Current and Future R&D at NTT DOCOMO for the 5G Era Current State and Progress in Each Area Evolution of Devices for the 5G Era

Communication Device Development Department Toshiyuki Futakata

NTT DOCOMO plans to begin full 5G commercial services in 2020 and is currently studying new devices and services toward that goal. However, although 2020 is one of our targets, we are also pushing forward with R&D to develop further after that. This article discusses prospects for the high-speed, high-capacity, low-latency, and many-terminal connectivity features introduced with 5G, as well as advances in the network expected in the future, technologies that will be required for various types of terminal devices and the services, and a vision for devices in 2020 and thereafter.

## 1. Introduction

NTT DOCOMO is working toward full commercial operation of a 5th Generation mobile communications (5G) system conforming to the specifications set by the 3GPP standardization body. The introduction of 5G will further increase speed on the downlink and the uplink, and also bring other advances to the network, anticipating connection of all kinds of objects to the Internet to make the Internet of Things (IoT). The speed of the uplink is being increased because devices are producing video and other high-volume data, in contrast with earlier devices that mainly retrieved and displayed information. As the IoT spreads further, we also anticipate that various new types of device not seen yet will appear, in addition to mobile phone and smartphone devices, which have already become

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familiar and permeated our lives.

We can even consider that the roles of communication tools for making calls or exchanging messages, and of communication devices for data communication, sending and receiving information, are different.

This article describes the significance of devices and advancing device technologies in the 5G era. It also discusses future trends from the perspectives of both consumer and industrial devices.

# 2. Significance of Devices and Evolution of Technology in the 5G Era

Here we discuss the significance of new devices that we can expect to appear in the future and also the evolution of various related technologies to consider what sort of devices will be needed in 2020 and later and to ascertain future device trends.

### 2.1 Significance of Devices in the 5G Era

The medium-term strategy of the R&D division of NTT DOCOMO has the three main themes of 5G, Artificial Intelligence (AI), and devices (**Figure 1**). Device technologies will certainly be used when 5G is introduced, and with the huge amount of all kinds of data, devices will have the role of gathering such data, using it with various Big Data and AI technologies, and outputting any valuable data obtained as a result. An important element for using AI is to somehow collect the necessary data. NTT DOCOMO has redefined devices in the 5G era as connecting through various communications technologies, including mobile wireless communications, wireless LAN, Bluetooth<sup>®\*1</sup>, and fixed communications, and inputting the data collected to the cloud.



Figure 1 Three main themes in the NTT DOCOMO R&D medium-term strategy

\*1

Bluetooth<sup>®</sup>: A short-range wireless communication specification for wireless connection of mobile terminals, notebook computers, PDAs, and other portable terminals. Bluetooth is a registered trademark of Bluetooth SIG Inc. in the United States.

#### 2.2 Evolution of Device Technology

In device related technologies, technologies already being used in current smartphones and tablets will advance, including various sensors and cameras, but other types of device utilizing individual functions will also emerge in the future, such as IoT home devices, fixed displays, wearable devices and flexible displays<sup>\*2</sup> (Figure 2). This polarization is continuing, on the one hand gathering all functionality into smartphones, and on the other, strengthening links with peripheral devices by using various types of connectivity to link devices to handle all types of requirements.

# 3. Trends in New Devices for the Future

Below, we describe target markets and device trends from various market viewpoints. In addition to devices for consumers, which have been the main target previously, we expect great advances in devices for industry. For this reason, in addition to new personal devices such as smart glasses and various other display type devices for consumers, there is also increasing anticipation for specialized devices that can be used in various industries (**Figure 3**).



Figure 2 Trends in evolution of device technologies

 \*2 Flexible display: Flexible video display equipment that can be folded or rolled up like fabric or paper.

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Figure 3 New device trends for the future

#### 3.1 Trends in Consumer Devices

With devices for consumers in 2020, we expect further polarization between the usual progression toward an "ALL-In smartphone," and specialized devices such as smart glasses, VR, and home devices (Fig. 3). Farther into the future, we may be entering a time when multiple devices cooperate with each other, using a variety of devices nearby for various purposes, according to the user's application or usage scenario.

As such, we now discuss concretely, what sort of future will be realized due to device advancement, in a world with specialized devices and linkage among devices. 1) Global Perspective for Specialized Devices

Figure 4 (a) gives an example of providing a realistic experience using a large display, while Fig. 4 (b) gives an example of providing new value using small, high-image-quality glasses. The former can realize communication that is similar to meeting faceto-face while remaining at a remote location using transmissive or reflective projection technologies. With the latter, video is input through the glasses, the location and objects in it are instantly recognized, information about them is found, and is overlaid on the scene being viewed, adding convenience for the user. 2) Global Perspective for linlage among Devices Figure 5 shows a world view with linkage among devices, where environments can be set to suit each user, freely switching between input devices by



Figure 4 World view of new types of device and example use cases



Figure 5 World view of device linking

just carrying an ID, and obtaining necessary information by simply logging in. One proposed way of using new devices in the 5G era is to provide an experience not dependent on specific devices, so that users can treat the various devices nearby as their own.

### 3.2 Trends in Devices for Industry

Currently, in most cases services are provided using carrier or manufacturer branded communications modules (a communication modem equipped with an interface to external equipment). Since devices for industrial use will have to cover many diverse scenarios in the future, some carriers foresee popularization of one-chip solutions that use a single semiconductor that includes a communication modem together with other functions such as an interface to a sensor or other external device. We also expect polarization depending on the application to continue here, with some devices requiring high speed and capacity, such as high-resolution surveillance cameras and infotainment<sup>\*3</sup> devices, and others requiring low-capacity, low-power devices, such as smart meters<sup>\*4</sup> (Figure 6).

These devices will be used in various applications, on site in agriculture and other industries, in medicine and disaster prevention, for advancing transportation systems, and even for sports events such as those planned for 2020. We can expect them to contribute to safe, secure, and rich lifestyles, and to realizing a convenient and highly efficient society (**Figure 7**).

## 4. Conclusion

This article has discussed the significance of



Figure 6 Trends in devices for industry

 \*3 Infotainment: A service integrating information and entertainment, such as a service combining enjoyment of video or music with viewing of information such as maps and traffic conditions provided in a vehicle.
\*4 Smart meter: A device that enables real-time measurement and visualization of electricity usage.



Figure 7 Applications of new devices in industry

devices, trends in their evolution, their roles and a world-view that could be realized with the full commercialization of 5G. Not much time remains till 5G is commercialized, but for further development after that, we will continue work to develop devices and services worthy of the so-called fourth industrial revolution.

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