KDDI's Perspectives Towards 5G

Akira Matsunaga
Senior Director
Mobile Network Technical
Development Division,
Technology Sector,
KDDI CORPORATION

Seiichirou Sakai
Manager
Next Generation Network
Development Department,
Mobile Network Technical
Development Division,
Technology Sector,
KDDI CORPORATION

Kenji Narita
Manager
Next Generation Network
Development Department,
Mobile Network Technical
Development Division,
Technology Sector,
KDDI CORPORATION

1. Introduction

Towards the realization of fifth-generation mobile communication systems (hereafter called 5G) in 2020, verification trials and demonstrations are ongoing in parallel with standardization activities at ITU-R and 3GPP.

It is expected that 5G will not only make improvements to networks, including substantial expansion of network capacity and enhanced peak data rates, but will also bring about major transformations in current mobile communication systems, including a greater diversity of applications, a more prominent role in society, and a closer relationship with industry.

This article describes the expectations of 5G, the shape of things to come in the 5G era, and the technologies that will make 5G a reality.

2. The environment surrounding 5G and the shape of things to come in the 5G era

2.1 Expectations

The changes that characterize 5G include the following:

(1) Substantial increase of network capacity and flexibility to satisfy diverse requirements efficiently.

The vision document of ITU-R* stipulates three use scenarios of 5G, namely, enhanced mobile broadband (eMBB), massive machine type communications (mMTC) and ultra-reliable and low latency communications (URLLC). 5G is expected to offer a variety of new applications and also to provide experiences that are difficult to achieve with previous generation systems including 4G technology. At the same time, 5G networks will have to adapt flexibly and efficiently to these increasingly diversified requirements. To offer enhanced capabilities including high speed and low latency, the 5G network will require closer end-to-end interworking, including radio access, backbone and core networks.

(2) Implementation of IoT, where everything is connected

The connection of everything by IoT, will create new added value. For example, it will be possible to track large numbers of objects and analyze them by using big data. To create this new added value, it will be necessary to develop new applications and build 5G networks that meet their requirements in cooperation with "vertical players" and business partners that use 5G.

(3) The dramatic rise in the role and expectations of supporting social infrastructure.

In the 5G era, it is expected that 5G will be an indispensable asset for society and will play a significant role in supporting the social infrastructure in 2020 by helping to solve various social issues.

As shown in Figure 1, 5G is expected to play numerous important roles in the changing society, including providing exciting entertainment services, supporting numerous industrial developments, helping to address social problems, such as the revitalization of local communities, and acting as a social platform that ensures the safety and security of its users. In anticipation of the advent of 5G era, KDDI is aiming to respond to the above expectations by expanding its network capability, implementing various new use scenarios, and targeting the provision of value-added services beyond communication services to realize life design in collaboration with the industry sector.

2.2 The 5G world

Figure 2 shows the use cases that are expected as a result of the enhanced capabilities of 5G. Typical examples are illustrated below.

(1) VR and AR

Typical services that make use of enhanced mobile broadband capability and ultra-low latency will include virtual reality (VR) and augmented reality (AR). One possible application of VR is "free-viewpoint" video, which allows people to view video from any angle. For example, video streams captured from different angles in a stadium could be used to synthesize video from any angle selected by the viewer. VR is going to provide ultra-realistic experiences that have never been offered before.

