ISSN 0915-3160

平成三十年十月十日発行（年四回一、四、七、十月の十日発行）通巻百二十号 New Breeze

New Breeze

Quarterly of The ITU Association of Japan

No. 4
Vol. 30 October 2018
Autumn

Special Feature

MIC Fifth Generation Mobile Communications System (5G) Field Trials Special Issue

Overview of 5G Field Trials 2017

NTT DOCOMO Activities in 5G Field Trials

Verification Trials of 5G Communications in High-speed Mobile Environments

5G Trial Overview (FY2017) Connected cars, Construction Equipment Remote Operation, Transmission of High Resolution Video from Drones

Trials of 5th Generation Mobile Communication Systems in Indoor Environments

5G Overall System Trial

Demonstration of Disaster-proof Warehouse and Smart Office Applications Using the Multiple Simultaneous Connectivity of 5G

New Breeze ISSN 0915-3160
Quarterly of The ITU Association of Japan
BN Gyoen Bldg., 1-17-11 Shinjuku, Shinjuku-ku,
Tokyo 160-0022 Japan
Tel: +81-3-5357-7610 Fax: +81-3-3356-8170
https://www.ituaj.jp/?page_id=310

Letters to *New Breeze*

New Breeze welcomes readers' opinions. Please send comments with your name, address, and nationality by e-mail, fax, or post to the editor.

e-mail address: kikanshi@ituaj.jp

Subscription forms are available on the ITU-AJ website:
http://www.ituaj.jp/english/subscription_form.pdf

Subscription Fee:

Single issue:	¥1,500
Annual subscription (4 issues):	¥6,000

Disclaimer: Opinions expressed in this publication are those of The authors and do not necessarily represent those of The ITU Association of Japan.

CONTENTS

About ITU-AJ

The ITU Association of Japan (ITU-AJ) was founded on September 1, 1971, to coordinate Japanese activities in the telecommunication and broadcasting sectors with international activities. Today, the principle activities of the ITU-AJ are to cooperate in various activities of international organizations such as the ITU and to disseminate information about them. The Association also aims to help developing countries by supporting technical assistance, as well as by taking part in general international cooperation, mainly through the Asia-Pacific Telecommunity (APT), so as to contribute to the advance of the telecommunications and broadcasting throughout the world.

Overview of 5G Field Trials 2017

New-Generation Mobile Communications Office
Radio Department
Telecommunications Bureau
Ministry of Internal Affairs and Communications

The Fifth Generation Mobile Communications System (5G) will pave the way for many new capabilities and features such as ultra-high speed, massive machine type communications, ultra-reliability, and low latency. 5G is expected to be developed in the years ahead as the essential ICT infrastructure supporting the IoT era and Japan's economic growth.

Japan's "Growth Strategy 2018", approved by the Cabinet on June 15 this year, highlights the importance of "rapid dissemination and development of 5G in rural areas of Japan". 5G is required as a powerful engine for growth nationwide, not only in urban areas but also in rural areas to activate those region and resolve the problems besetting rural areas.

To make Japan as one of the first countries to commercialize 5G in the world, the Ministry of Internal Affairs and Communications (MIC) has strengthened international partnerships with Europe, U.S., and other Asian countries. In October 2016, MIC consulted the Information and Communication Council about "Technical Conditions Concerning New Generation Mobile Communication System" to begin consideration of allocating spectrum bandwidth to 5G, and the Council reported on 5G technical requirements in July 31, 2018. MIC will allocate spectrum to 5G by the end of the fiscal year.

Meanwhile, MIC continues to promote R&D to commercialize 5G and carry out field trials to demonstrate actual 5G applications. The trials began last year, and stakeholders in a number of relevant fields—transportation, tourism, medicine, etc.—took part in six demonstration projects that have already yielded good results.

This special issue provides an overview of the 5G Field Trials (hereafter *Field Trials*) of 2017 sponsored by MIC.

1. Introduction

The capabilities of 5G represents a major advancement over current wireless systems—very high speed of 10 Gbps (100 times faster than LTE), up to a 1,000,000 connected devices /km^2 (100 times the number of devices supported by LTE), 1 ms delay (one-tenth the delay of LTE)—which promises to open up all kinds of new service offerings and applications across many different industrial sectors.

3GPP (3rd Generation Partnership Project) and ITU-R (ITU Radiocommunication Sector) have stepped up international standardization activities to make 5G a reality by the year 2020. Governments and 5G promotional organizations of countries and regions around the world have been actively discussing international coordination regarding spectrum for 5G, 5G use cases, and migration scenarios from 4G to 5G with some of the industries that have the most to gain from exploiting 5G.

