Small-cell-based Solution to Make Diverse Services Possible

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The Internet of Things (IoT) has brought the age of connection where everything is linked to a network, but it is also causing an eruption of mobile network traffic and non-uniform traffic concentration in certain areas. While a mobile telecommunication network will become more important than ever, the current network configuration is not capable of handling the increasing demand. To address this situation, and having the future mobile network in mind, it is important to consider reinforcing the existing macro cells with small cells to counter data traffic concentrations in certain small areas called hot spots. This paper introduces the small-cell-based solution that has been developed to address this challenge by bolstering the data traffic capacity in specific areas. It explains the solution in terms of its structure as well as the functions and technologies that it deploys. The paper also describes the services this solution offers, touching on the diversity of the applicable fields as well as the solution's scalability and adaptability to future technologies.

1. Introduction

Fujitsu offers network systems that comprise an important part of social infrastructure. In particular, where mobile networks are concerned, the company offers a comprehensive range of products and services, including mobile devices for users, wireless base stations to which the devices directly connect, and core networks which carry all such data traffic.

In view of the rapid increase in mobile data traffic, it is crucial that the next-generation mobile network is able to leverage small cells to accommodate localized traffic surges efficiently in order to provide users with a stress-free network environment.

This paper explains Fujitsu solutions centered on the small-cell[note 1)] technology under development.

2. Trend of mobile market

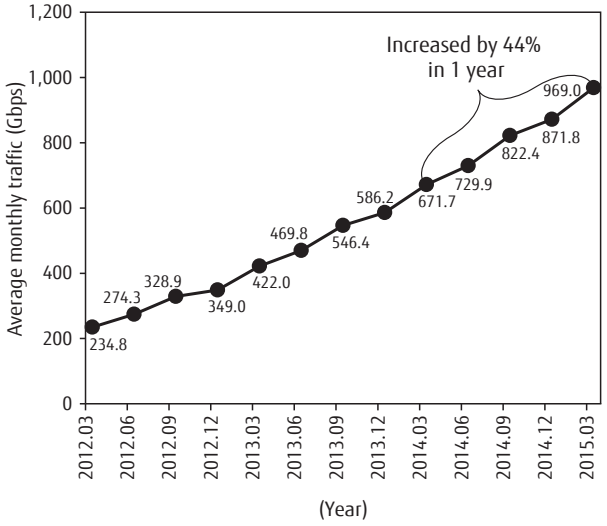
According to a Ministry of Internal Affairs and Communications report,[1)] the data traffic on mobile networks increased by approximately 44% during a 12-month period from March 2014 to March 2015 (**Figure 1**). This was due to the increase in the number of smartphones in use and video content being made available. It is likely that this tendency will continue in the future.

The data traffic increase, however, is not universally observed; it is often concentrated in urban areas, with non-uniform distribution patterns and significant fluctuations over time. Certain social events and changes in weather sometimes cause localized surges in data traffic, and these are called hot spots. The existing simple cell configuration is fast approaching its limit of traffic-handling capacity.

Also, the future network of the Internet of Things (IoT) is on horizon, where not only mobile phones and smartphones, but other objects will also connect to the Internet. The network will need to have choices of wireless connections from which to select the best methods of data transmission for devices, varying in terms of regions and purposes, based on their characteristics.

To address these challenges posed by the growing mobile network and mobile data traffic, Fujitsu is developing a small-cell-based solution (hereafter,

note 1) In this paper, a small cell refers to one with a coverage area with a radius of 100 m, as opposed to a macro cell which covers an area with a radius of 1 km.



Source: Ministry of Internal Affairs and Communications of Japan: Mobile data traffic in Japan (March 2015)[1].
http://www.soumu.go.jp/johotsusintokei/field/tsuushin06.html

Figure 1
Mobile data traffic.

the Solution) that works on the LTE[note 2] system. The Solution is designed to cover target areas with small cells, and provide varied area-specific services. We will describe the technology in the following section.

3. Structure, features and technology of the Solution

The main concept for the Solution is a private LTE network that addresses the hot spot issue as well as the creation of area-specific convenience and value through localized services.

More specifically, the technology makes it possible to easily set up LTE networks with the following characteristics in places such as office buildings, hospitals and event venues.