(2) Connected cars

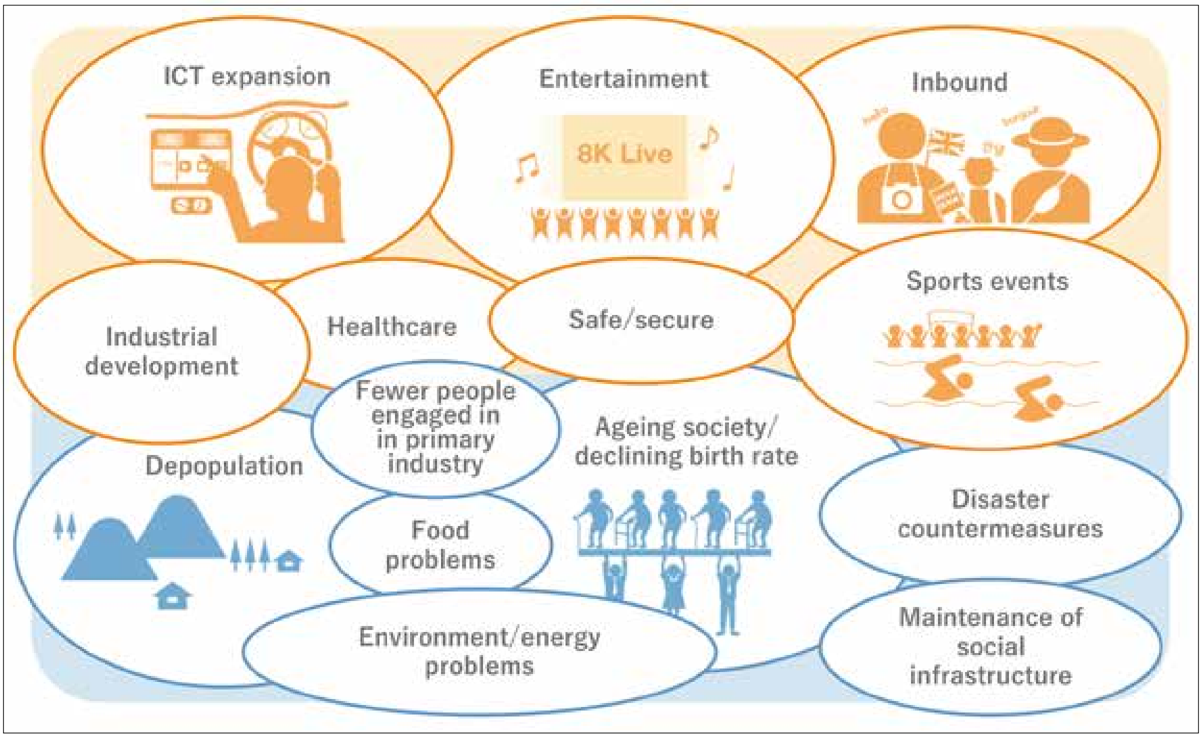
5G's ultra-low latency and high reliability are expected to open up new possibilities in various fields such as connected cars and the remote control of farm equipment. It is also expected to meet the requirements for ensuring that people are able to live safely and securely . Some connected car applications will require safe and secure service features, including vehicle diagnostics, driver health monitoring, and emergency vehicle communication in the event of an accident.

(3) IoT (Massive machine-type communications)

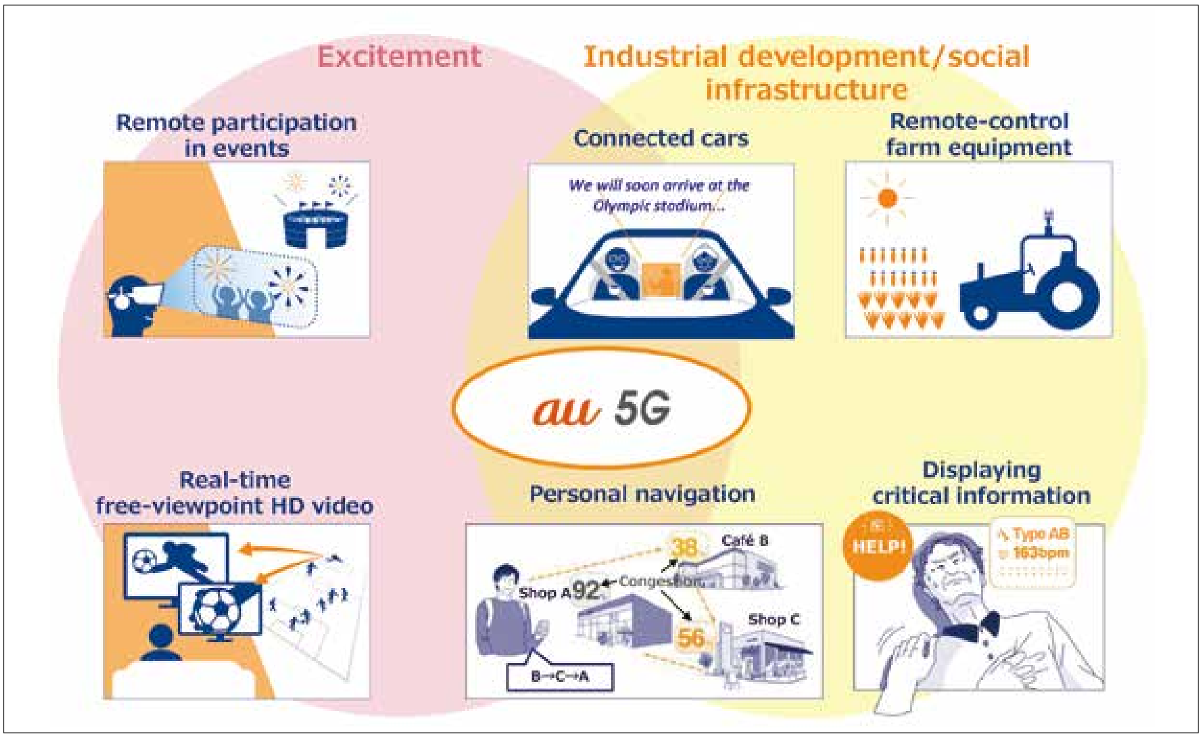
In the 5G era, IoT is expected to cause a dramatic increase in the number of connected devices and diverse use cases. This will contribute to the development of — and significant changes to — industry and the social infrastructure. In the industrial sector, it is envisaged that new value will be created by analyzing and processing big data from a number of sensors using optimal