From this background, six projects were carried out as part of the Field Trials to assess the performance of 5G and to clarify the technical conditions in different test environments. These projects assessed radio wave propagation characteristics and specific applications and services when introducing 5G on frequency bands from 3.6 GHz to 4.2 GHz and from 4.4 GHz to 4.9 GHz (referred to as the 4.5 GHz band) and from 27.5 GHz to 29.5 GHz.

This paper provides an overview of the Field Trials and a detailed description of the six projects by the companies and organizations responsible for the projects.

2. Setting Technical Targets

Numerical targets were set to get an estimation of the achievement levels for the specific services and applications under test.

3. Preconditions

Preconditions for the 5G system were clearly specified to define the system and ensure that there were no inconsistencies among the various projects. Here we assume that the mobile communications system is the 5G system now being investigated by the 3GPP, which is expected to be recommended by the ITU-R as the IMT-2020 system.

4. Test Environment

We use the scenarios, technical performance requirements, and required values for the evaluation environment of 5G as defined by the ITU-R.

1) Usage Scenarios

The ITU-R drafted the recommendation "IMT Vision" (M.2083), which summarizes the basic 5G capabilities and concepts.

In this recommendation, three 5G usage scenarios are described:

(1) eMBB (enhanced Mobile Broadband)

(2) mMTC (massive Machine Type Communications)

(3) URLLC (Ultra Reliable Low Latency Communications)

The eMBB scenario supports ultrahigh-speed transmission of high-definition 4K/8K video and other HD applications; the mMTC scenario supports a large number of communication endpoints with infrastructure maintenance, low-power IoT, and so on; and the URLLC scenario supports real-time communication such as autonomous driving, real-time operation of remote robotics, and remote surgery.

5G does not require all of these scenarios in a single network. Rather, 5G will create a communications environment that satisfies a full range of needs by delivering the performance needed to address these various usage scenarios.

2) Performance Requirements to be Achieved by 5G

ITU-R Recommendation M.2412 provides a guideline for evaluating radio interface for IMT-2020 (5G). Within the guideline, test environments are defined for an evaluation that combines a usage scenario and a geographic environment. The evaluation environments are classified as "indoor hot spots", "dense urban", "rural", and "urban wide areas." The guideline is associated with a list of up to 13 requirements: peak data rate, and so on.

The key technical performance requirements in the guideline are a peak data rate of 20 Gbps, a connection density of 1,000,000 devices/km^2, and a latency of 1 ms.

The test environment for the Field Trials is fully compliant with these guidelines.

5. Implementation System

The Field Trials were conducted in collaboration with major telecom companies and institutions that were selected to execute the six projects. Applications were provided by trial partners, and the 5G trials were conducted not only in the Tokyo metropolitan area, but in rural parts of Japan as well.

6. Conclusion

There has been a great deal of interest within Japan and overseas in the results of performance assessments of actual applications in the 2017 5G Field Trials. We have shared the results at two conferences, and many inquiries have been received from overseas.

The Field Trials are scheduled to continue for three years and will focus on 5G services that help resolve rural issues in 2019. Through these efforts, Japan will commercialize 5G as the most advanced system in the world, and 5G will provide a trigger for robust economic growth in urban and rural areas throughout Japan.

NTT DOCOMO Activities in 5G Field Trials

Yukihiko Okumura
Satoshi Suyama
Jun Mashino
5G Laboratories
NTT DOCOMO, INC.

From the left: Jun Mashino, Yukihiko Okumura, Satoshi Suyama

1.Introduction

In addition to featuring higher capacity and transmission speed, 5th generation mobile communication systems (5G) will feature massive connectivity and ultra-reliable and low-latency communication. These features are also highly anticipated for when commercial services begin in 2020. NTT DOCOMO has been a primary implementer of the FY2017 Ministry of Internal Affairs and Communications (MIC) initiative, "Study of technical requirements for 5th generation mobile communication systems, which will enable ultra-high-speed communication exceeding 10 Gbps in densely populated areas" (study group one (GI)). This article gives an overview of this study and introduces some examples of trials in related application areas.

2. Trial Overview

The concrete 5G field trials being conducted by the Ministry of Internal Affairs and Communications (MIC) in various application fields are proceeding with a 3-year plan starting in FY2018, keeping in mind the implementation of 5G in society, building an open environment in which enterprises and universities from around the world can participate, and working toward a world-leading introduction of 5G in Japan. As part of this, NTT DOCOMO has conducted studies to understand radio propagation characteristics and evaluate 5G performance for ultra-high-speed transmission using the 3.6-4.2 GHz, 4.4-4.9 GHz and 27.5-29.5 GHz bands. These were done in densely-populated urban environments with user terminals travelling at speeds up to 30 km/h, so that 5G can be introduced using these frequency bands. We observed throughputs of up to 10.2 Gbps with two users, both connected in an outdoor environment at Tokyo Skytree Town®, and this confirmed that ultra-high-speed and high-capacity communication can be achieved in the field. Besides the radio transmission trial, the study group GI evaluated radio propagation characteristics, performed simulations of transmission characteristics, and conducted trials to check the feasibility of various 5G services in the areas of entertainment, smart-city/smart-area, and medicine, in collaboration with partner enterprises (see Table). These case studies are introduced below.