1) Realizing a flexible network configuration through virtualized features to meet the needs of customers in their environment, and enabling them to offer a voice service, location-based service and other services corresponding to places, devices and purposes.
2) Reducing the data traffic on the backhaul[note 3] of the wide area network by setting up a private network within a local area network.
3) Realizing a high-speed wireless network with enhanced accommodation ability by incorporating both LTE and Wi-Fi.

Figure 2 illustrates a case in which the Solution is introduced to a company with branches in the regions away from its main office. Through the network configuration as shown, it can realize internal communications via the LTE network. Also, the use of telecom networks allows enterprises to adopt consumer-type mobile devices, such as smartphones and tablets, for in-house use.

3.1 Components

The Solution is comprised of the following components.

1) Femtocell base station (Femtocell)

This is a small base station based on the LTE connection, designed to cover small cells such as indoor areas. It has been commercialized for telecom carriers as Fujitsu BroadOne LS100/200 series.[2]

2) Evolved packet core (EPC)

This is a core server for a network that includes LTE base stations. Full functionality of an LTE core network is contained in one server. Such functionality includes device authentication, packet routing between the devices and service networks, which are linked to the core network, and device mobility management.

3) Small-cell solution server (SCS-Server)

This is a collection of servers with various technologies and functions offered by the Solution. The system is scalable as a number of servers can be added depending on the features to be offered and the area of the required network coverage.

4) LTE devices (UE)

These are user devices (user equipment: UE) that communicate through the LTE network, generally referring to commercially available smartphones and tablets. These may have applications installed as required, to provide services to users.

5) Local gateway (LGW)

A gateway with a local breakout feature to

note 2) LTE: Long Term Evolution. A cellular network standard developed by the 3rd Generation Partnership Project (3GPP), a standardization body mainly formed by European telecom carriers and vendors. It is also known as 4G cellular network.

note 3) An intermediate line connecting a wide area network (WAN) or wireless base station to core networks.

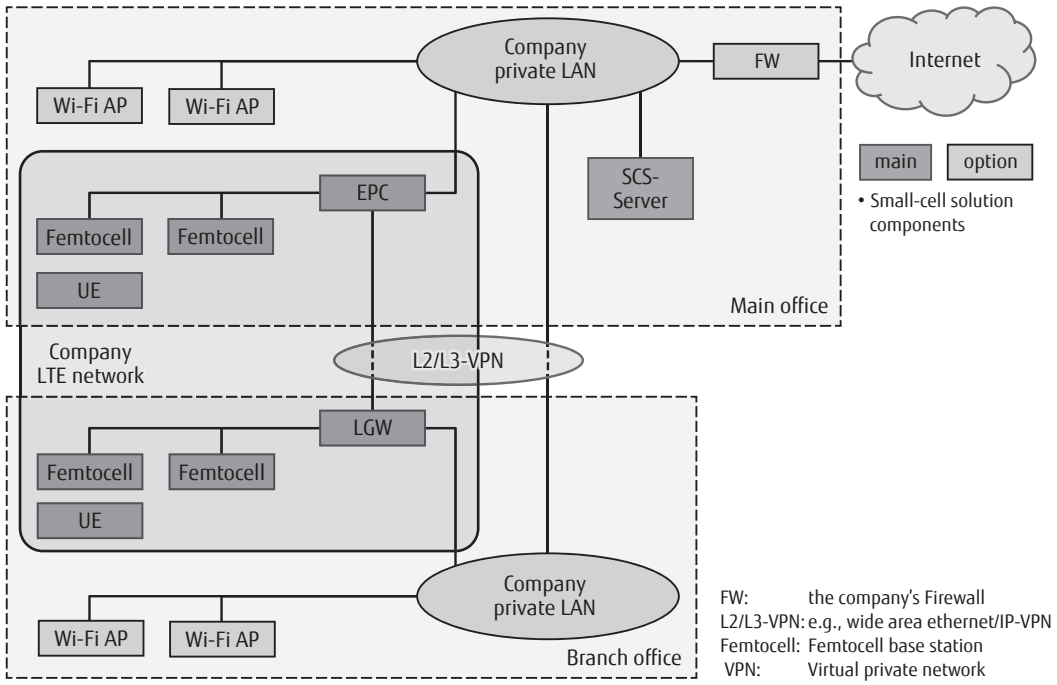


Figure 2
Example of applying small-cell solution

facilitate the shortest-possible routing to a local company private LAN. This feature is explained later.