* IMT Vision: "Framework and overall objectives of the future development of IMT for 2020 and beyond", ITU-R, Rec. M.2083-0, September, 2015

■ **Figure 1: Changes in the environment towards 2020**



■ **Figure 2: The 5G world**



computing resources in the network. It is also expected that data from indoor and outdoor sensors and wearable devices will be utilized to contribute to people's wellbeing and safety.

In the example of "personal navigation", a number of sensors will be used to collect huge amount of information in real time, such as the weather and traffic conditions. The information collected this way will be used to navigate an optimal route according to the user's schedule, in combination with information that has already been stored on the network.

3. System architecture for 5G services, and the "user-centric" concept

As mentioned above, the augmentation of 5G network capabilities — including their capacity, peak data rate, massive machine-type communications, high reliability and low latency — will give rise to various new applications, and the 5G networks will have to adapt flexibly and efficiently to their diverse requirements. Unlike previous systems, where users must sometimes adapt to the system's performance, the aim of the 5G network is to provide users with a satisfactory experience every time, and in any place.

New experiences and new value can also be created, by using big data, numerous sensors and enhanced network capability to propose new values to users. 5G thus aims to implement the concept of a user-centric service that provides quality of experience that meets the user demand. System architectures for this purpose should be built and the following network technologies should be embodied:

① Dynamic sharing of computing roles between hierarchical layers

② Construction of radio access network areas

③ Provision of a seamless network where users need not be aware of differences in technology

3.1 Optimal network usage for different roles

In the 5G network, in addition to realization of the new requirements expected to 5G, such as low latency and real-time communications, it is also necessary to use appropriate network resources efficiently to satisfy the requirements of diverse applications. Figure 3 shows an example of the hierarchical structure of computing resources. In addition to computing in the cloud and client devices, it will also be useful to perform computing at network edges in some applications in the 5G era. These three layers share out computing tasks dynamically and optimally in consideration of the following characteristics, thereby making efficient use of the network resources and ensuring that 5G services satisfy their requirements. One idea is that big data processing may be performed by the cloud, which is suitable for collecting large amounts of data, while real-time processing and localized processing could be conducted by edge computing and devices respectively.

- Cloud: totally optimal, centralized, integrated
- Edge: partially optimal, distributed, cooperative
- Device: locally optimal, autonomous