3. 5G field trials in the entertainment area

3.1 Entertainment system using VR/MR

In December 2017, we conducted a trial of a VR entertainment system which captured video using a 4K high-definition 360° live camera at Tokyo Skytree Town®, which was then transmitted using 5G to a 220° wide viewing angle head-mounted display for viewing (Figure 1). Stable delivery was achieved using a variable-rate video encoder implemented on the distribution server, compressing the video according to the state of communications for each user, from one minute to the next. During the same period, a 5G connection was made from inside the observation deck of Tokyo Skytree® (340 m

Table: Organizations participating in GI and their roles

Organization Participating in GI	Role
NTT DOCOMO	・Overall promotion and supervision of the field trials ・Provision of trial environment (5G Trial Site)
Fujitsu	・Trial of high-definition video transmission in densely populated indoor environments such as shopping malls. ・Provision of 5G radio equipment (in entertainment area)
Huawei	・Trial of a communication system that projects an MR image on a holographic lens ・Provision of 5G radio equipment (in entertainment area)
Ericsson	・Trial of 5G transmission in densely populated environments ・Provision of 5G radio equipment (in entertainment area)
Nokia	・Trial of 5G transmission in sports stadiums and other densely populated environments ・Provision of 5G radio equipment (in entertainment area)
Tobu Railway	・Promotion of trial in the entertainment area
Tobu Tower Skytree	・Organization and preparation of trial environment at Tokyo Skytree Town® as 5G Trial Site
Panasonic	・Trial of VR entertainment using 4K 360° live camera ・Provision of 220° wide-viewing-angle head-mounted display (in the entertainment area) and 4K close-up camera (in medical area)
Sharp	・Trial of 8K multi-channel MMT transmission ・Provision of 8K decoder supporting forward error correction in application layer
Japan Display	・Trial of outdoor digital signage using low-power-consumption display ・Provision of 4K reflective display
NTT	・Trial of video transmission from high-definition relay camera at sports events ・Provision of cooperative wireless LAN system
IOFOCITY	・Trial of high-resolution live viewing service for sports events ・Provision of HD camera, 4K live encoder, and video switcher
Sohgo Security Services (ALSOK)	・Trial of security operations for in-facility and wide-area monitoring ・Provision of HD camera system for wide-area monitoring
NEC	・Trial of security systems such as face recognition gates for in-facility security ・Provision of 5G radio equipment (in smart city/smart area and medical areas)
Wakayama Prefecture Wakayama Medical University	・Trial of remote medical examination service using high-definition video transmission ・Provision of trial environment (at medical university and clinic)
NTT Communications	・Trial of high-definition video conference system for remote medical examination service interviewing ・Provision of 4K video conference system

Figure 1: Entertainment system for trials

above the ground) to the roof of Asakusa train station EKIMISE building, for a trial of a new communication style using mixed-reality (MR) technology. For the trial, video of people inside the Asakusa station building (Figure 3) was transmitted at speeds up to 4.5 Gbps, even at the transmission distance of 1.2 km, successfully reproducing the people from the remote location on a 3D holographic video display.

3.2 Trials at Tokyo Skytree Town®

In March 2018, we built indoor and outdoor test environments in Tokyo Skytree Town® and Tokyo Soramachi®, and verified the feasibility of services using 5G in a densely populated commercial facility (Figure 2). In one trial, 8K multi-channel video was transmitted using 5G, confirming the ability to receive stable video quality after forward error correction on both the radio access (physical) layer and the video (application) layer. In a digital signage trial using ultra-low-power reflective displays, four tiled reflective displays were installed outdoors, and 4K video content simulating advertising was sequentially transmitted to them from a base station and displayed. This trial confirmed that the content could be reproduced in outdoor light without loss of image quality, and with good contrast, and color reproduction. In a trial of video transmission in an indoor environment modeled after a commercial facility, 5G ultra-high-density distributed antennas were deployed, transmitting 4K HD video to a mobile terminal, with several pedestrians walking around the terminal. This trial confirmed that stable transmission of video was possible, even when entering tenants having complex premises.

4. 5G field trials in the smart city area

We conducted a trial of a new security model for urban spaces needed in smart cities, toward realization of advanced security services that can handle crimes that current preventative measures cannot, such as crimes of conviction (terrorism, random attacks, child predation, etc.). The trial used HD video, AI, and 5G to capture predictors of crime so they can be prevented before they occur (Figure 3).

