Fujitsu's Multi-access Edge Cloud to Realize Diverse Digital Services in 5G Era

● Yoshihiro Andoh ● Jun Ogawa ● Hitoshi Ueno ● Nobuhiro Takahashi

The fifth generation mobile communication system (5G) will soon become mainstream. This technology enables enhanced network environments with enhanced mobile broadband (eMBB), ultra-reliable and low-latency communications (URLLC), and massive machine type communications (mMTC), which can be leveraged in creating and providing highly sophisticated digital services. It is important that these services are provided with flexibility in accordance with individual users' unique environments and situations. Fujitsu's Multi-access Edge Cloud realizes an innovative platform that can provide such services in the 5G era. It realizes a distributed network system that makes it easier to provide various digital services through the efficient usage of computing resource deployed over the whole network. Fujitsu conducted a field trial of this multi-access edge cloud in FY2017 using a live commercial network, and verified that it helped to make providing services at the edge of the network (appropriate points where the service requirements can be handled) easier. This paper outlines the features comprising the Fujitsu's Multi-access Edge Cloud that makes it easy to provide diverse 5G-era digital services and describes the major technologies to realize it.

1. Introduction

In the era of 5G (fifth generation mobile communication system), a new world where advanced digital services are created is expected. These technologies are considered to develop along with the progress in network technologies that improve communication performance and digital technologies including cloud technologies and AI. Network technologies in the 5G era include enhanced mobile broadband (eMBB), ultra-reliable and low latency communications (URLLC), and massive machine type communications (mMTC).

Up until now, services that widely sent homogeneous information from the cloud were the mainstream. Moving forward, as 5G and the IoT become widespread, services that provide fine-tuned information to people in specific locations are expected to increase. In the case of sporting events held in stadiums, for example, data were conventionally gathered for broadcasting and delivered. In the future, in addition to these data, video data from cameras not used for broadcasting to available. This will allow spectators in stadiums, letting them freely watch highlights from various angles of 360 degrees whenever they want and enjoy the game from players' points of view by combining the data with augmented reality (AR) technology. In this way, providing stadium visitors with high-value-added content is expected not only to increase the number of spectators but also to revitalize the whole surrounding town.

Along with these expectations, new issues emerge as well. In order to support advanced digital services, networks are required to handle various tasks such as data storage, assessment, and processing in addition to efficient transfer of large volumes of data from various types of IoT devices. To take a connected car as an example of a real-time service, networks are required to transmit information to the vehicle with a latency demanded by the service. Digital services need to be readily provided taking into account the fulfillment of these network requirements.

Fujitsu provides Fujitsu's Multi-access Edge Cloud, which realizes an innovative platform capable of offering a variety of services in the 5G era. Fujitsu's Multi-access Edge Cloud is intended for the optimum provision of various digital services through the distribution and integration of clouds[note1)] and networks according to the environment in which the user is located. This can be applied to allocate computing resources over an entire network and utilize them efficiently, thereby realizing a distributed system for facilitating the provision of various digital services.

This paper first defines Fujitsu's distribution and integration of clouds and networks. Next, it presents the functions that constitute Fujitsu's Multi-access Edge Cloud, and lastly describes the major technologies used for its realization.

2. Distribution and integration of clouds and networks

This section defines distribution and integration of clouds and networks to be discussed in this paper.

2.1 Distribution

To efficiently provide services that make use of the features of 5G while maintaining high availability and security, use of cloud-datacenter via the Internet has its limitation due to a concentration in processing. In order to solve this problem, data and computing and network resources must be distributed in locations where they are actually required. In other words, the distribution of clouds and networks involves the following two things.

1) Distributing computing resources in appropriate locations (at the edge) to function as a cloud in charge of data processing in order to meet service requests and to efficiently process data while working together with clouds in other locations. Here, the edge is defined as appropriate points where the service requirements can be handled.
2) Making network resources such as multiple network paths available for selection.

2.2 Integration

In order for developers to provide digital service applications more easily, the availability of computing and network resources without the need to be aware that they are distributed is key. And in terms of infrastructure, the provision of applications and network functions on multiple servers is not economical. In other words, the integration of clouds and networks involves the following three things.

