*10 docomo Open Innovation Cloud: A trademark or registered trademark of NTT DOCOMO.

*11 eLTE: An LTE communication specification conforming to 3GPP Rel. 15 or later.

*12 Non-standalone: An operation format that provides services through a combination of NR and an LTE area—in this format, a service area cannot be provided by NR alone.

*13 Advanced C-RAN: A new centralized radio access network (C-RAN) architecture proposed by NTT DOCOMO. Being controlled by the same base station, a radio access network makes a linkage between a macro cell (which covers a wide area) and a small cell (which covers a local area) by applying carrier aggregation.

base station equipment (signal send/receive rules) differed from vendor to vendor without sufficient consideration given to international standards. This situation made it difficult to interconnect base station equipment of different vendors so the usual approach was to interconnect base stations from the same vendor. However, in the 5G launch period, in which expansion of the 5G area would take place while using the existing 4G network, this approach would limit the vendors of 5G base station equipment that can be selected to vendors of 4G base station equipment. To solve this problem, the Open Radio Access Network (O-RAN) Alliance that NTT DOCOMO has been participating in promoted the international standardization of interoperability specifications between base stations thereby unifying interoperability specifications across 4G and 5G base station equipment and enabling multi-vendor connections.

These interoperability specifications have made it possible to deploy newly developed 5G base stations without having to rely on 4G base-station vendors and to achieve a speedy 5G rollout while using existing 4G assets.

4. Overview of 5G Commercial Services/Solutions and Terminals

In the 5G commercial service, NTT DOCOMO is providing a variety of services and solutions that exploit the 5G features of high-speed/large-capacity transmission including spectator support services such as multi-angle (multipoint) viewing and high-presence public viewing. The plan is to provide more new 5G services and solutions for the Olympic and Paralympic Games Tokyo 2021 and other events.

For the 5G commercial service, compatible terminals will perform NR communications using a 100 MHz bandwidth in the "sub-6" 3.7-GHz/4.5-GHz frequency bands and a 400 MHz bandwidth in the "millimeter-wave*15" 28 GHz frequency band. Using wide frequency bandwidths not available in past systems makes it possible to achieve the 5G feature of high-speed/large-capacity transmission. However, this also means high frequency bands in addition to wide frequency bandwidths, so there will be a need for radio terminals equipped with advanced antenna technologies that will enable high-frequency and ultra-broadband transmission not provided in past systems.

5. Conclusion

This article described an overview of NTT DOCOMO's 5G commercial service. NTT DOCOMO is committed to technology development with the aim of using 5G to create a new world with totally new experiences and to make all of our lives more convenient and comfortable.

REFERENCES

[1] T. Shimojo, et al.: "Future Core Network for the 5G Era," NTT DOCOMO Technical Journal, Vol.17, No.4, pp.50–59, Apr. 2016.
[2] A. Harada, et al.: "5G Trials with Major Global Vendors," NTT DOCOMO Technical Journal, Vol.17, No.4, pp.60–69, Apr. 2016.
[3] S. Abeta, et al.: "Radio Access Network in 5G Era," NTT DOCOMO Technical Journal, 25th Anniversary, pp.16–24, Dec. 2018.

*14 DC: A technology that connects multiple base stations and performs transmission and reception using multiple component carriers supported by those base stations.

*15 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."