4.1 Facility monitoring

In November 2017 at the National Museum of Emerging Science and Innovation ("Miraikan"), we conducted a trial of a new security system for inside facilities, using high definition surveillance camera video and face-recognition access gates. The information needed to implement security for specified areas is recognized in images obtained using the surveillance cameras in real time, using image recognition technology involving face comparison and AI. We confirmed the ability to increase the frequency of face checks by a factor of six with 5G, compared with using 4G.

4.2 Wide-area monitoring

In March 2018, we conducted a trial of wide-area monitoring using a 4K high-definition camera mounted on the observation deck of Tokyo Skytree® and an AI processing server. We analyzed the video from the wide-area camera to recognize vehicles driving on highways, areas of congestion potentially caused by traffic

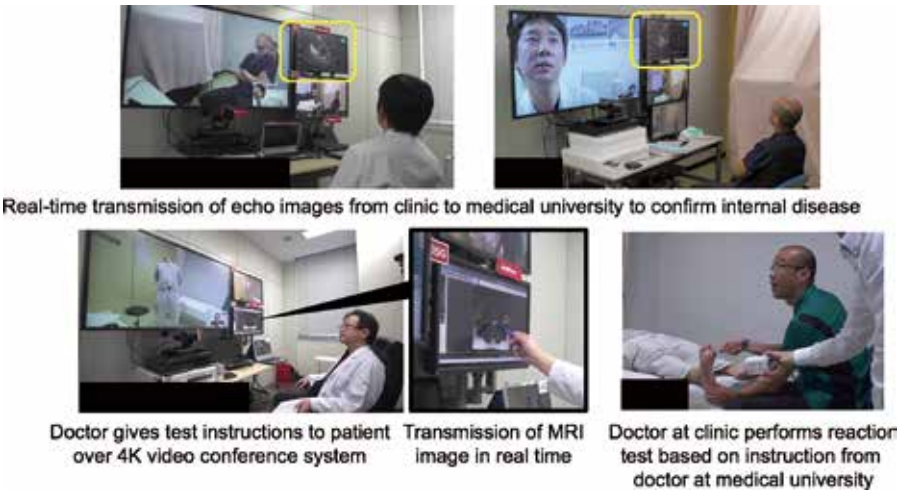
Figure 2: Trials at Tokyo Skytree Town

Figure 3: Trials of security in facility and urban spaces

Trial of facility monitoring using face recognition

Trial of monitoring traffic conditions using wide-area

Figure 4: Trials of remote medical examinations



Real-time transmission of echo images from clinic to medical university to confirm internal disease

Doctor gives test instructions to patient over 4K video conference system

Transmission of MRI image in real time

Doctor at clinic performs reaction test based on instruction from doctor at medical university

accidents, fires and other phenomena. The results showed that the ability to distinguish distant objects was clearly superior when using the relatively higher-resolution video transmittable using 5G, compared with 4G.

5. 5G field trials in the medical area

We conducted a trial of an advanced remote medical examination service, providing improved medical examinations in rural and mountainous areas, comparable to those available in urban general hospitals (Figure 5). We connected the Wakayama Medical University Community Medical Support Center (Wakayama City) and the Japan National Health Insurance Kawakami Clinic (Hidakagawa Town, Wakayama Prefecture) by network including 5G. We then introduced capabilities to transmit video from a 4K high-definition close-up camera used for diagnosis of conditions of the skin, dental/oral, and other external injury, and from other equipment used for internal examinations, such as ultrasonic imaging (echograms), and also a 4K high-definition video conferencing system for medical interviews and consultations between doctors.

In February 2018, we conducted a trial following the medical treatment of patients for five cases (three dermatology, one plastic surgery, and one cardiology case). Impressions from the doctors and patients participating in this trial are described below.

5.1 Doctor impressions

- Using the 4K camera capabilities and ability to examine closely, I was able to see the external trauma well and perform the examination, which was not possible using earlier video conferencing systems. Wonderful! (Dermatologist).
- The 4K video was clear and of quality in no way inferior to the images when using the echogram directly. I look forward to using it to improve medical treatment in regional communities (Cardiologist).
- The feeling that specialists can be present immediately is reassuring. This should be very effective in improving care at clinics, and especially as an educational tool for young doctors. (Clinic doctor).

5.2 Patient impressions

- With the doctor from the Medical University on the large screen, I was able to receive the medical examination exactly as if I was there as an outpatient.
- This time, I used this remote medical examination to get a second opinion. I had the examination through a screen that gave a strong sense of presence, and received excellent findings and new treatment methods as I would expect from a specialist at the general hospital. It was a real eye-opener!