1) Making computing resources available from applications as a system incorporated in a network regardless of whether they are provided in the data center or at the edge.
2) Making differences in network resources transparent in terms of their locations, connection paths, or the types of physical networks to which devices belong.
3) Providing computing resources for applications and for network functions in the same server.

3. Functions constituting Fujitsu's Multi-access Edge Cloud

Fujitsu's Multi-access Edge Cloud is based on the Multi-access Edge Computing (MEC)[1)] technology being standardized by the European Telecommunications Standards Institute (ETSI), a European organization for telecommunications-related standardization. In ETSI's MEC, data transmitted from devices such as smartphones and sensors are processed by using a server located near a wireless base station system. In this way, the technology realizes lower-latency response and network load distribution as compared with configurations that use a cloud-datacenter.

Fujitsu's Multi-access Edge Cloud has the following three functions for achieving distribution and integration of clouds and networks in addition to incorporation of the MEC technology (**Figure 1**).

3.1 Integrated platform

A platform is provided that handles network and computing functions respectively as building blocks to achieve integration suited for the requirements of business applications responsible for digital services and the site environments. For network functions, physical connection is made possible to wireless networks including Wi-Fi and Bluetooth and wired networks such as optical broadband, in addition to mobile networks such as LTE and 5G.

3.2 Virtualization

Business applications are run on a virtualized platform, which allows them to be handled in the same way as a cloud even at the edge, without the need for

note1) The clouds mentioned in this paper include center centralized clouds and distributed clouds integrating multiple edge computing deployments.