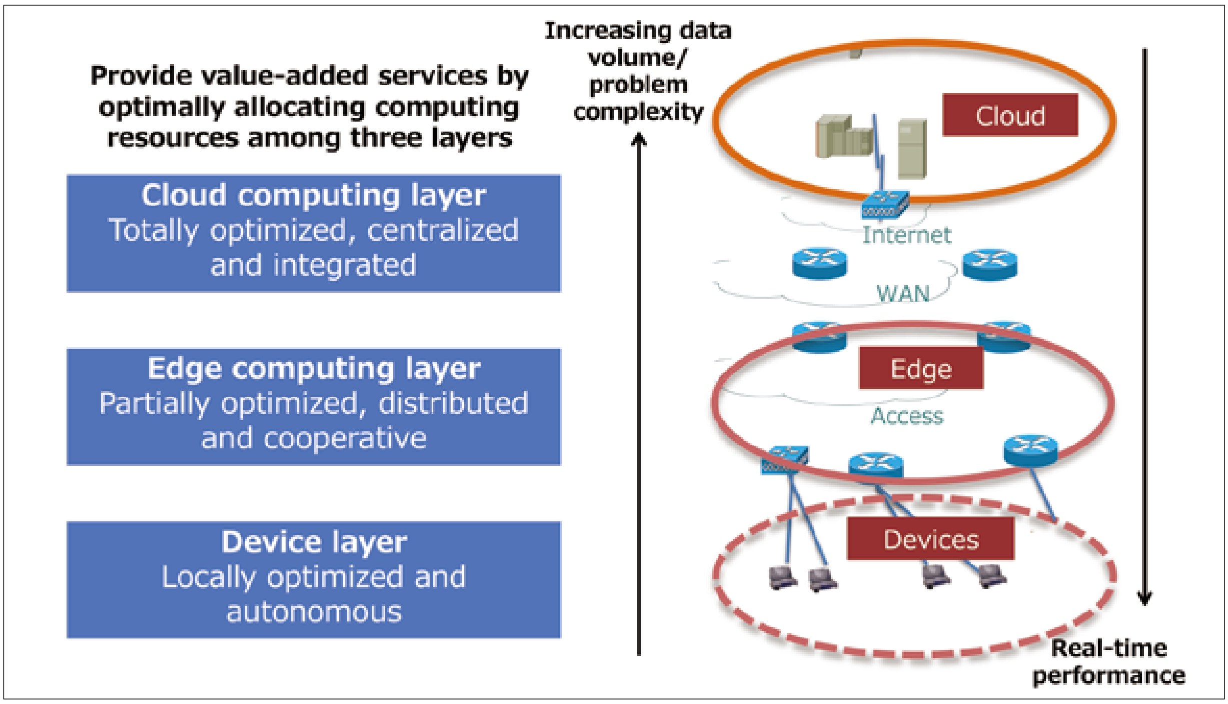
3.2 Area structure of wireless systems

To meet the diverse requirements of different use cases, such as high capacity/high peak data rate, massive machine type communications, and low latency, an optimal wireless area must be built by taking into consideration the following elements:

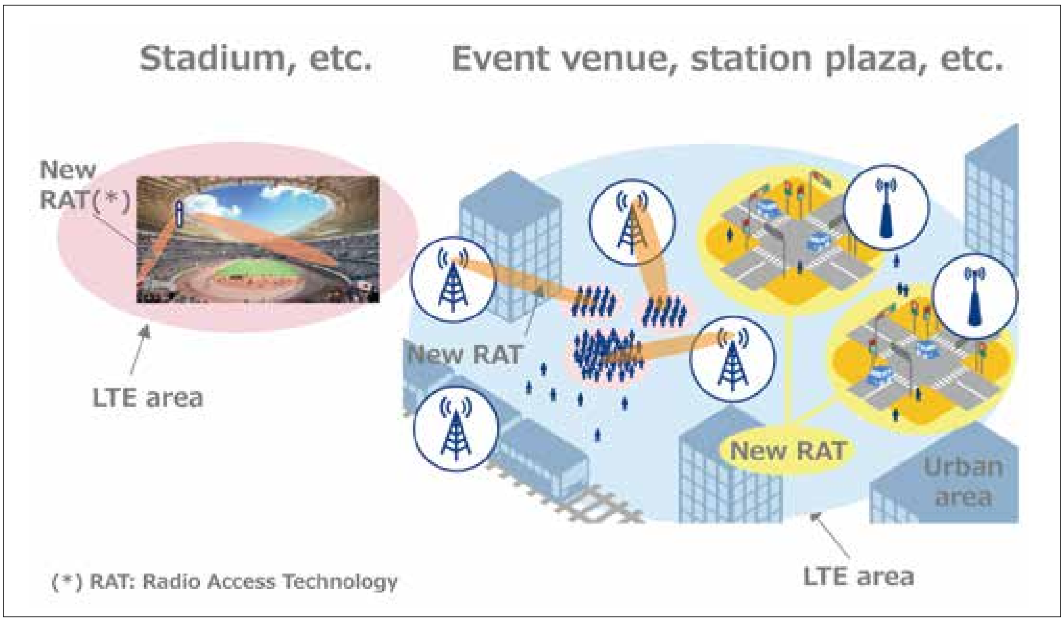
- Characteristics of the frequency band used by the system (above 6 GHz, below 6 GHz, etc.)
- Choice of multi access technologies (Massive MIMO, beamforming, etc.)
- Envisaged use cases (mobile broadband, IoT, low-latency, etc.)
- Requirements (speed, cell size, indoor/outdoor, terminal density, etc.)
- Need for interworking with existing systems