Verification Trials of 5G Communications in High-speed Mobile Environments

Masanori Ichinose
Director
Solution Services
NTT Communications Corporation

Ichiro Nakagawa
Senior Manager
Solution Services
NTT Communications Corporation

1. Introduction

The Fifth Generation Mobile Communications System (5G) will provide across-the-board enhancements—unrivaled capacity, ultra-high speed, multiple simultaneous connections, ultra-reliable and low latency—and should lead to early implementation of an ICT infrastructure supporting the IoT era and sustained growth of Japan's economy for years to come. With a planned rollout of 5G slated for 2020, R&D supporting 5G wireless access and other technologies, and Field Trials for new 5G services are well under way.

This article provides an overview of Field Trials recently conducted by NTT Communications (NTT Com) in collaboration with NTT DOCOMO to assess technical and operating conditions of a 5G mobile communication system capable of supporting high-speed 2Gb/s Gbps throughput for high-speed public transportation. The system is designed to provide entertainment for passengers when traveling on fast-moving trains and motor vehicles.

2. 5G wireless transmission characteristics in high-speed mobile environments exceeding 90 km/h

Two trials were conducted to assess the transmission performance of 5G wireless access for motor vehicles (cars and busses) running on highways and for conventional trains operating at high speed: the vehicle transmission trials were carried out at Fuji Speedway while the railway transmission trials were conducted on the Tobu Railway Nikko Line.

2.1 Vehicle transmission trials at Fuji Speedway

The vehicle trials were conducted on February 7-9, 2018 at Fuji Speedway (in Shizuoka Prefecture) by constructing a 5G transmission zone near the grand stand and transmitting 5G wireless content to vehicles driving around the track at high speed (Figure 1).

The base station was set up near the grandstand along the home straight with a 45° angle of orientation to the course, and the mobile station was mounted on the roof of the test vehicles. Specifications of the transmitter were as follows: center frequency of 27.875 GHz, bandwidth of 700 MHz, and number of antenna elements (base station: 96, mobile station: 64). Through these trials, we were able to verify a maximum throughput of 2.24 Gbps at vehicle speeds above 90 km/h.

2.2 Train transmission trials on Tobu Railway Nikko Line

The train trials were done in collaboration with Tobu Railway on February 19-23, 2018. For the purpose of these trials, 5G transmission zones was deployed near Ienaka Station and Niregi Station along the Tobu Nikko Line, and 5G wireless content was transmitted to the Sky Tree Train, EMU 634 (a sightseeing

Figure 1: Wireless transmission trials for high-speed vehicles at Fuji Speedway

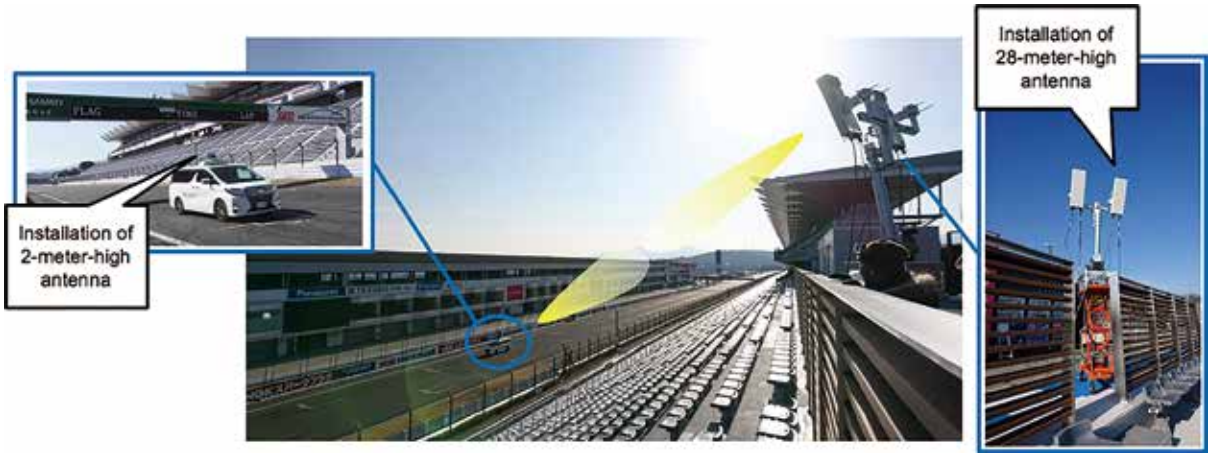


Figure 2: Wireless transmission trials for high-speed trains on Tobu Railway Nikko Line