6) Wi-Fi access point (AP)

This Wi-Fi AP is equipped with a feature to coordinate LTE and Wi-Fi networks, which we will explain later.

3.2 Features and technologies

In this section, we will explain the features and technologies offered in the Solution.

1) Voice service

In order to realize voice over LTE (VoLTE), the IMS[note 4)] network is used for this service. Actual applications include a mobile telephone extension service and private branch exchange feature. By connecting to a public telephony line, users may make voice calls externally.

2) Broadcasting service within small-cell network

This service is offered based on the broadcasting feature designed to transmit certain information to all base stations or across the network. It enables simultaneous announcement of the information provided on the network side to all or specific devices that are connected to the network, without these devices having to have a dedicated application installed. The service will enable, for example, company-wide simultaneous announcements, event advertisements in public facilities, and public announcements of evacuation information in an emergency.

3) Enhanced location-based information services

Tracking area identity (TAI) is an extension with which an LTE-based core network manages information on device locations. This service enables the network to assign TAI at the level of femtocell base stations. By incorporating the SCS-Server to manage this information, software applications can be variously activated in response to the locations of the devices. As illustrated in **Figure 3**, it can adopt a pull-type function in which the device identifies its location and the installed applications access the content relevant to this location; and also a push-type function in which the device provides its positional information, which the network detects and then transmits specific information to the device. The pull-type function requires the devices to have

note 4) IMS: IP multimedia subsystem. This is a technology for standardization developed along LTE by the 3GPP, and it enables multimedia services such as voice and images to be delivered over IP.

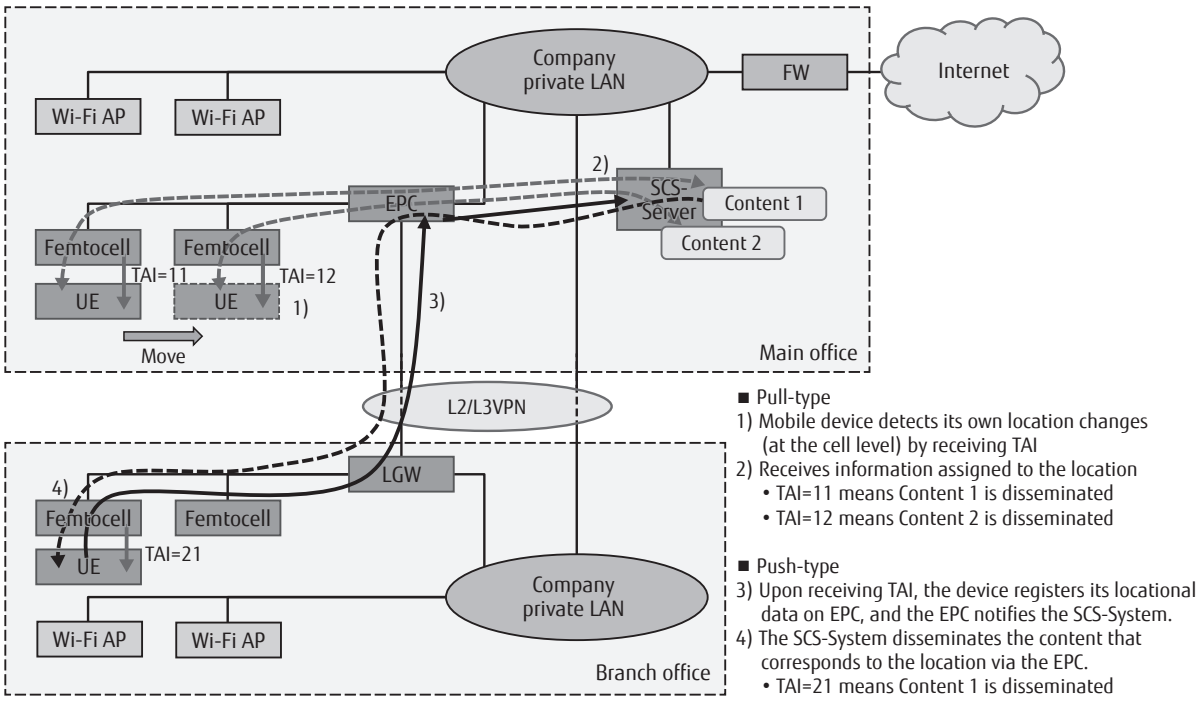


Figure 3
SCS-System and location-based information functions.

certain applications installed, and therefore it can be applied to cases where users proactively seek location-based information. By contrast, the push-type one does not require applications to be installed on devices, and thus it is more suitable for distributing location-specific information to unspecified devices. We are aiming to make this function compatible with the indoor messaging system (IMES: indoor positioning technology that uses GPS), beacon frames, and other positioning technologies to improve the precision in identifying the device location, leading to better services.