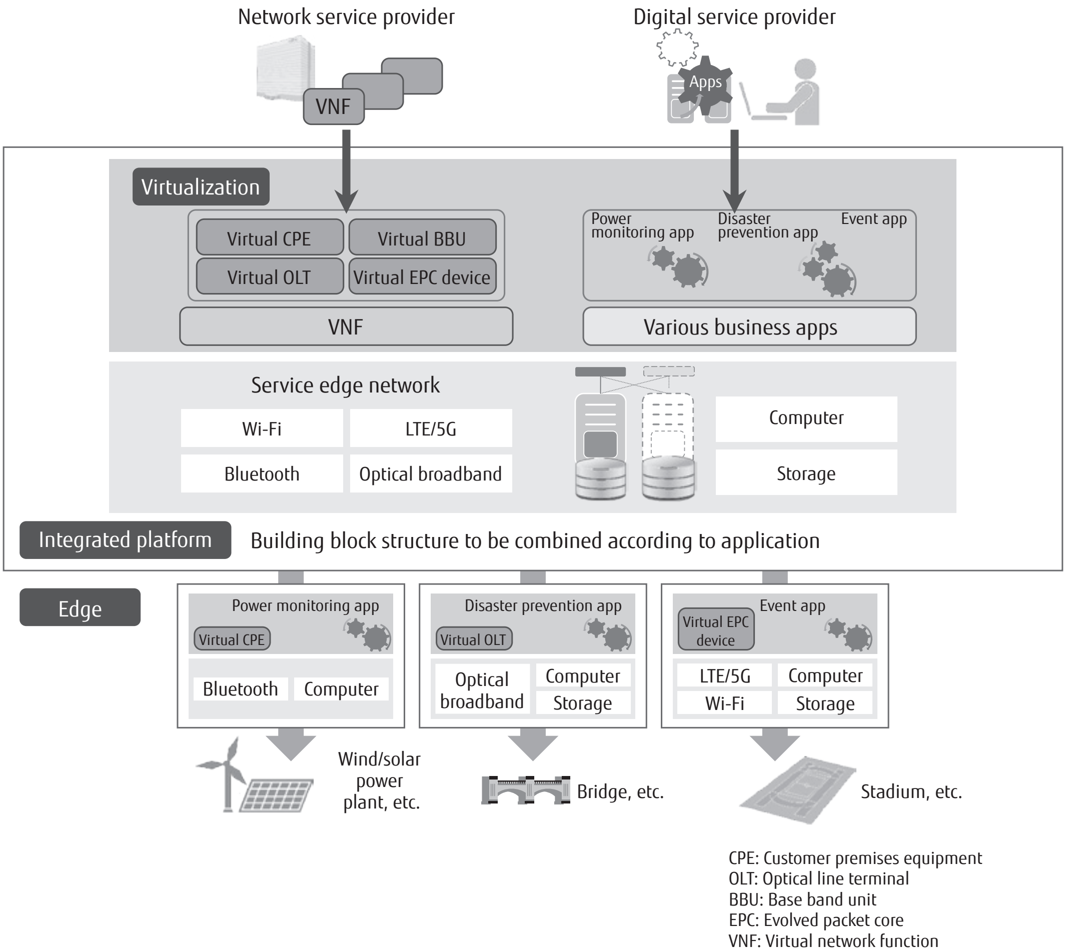

Figure 1
Configuration of Fujitsu's Multi-access Edge Cloud.

being aware of the deployment location.

In order to provide an optimum network suited for the requirements of business applications and the site environments, network functions are prepared as VNFs[note2)] for execution on the integrated platform. This abstracts wired and wireless networks and makes it possible to offer network functions with the difference in physical networks hidden to business applications.

Use of the integrated platform allows these virtualized network functions and business applications to be flexibly deployed where required and used and deleted as needed.

note2) Stands for virtual network functions. Network functions that are virtualized and provided as software on a general-purpose server, rather than as conventional dedicated devices.

3.3 Edge

The integrated platform and virtualized functions as described above can be used to realize "local consumption of data, which is generated in that area." Data processing of digital services is optimized from the perspective of service response and communication costs according to the computing and network environment to process site data as close to the site as possible to make the data available.

In addition, both applications that run on the integrated platform and information stored there must be available for use anywhere. Accordingly, efficient data movement and strong security are realized to make optimum on-site customization possible without affecting the entire system.

These functions are used for the distribution and integration of distributed clouds, including the edge, the cloud-datacenter, and computing and network resources, which has led to the achievement of a system capable of flexibly providing various digital services.

4. Characteristic technologies to realize respective functions

This section presents three technologies that realize the three functions described in the previous section to provide optimum services for devices by using the cloud-datacenter and distributed clouds.

4.1 Integrated platform construction technology

The integrated platform provides edge networks optimized for a variety of services used. For its realization, edge networks according to the various services, including mobile networks, are prepared as VNFs on the integrated platform, as described above. Each of them is configured as a building block, and physical networks are abstracted to make them freely selectable.

We realized the high-speed data processing by VNFs for mobile network even with a bump-in-the-wire system.[note3] For data processing, the Data Plane Development Kit (DPDK) is used for high-speed processing of Security Architecture for Internet Protocol (IPSec), mobile network protocols, and packet routing. Accordingly, services can be provided at the edge without affecting existing devices such as LTE base stations and core network (Evolved Packet Core) devices.

In connection to these approaches, Fujitsu has carried out a field trial using an existing commercial LTE network in FY2017.[2] The trial is intended to demonstrate service provision at the edge by connecting Fujitsu's Multi-access Edge Cloud to NTT DOCOMO's LTE wireless base station. As the access network for service provision, a Wi-Fi network has been used in addition to an LTE network.

The results of this trial have shown that Fujitsu's Multi-access Edge Cloud can be used to easily provide services using the edge without affecting existing network devices.

4.2 Connection destination control technology for LTE/Wi-Fi providing virtualization technology

A network virtualization technology is required not only to prepare VNFs but also to provide an optimum network without needing business applications and their users to be aware of the difference in the types of physical networks. Accordingly, Fujitsu's Multi-access Edge Cloud has taken advantage of its feature to allow connection destination control of the LTE and Wi-Fi for virtualizing the access network (**Figure 2**).[3),4)]

Conventionally, concentrations of devices for high-load communications such as streaming videos in a Wi-Fi network service area caused a problem of deterioration in terms of communication speeds for each of these devices. To deal with this problem, a technology

note3) One approach to realizing edge computing proposed by the ETSI. In this system, computing resources are located on the line path between an LTE base station and LTE core network for protocol termination.