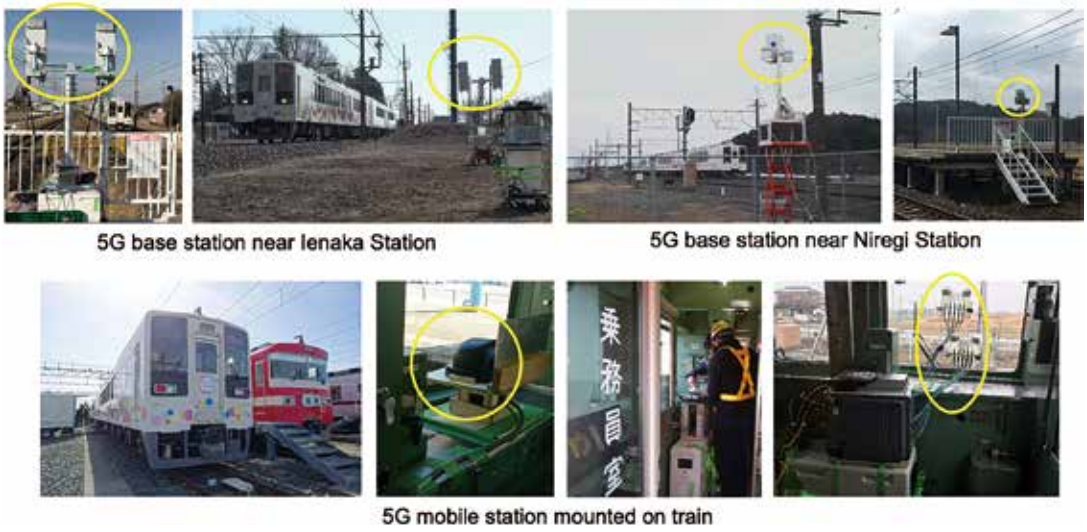
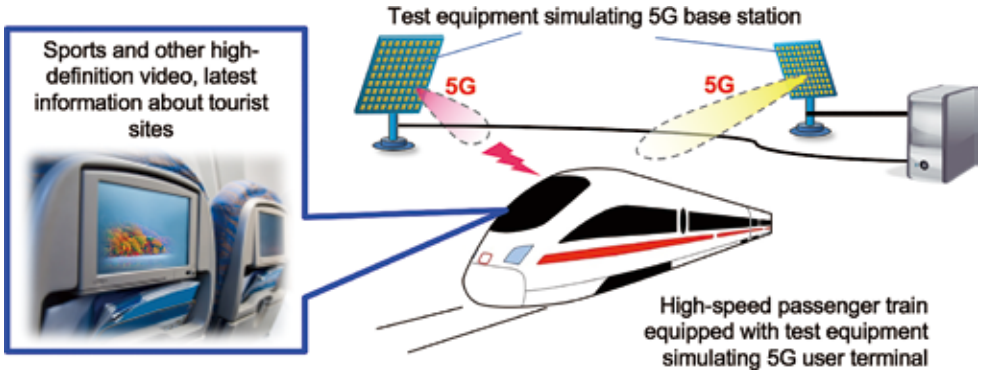


Figure 3: Overview of entertainment delivery trial



train operated by Tobu Railways) that was traveling at high speed (Figure 2).

The equipment was set up so we could assess handover performance of 5G transmissions: the base stations were under the control of the core network near Ienaka Station, with base station base band unit 1 deployed at the north end of the platform and base station base band unit 2 set up in a vacant lot south of the station. Two antenna units were connected to each base station base band unit to provide transmission diversity. The antenna was attached to the mobile station in such a way that it was visible through the front windshield of the train crew cabin. Specifications of the transmitting equipment were as follows: center frequency of 27.875 GHz, bandwidth of 700 MHz, and number of antenna elements (base station: 96, mobile station: 64). Based on the trials, we were able to verify a maximum throughput of 2.08 Gbps when the train was moving at a speed of 90 km/h. We also confirmed that the handover occurred seamlessly without issue.