4) Company private LAN access

The devices that connect to the small-cell network would normally access a company private LAN via EPC through a base station. Every small-cell network system has only one EPC. Therefore, accessing the company private LAN within the bases without EPCs would have to make a detour as depicted in **Figure 4**. This would not only cause redundant traffic, but also be problematic for certain applications due to the delay in access. The Solution provides the network with an LGW, which facilitates direct access to the local private LAN using the local breakout technology, thereby solving the problem. This is a standardized technology that enables direct transmission of device-derived data packets from within an LTE network without putting them through the EPC, and vice versa.

5) Autonomous interference control feature

It is expected that the Solution will be installed inside a building in a high-density way to achieve the required area coverage. The femtocell base stations installed will share the same frequency, which may cause radio interference between them. Moreover, there is a possibility that interference will occur between the base stations and a macro base station. These would lead to performance degradation. There are two patterns of possible radio interference, which are illustrated in **Figure 5**.

1) Interference between femtocells

- Interference between two femtocell base stations, each placed in one of two adjacent rooms [**Figure 5 a)**]
- Interference involving a multiple number of femtocells arranged in a large area such as a shopping mall [**Figure 5 b)**]

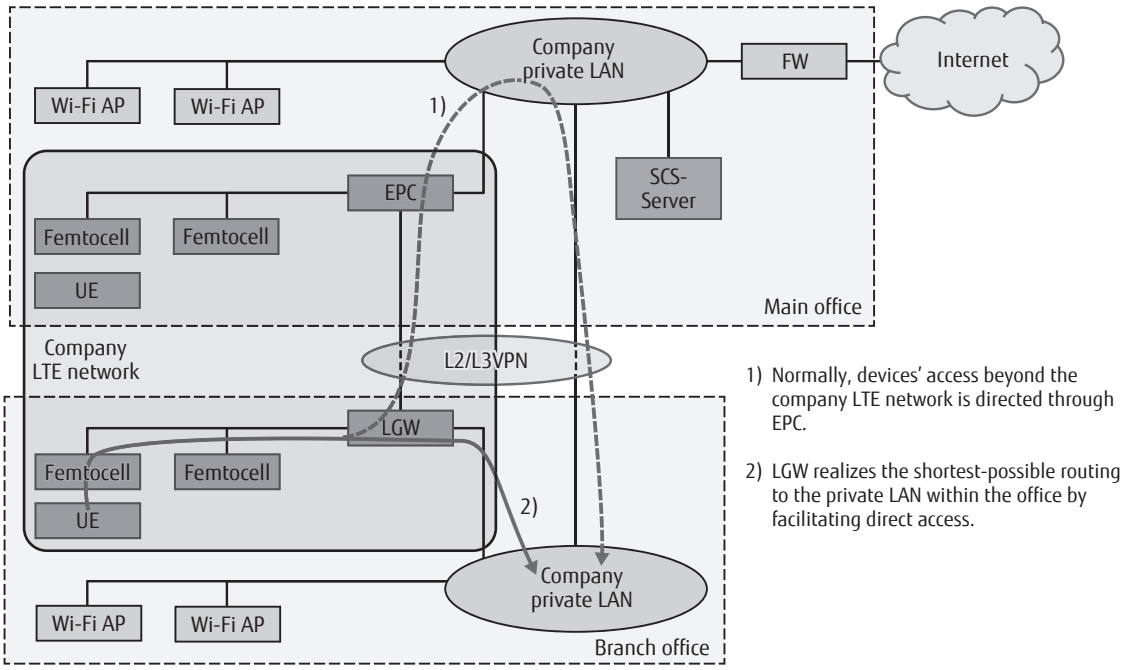


Figure 4
Direct access to local private LAN using the local breakout.