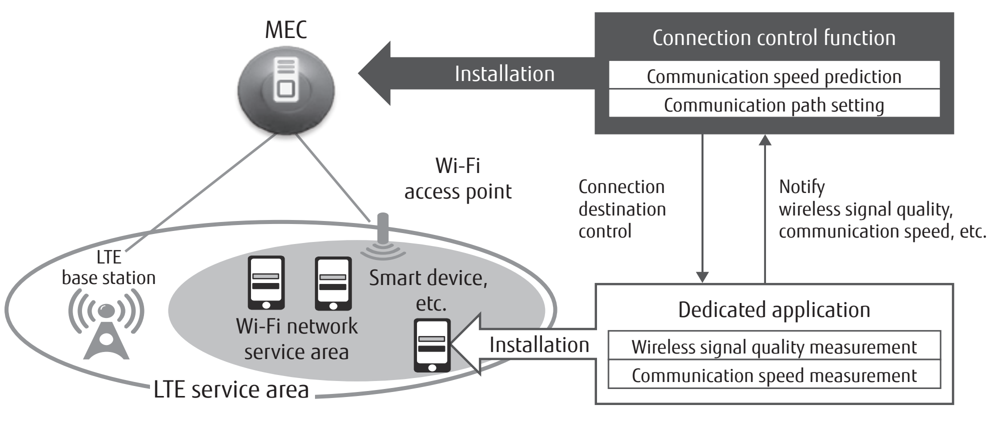

Figure 2
Developed connection destination control technology.

has been put into practical use that mitigates communication speed deterioration by enabling the devices to choose communication paths with less congestion. With this technology, however, each device independently determines the communication path without regard to the impact on other devices, which instead caused overall communication speed to decrease.

With the technology developed by Fujitsu, the result of the wireless signal quality measurement of each device is used to predict the communication speed that results when multiple device connections are changed at the same time. Based on that result, the communication paths of multiple devices in the Wi-Fi network service area are automatically set all at one time. This function has been implemented in Fujitsu's Multi-access Edge Cloud as a connection control function. To realize seamless switching without making changes to the current devices or OSs, we have also developed a dedicated application that provides wireless signal quality measurement information from devices to change the communication paths in real time according to the network settings.

By using this technology, we were able to verify that both Wi-Fi and LTE networks can be optimized and that communication speeds can be increased on average to about twice those of conventional connection control technologies.

This function was also tested in the field trial with NTT DOCOMO mentioned earlier. As a result, it was confirmed that video streaming is possible while LTE and Wi-Fi network connection destinations are appropriately switched 10 ms at the earliest, and that optimization of wireless connection can be realized.

While current LTE and Wi-Fi communication networks were used for this field trial, in the 5G era, eMBB, URLLC technologies will be incorporated. When that becomes a reality, the high-performance communications infrastructure only available through 5G with features including communication latency of 0.5 ms will be readily available.

4.3 Wide-area distributed data access technology providing edge function

Edge computing is a concept of distributed storage and processing of an enormous amount of data generated on site (at the edge) using edge servers located near the site. In the future, very large volumes of data are expected to be generated by vehicles, roadside cameras installed at intersections, and robots operating in factories, increasing the need for understanding situations on site based on them.

Processing using edge servers is effective for improving service response and reducing communication costs. Therefore, it will be necessary to allocate and manage processing and data in edge servers distributed over wide-area according to changes that occur on site in order to process data locally, generated in that area.

To that end, we are developing wide-area distributed data access technology that reduces communication time and costs.[5),6)] In this Technology, site data is stored at the source or in a distributed cloud in the vicinity to allow only the required data to be transferred to the cloud-datacenter in response to requests from digital service applications. With the locations of data storage distributed, it is difficult for digital service applications to find where the required data are stored. To deal with this issue, combinations of site data attribute values such as the time and place of generation and the storage server addresses can be maintained as metadata. With these, digital service applications can acquire the desired data simply by searching with attribute values used as keys.