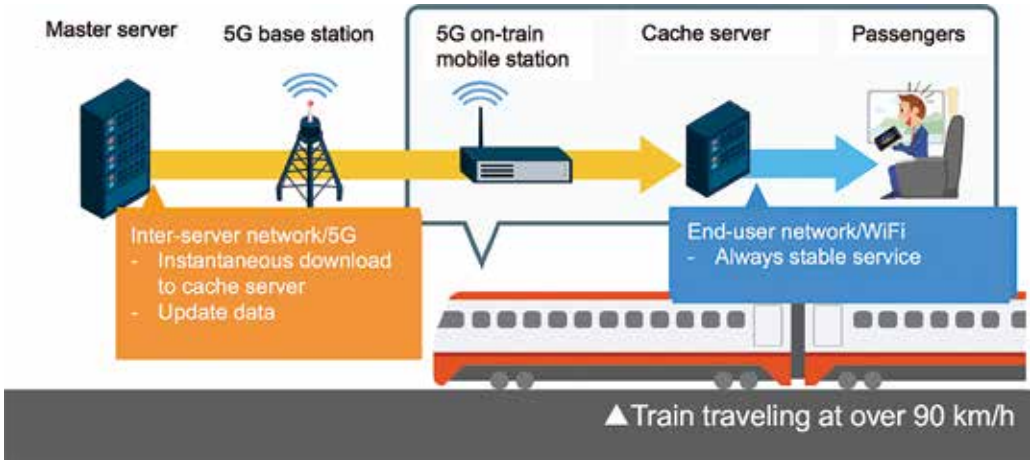
The two antenna units subordinate to the base station base band unit installed near Niregi Station were deployed in a distributed configuration. Specifications of the transmitting equipment were as follows: center frequency of 27.900 GHz, bandwidth of 730.5 MHz, and number of antenna elements (base station: 128 × 2 unit, mobile station: 8). To make sure the mobile station was within direct line-of-sight of the base station transmission point inside the train car, the antenna was mounted on the front windshield in front of the driver's seat shielded by a sheet of clear acrylic. Here again we verified a maximum throughput of 2.90 Gbps when the train was traveling at 90 km/h.

3. Entertainment field trials

Riding long distances on public transportation can take considerable time, and this of course increases the demand for ever faster travel speeds. Providing passengers with entertainment in the form of high-definition video services while traveling is also exceedingly important, for it helps passengers pass the time while in transit. These considerations led us to carry out these trials to test and evaluate 5G high-definition video services for passengers riding on trains and busses and taxies operated by passenger automobile transport businesses at speeds in excess of 90 km/h (Figure 3).

We might assume that the most basic 5G services sought by train and car service passengers will be Internet connectivity services. But the goal of these trials was to assess and visualize services that exploit 5G capabilities, so we focused on high-definition video services for passengers traveling at high speed on various modes of public transportation. Compared to legacy transmission services, delivering high-definition video to passengers in trains and vehicles offers significant advantages, most notably the very high capacity of 5G transmission. We can

Figure 4: Hybrid video distribution service



anticipate that this larger capacity will provide sharper higher definition video, a greater range of channels, and instantaneous live feeds and other information delivery services.

There are two types of video distribution services—linear distribution (program organization) services and on-demand distribution services—but for these trials we deployed very few base stations and the communication time was exceedingly limited. So for our purposes, we adopted a hybrid compromise type distribution service so we could assess both the instantaneous nature of the linear distribution service, and the convenience of the on-demand distribution service (Figure 4).

We installed a video distribution server (master server) on the base station side and a cache server between passenger user terminals inside the train, then split the network into two sub-networks: an inter-server network between the master server and the cache server, and an end-user network between the cache server and the user terminals. With this architecture, even if the cache server cannot exploit G5 communication to add and update content added or updated on the master server by the carrier, content on the cache server can be appropriately updated later using 5G communications to deliver almost instantaneous services very similar to live streaming to users.

Using this system, we conducted trials on February 19-23, 2018 by downloading multiple 4K/8K video files within the 5G transmission zone near Ienaka Station on the Tobu Railway (Figure 5). During the 21 seconds it took for the train to pass through the 5G transmission zone, a total of 1.2 GB of 4K/8K video data was transmitted over the system which were shown on a 4K display and on a 17-inch 8K display set up in the train for the experiment. By providing very-high-speed Gbps-class communications in high-speed mobile environments, this will make it possible to deliver breaking news and other high-definition video clips in a timely manner to passengers riding on high-speed trains.

4. Conclusions

In these trials we evaluated the performance of 5G high-speed communication in the 28-GHz band for vehicles and trains moving at 90 km/h. In the vehicle transmission trials at Fuji Speedway and the train transmission trials on Tobu Railway Nikko Line we demonstrated that very high throughputs in excess of 2 Gbps were feasible at speeds of 90 km/h.

This ability to deliver very-high-speed Gbps-class communications in high-speed mobile environments will open the way to many new 5G entertainment services tailored for public transportation including the delivery of breaking news clips of the 2020 Tokyo Olympics and Paralympic Games to passengers while travelling on Japan's high-speed trains.

Figure 5: High-definition video trials for high-speed trains on Tobu Railway Nikko Line

On-train cache server and displays

Delivery of 4K video to smartphone

Delivery of 8K video to 17-inch 8K display

5G Trial Overview (FY2017) Connected cars, Construction Equipment Remote Operation, Transmission of High Resolution Video from Drones

Akira Matsunaga
Senior Director
Mobile Network Technical Development Division
KDDI CORPORATION

Satoshi Nakano
Assistant Manager
Next Generation Network Development Department
Mobile Network Technical Development Division
KDDI CORPORATION

1 Introduction

In preparation for implementation of 5th Generation mobile communication systems (5G), the Ministry of Internal Affairs and Communications (MIC) began 5G Trials in FY2017. The authors, together with other collaborating organizations, participated in a group conducting trials of applications using 5G low-latency communication, measuring radio propagation characteristics and evaluating performance of 5G, generally and in applications, using the 4.5 GHz and 28 GHz bands in urban and suburban areas. This article reports on the results of these activities.