2) Interference between femtocell and macro base stations

- Interference from a macro base station on a UE connected to a femtocell station but located near the macro station [**Figure 5 c)**]
- Interference from a nearby femtocell base station on a UE that is connected to a macro cell [**Figure 5 d)**]
- Collective interference on a macro cell from an area where numerous femtocell base stations concentrate [**Figure 5 e)**]

The femtocell base stations employed in the Solution are equipped with an autonomous interference control feature. They automatically scan the environment and automatically adjust the power levels and transmission timing to minimize the radio wave interference. As the interference is reduced, wireless communications can have a maximized performance. With this feature, it is possible to expand the area coverage of the Solution.

6) Efficiency enhancement of wireless access through LTE and Wi-Fi coordination

As wireless LAN (Wi-Fi) requires no radio licenses to operate, it is becoming widely used by businesses and consumers. The Solution offers an option of incorporating Wi-Fi APs, allowing Wi-Fi-enabled devices to connect to the network based on the Solution. Furthermore, introducing the following technology will make the Solution more convenient.

- Automatic LTE/and Wi-Fi selection feature [**Figure 6 a)**]

The Solution constantly monitors the quality and traffic both of the LTE and Wi-Fi networks. Based on this information, the Solution controls the device connections and smooths out the data access congestion on the LTE and Wi-Fi networks. The Solution is thus able to provide an optimal environment for wireless access without users being aware of which network their devices connect to.

- High-speed simultaneous access to LTE and Wi-Fi networks [**Figure 6 b)**]

The Solution employs the multipath TCP (MPTCP) technology, realizing simultaneous data transfer on both the LTE and Wi-Fi networks[3] on the TCP layer. The LTE and Wi-Fi simultaneous data transmission technology[4] has already been realized in wireless devices. However, it is confined within the HTTP layer, which allows only downstream data traffic. By contrast,

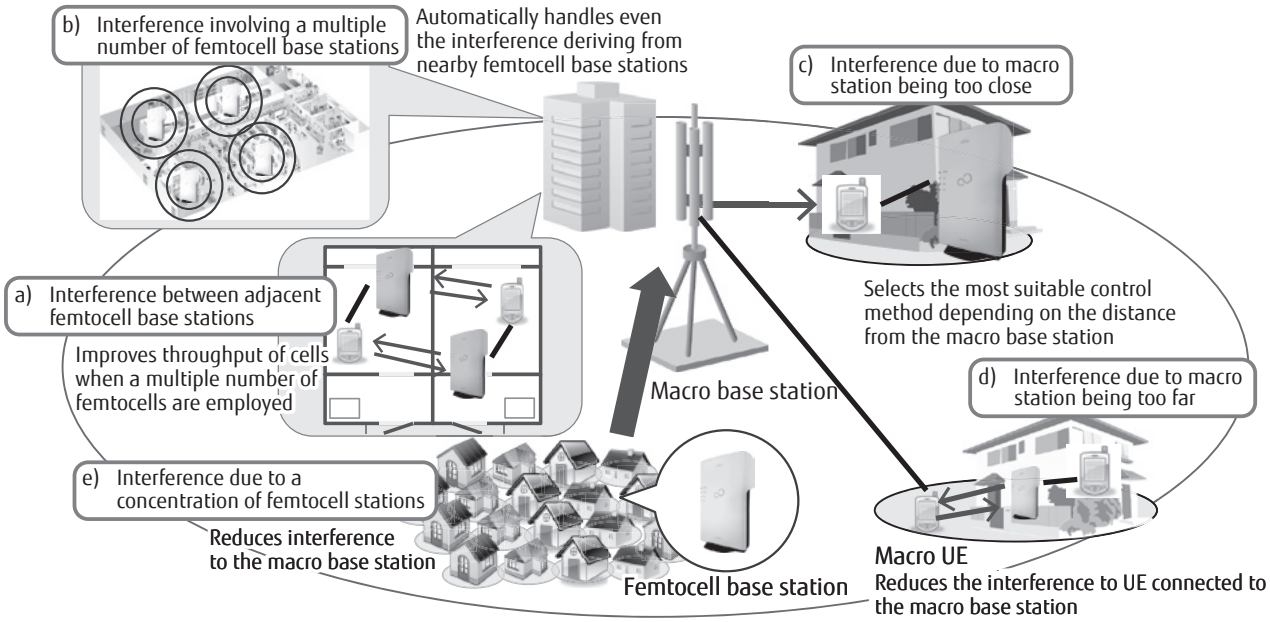


Figure 5
Technology to autonomously control femtocell interference.