For example, a new radio access network may be deployed in a service area (e.g. stadium) in order to provide new ultra-realistic VR/AR services as shown in Figure 4. Another example is an event venue or train station plaza, where a new radio access network may be deployed to accommodate densely concentrated traffic.

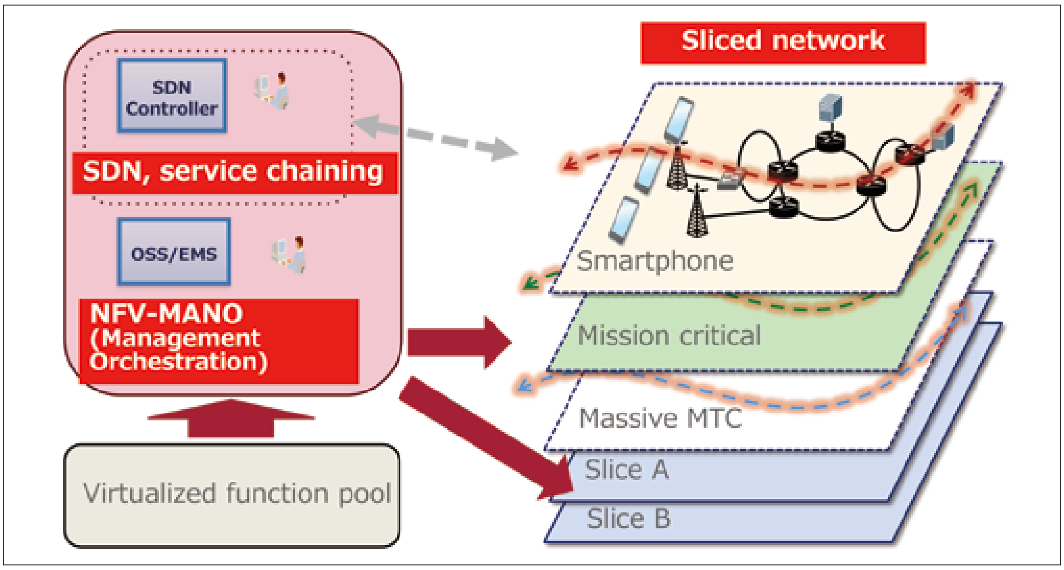
■ Figure 3: Providing value-added services by optimal resource allocation



■ Figure 4: Examples of deployment of 5G networks



■ Figure 5: Flexible network structure & operational enhancement



3.3 Seamless networks

5G must be able to cooperate with various other wireless systems including previous generations such as 4G, and should be able to select the optimal network from a variety of infrastructures, platforms and technologies without making the user aware of the difference of technologies. As a result, the network should communicate as a seamless whole to provide the user with an excellent experience at anytime, anywhere.

To respond flexibly to the diverse requirements of 5G applications and to build a network that strengthens links with industry and vertical players, a seamless network may be virtually divided into a sliced network as shown in Figure 5, allowing it to respond efficiently and flexibly to diverse service requirements. The capabilities to be realized and the element technologies that will be required are listed below:

- Responding to diverse network requests:
  Sliced network
- Flexible network structure:
  NFV (network function virtualization)
  SDN (software defined network), service chaining
- Enhancing the speed and functioning of network architecture:
  NFV
  NFV-MANO (management & orchestration)

4. Conclusion

This article introduced the environments that 5G systems will face and the world 5G will seek to realize, as well as the 5G system architecture that will be needed to achieve these goals. As we approach the launch of 5G, it is expected that standardization activity and verification tests/trials will be performed more actively, and KDDI will promote its efforts continuously to realize user-centric 5G services.