Figure 3 outlines a system of wide-area distributed access. Metadata databases are deployed on servers in distributed clouds near the data sources (sites). Additionally, search keys of the metadata databases are summarized and deployed in the directory database in the cloud datacenter. Digital service applications can find the locations of data by querying the directory database. In this way, metadata are managed hierarchically using metadata databases and the directory database to achieve both improved efficiency of metadata management and higher search speeds.

Figure 4 shows an example application of a service for checking road conditions using this technology. In this technology, a video shot with a dashboard camera mounted on a vehicle that travelled on a snowy road is provided to a following vehicle planning to travel in the same area. Conventionally, transmission of the video from the dashboard camera to the cloud-datacenter incurs sizeable communication costs, which made this type of service difficult to achieve. In wide-area distributed data access, the cloud-datacenter is

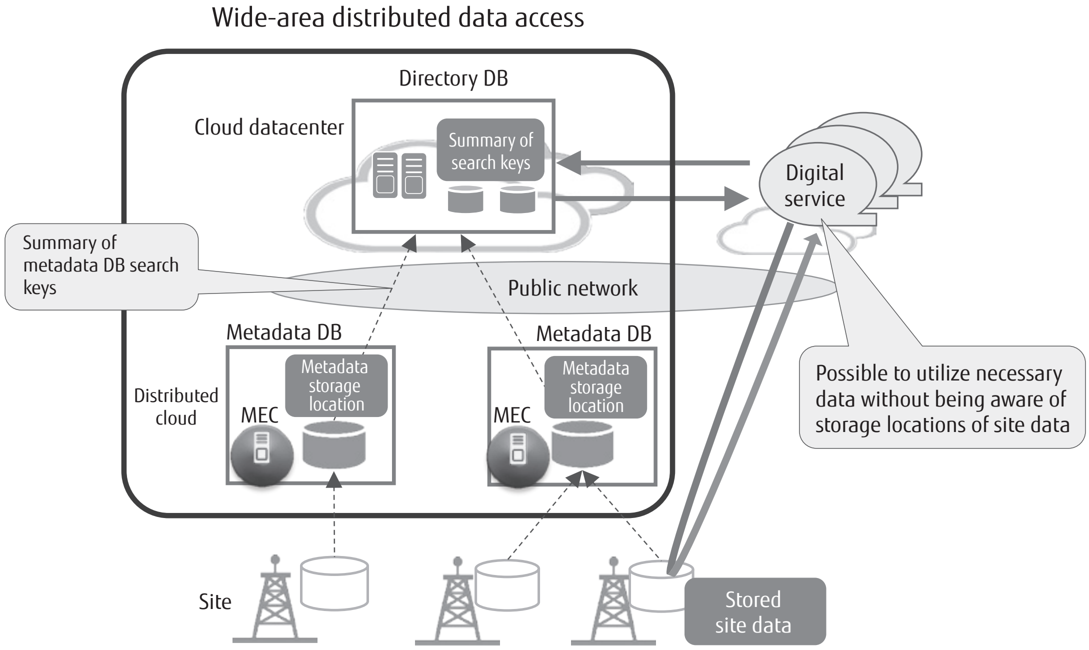

Figure 3
Wide-area distributed data access technology.