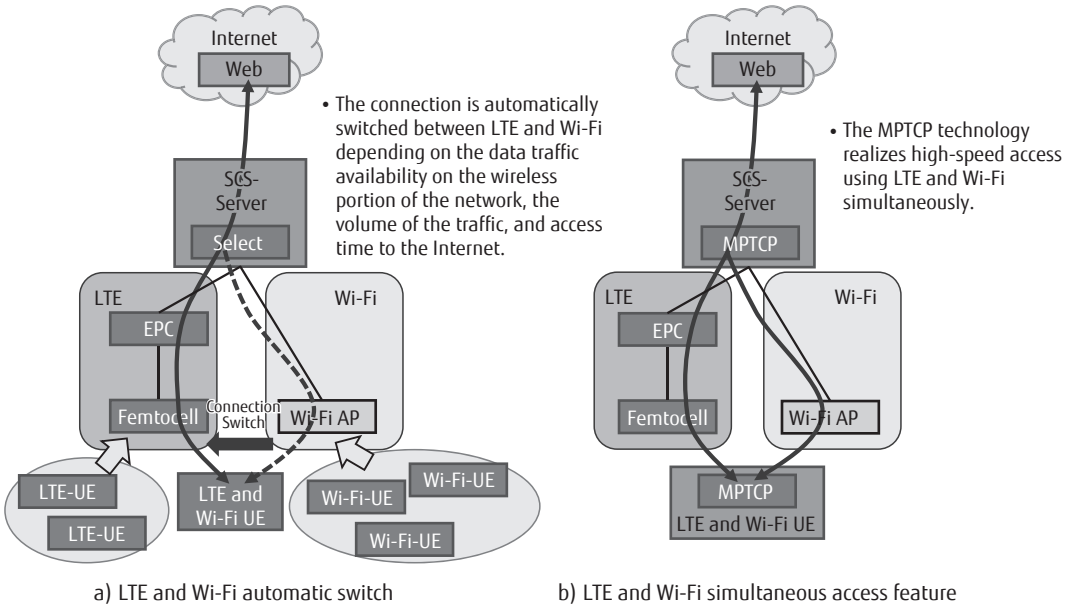


Figure 6
LTE and Wi-Fi coordination technology.

MPTCP technology is applied to the TCP layer, which is below the HTTP layer. Therefore, it is applicable to both directions of data traffic. The scope of applicable applications increases, further enhancing the convenience of the network access. Users can benefit from a faster wireless environment with this feature.

4. Future challenges and next step

There are two challenges related to the Solution. One is to create services that offer convenience and value unique to the location where the Solution is applied. Possible places of applications we have considered are as follows:

1) Shopping malls

Distribution of store-specific content, shopping floor navigation, staff communication, and emergency announcements,

2) Hospitals

Staff communication, locational identification and management of on-site medical equipment, patient paging system,

3) Event venues

Distribution of event-specific content, video streaming, on-seat food/drink ordering system,

4) Art galleries and museums

Voice and visual guides based on the locations of exhibits.

Some of these services have already been realized using existing technologies. Thus our challenge will be to integrate and enhance such services by leveraging the characteristics of small cells.

Another challenge is the future compatibility with new technologies. As wireless technology continues to develop, it is likely that the existing technologies will improve and new systems will be introduced. For example, the 3GPP is considering technology for enhanced LTE architecture, called LTE-Advanced, as well as technology for LTE in an unlicensed frequency band. We consider that the Solution must incorporate these future technologies as soon as they become available to be offered to customers in order to achieve future growth.

5. Conclusion

This paper gave accounts on the small-cell-based solution that is designed to address the issues deriving from fast-growing mobile data traffic, and provide users with a stress-free wireless access environment, explaining its structure and applied technologies. It also described some possible applications of the solution, together with future challenges and next step to take. We will strive to develop software applications that leverage the small-cell-based solution, in order to enhance the mobile network utility for our customers and their users. In this way, we hope to contribute to the development of society.

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