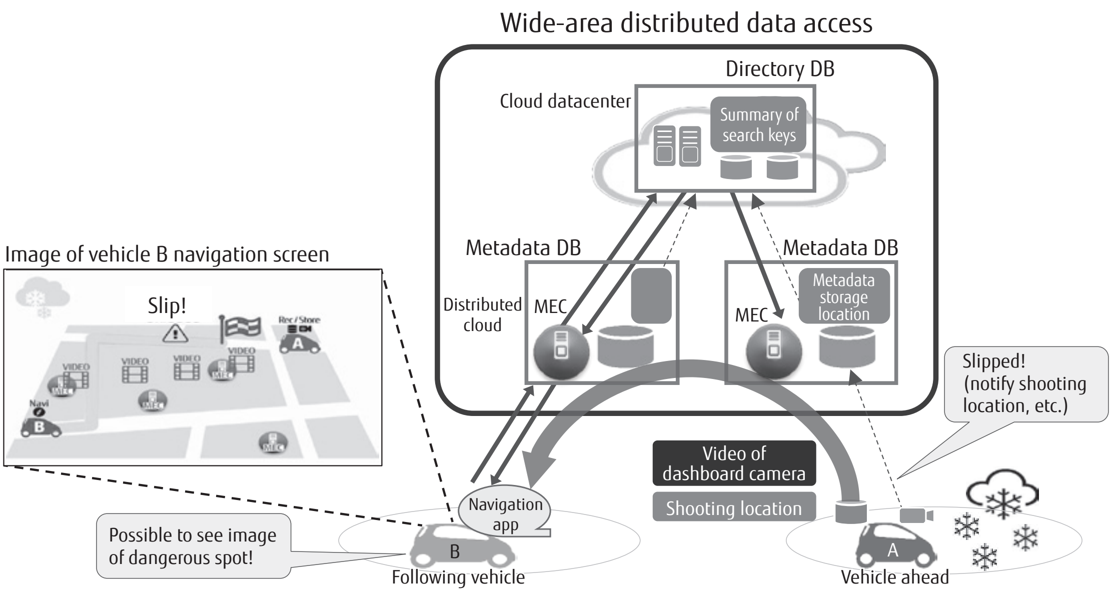

Figure 4
Example of technology application: Snowy road information service.

used to manage the attributes of the videos shot such as the shooting time and location and the access information for the vehicles where the videos are stored, such as identifiers of the vehicles that shot the videos. This allows the following vehicle to find the vehicle travelling ahead, which is the storage location, and directly receive the videos shot by this vehicle.

In this way, increases in network traffic are reduced by only exchanging necessary information when required, rather than gathering all videos in the cloud-datacenter.

5. Conclusion

This paper presented Fujitsu's Multi-access Edge Cloud, which will provide various digital services for the 5G era according to the environment of each and every user. Here we introduced Fujitsu Laboratories' proprietary LTE/Wi-Fi connection destination control technology and wide-area distributed data access technology as major technologies that support the realization of latency reduction.

In the future, we intend to make use of these technologies and develop them into a platform that supports Fujitsu's Connected Services through field trials with various customers for its targeted release by the first half of FY2019.

References

1) ETSI: Multi-access Edge Computing. *https://www.etsi.org/technologies-clusters/technologies/multi-access-edge-computing*
2) NTT DOCOMO, Fujitsu, and Fujitsu Laboratories: Success in field trial using commercial LTE network for provision of service making use of mobile edge computing to realize reduced latency and load distribution of networks. *http://pr.fujitsu.com/jp/news/2017/10/12-1.html*
3) T. Nakayama et al.: A LTE/WLAN selection method based on a novel throughput estimation method. 2017 IEEE 28th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC), October 2017.
4) D. Kimura et al.: A Novel RAT Virtualization System with Network-Initiated RAT Selection between LTE and WLAN. 2017 IEEE Wireless Communications and Networking Conference (WCNC), March 2017.
5) K. Matsuda et al.: A method to construct redundant distributed KVS designed for geographically dispersed data management, Technical Committee on Information and Communication Management, July 2016.
6) M. Yamazaki et al.: A Meta-data Management Method Avoiding Traffic Convergence for Wide-area Distributed Data Accessing, Technical Committee on Information and Communication Management, March 2017.

Yoshihiro Andoh
Fujitsu Ltd.
Mr. Andoh is currently engaged in the development of Fujitsu's Multi-access Edge Cloud.

Jun Ogawa
Fujitsu Laboratories Ltd.
Mr. Ogawa is currently engaged in research activities relating to distributed computing.

Hitoshi Ueno
Fujitsu Laboratories Ltd.
Mr. Ueno is currently engaged in research activities relating to orchestration and service quality analysis in distributed computing environment.

Nobuhiro Takahashi
Fujitsu Ltd.
Mr. Takahashi is currently engaged in network-related business planning.