2 Sample applications, locations, and frequencies used in trials

Trials with three applications: Connected car, ICT Construction, and Drone aerial photography; were conducted as shown in Table 1.

Table 1: Sample applications

Sample applications	Environment	Demonstration location	Frequency
Connected car	Urban Suburban	Tokyo Aichi Prefecture	4.5 GHz 28 GHz
ICT Construction	Suburban	Saitama Prefecture	28 GHz
Drone aerial photography	Urban	Tokyo Kanagawa Prefecture	28 GHz

3 Assumed use cases and test details

The assumed use cases and test details are described below.

3.1 Connected car (Figure 1)

In the use case studied, a server application receiving instructions from an operator instructs the on-board camera in a vehicle travelling below 60 km/h to record images of a moving object. This application requires a low-latency transmission channel to minimize the time between when the operator issues the instruction and when video capture begins, to minimize changes in relative positions of the camera and subject during that time. Tests of transmission from the vehicle were conducted during FY2017.

3.2 ICT Construction (Figure 2)

Due to the demand for rapid recovery after severe natural or other disasters and the need to rebuild social infrastructure, and considering the social issue of declining numbers of skilled laborers, there is increasing anticipation placed on construction robots and remote operation of equipment. In this application, video captured by 4K 3D cameras installed on construction equipment and multiple overhead HD cameras is transmitted using 5G to a remote control room, where operators watch the video and operate the equipment remotely. Current remote control systems use Wi-Fi, but the high capacity and low latency of 5G makes use of high-resolution video possible and is expected to increase efficiency of remote operation. In FY2017, field tests

Figure 1: Connected car application

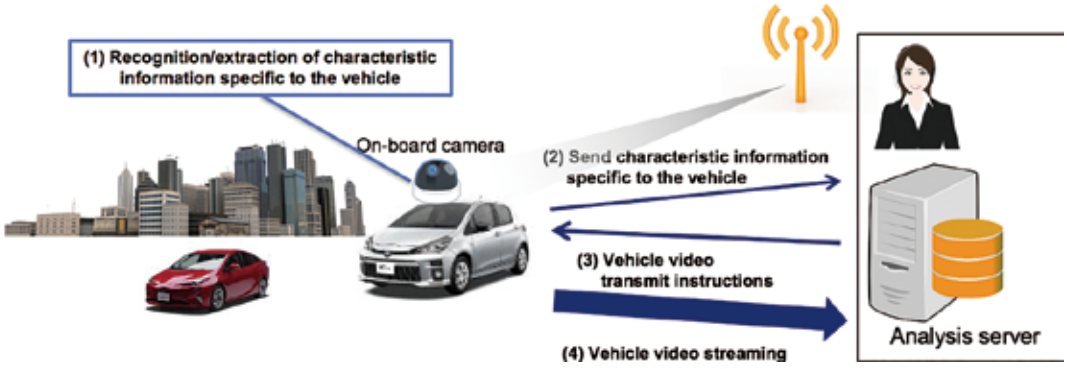
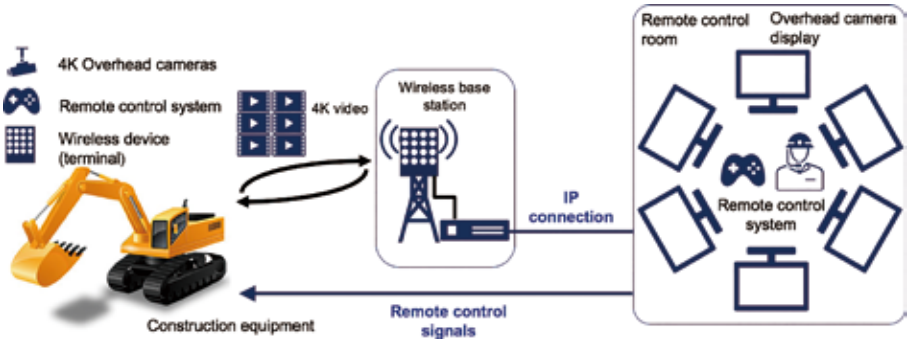


Figure 2: ICT construction application



conducted in a simulated construction environment quantitatively demonstrated the effectiveness of 5G by comparing remote control through both Wi-Fi and 5G.

3.3 Drone photography (Figure 3)

The objective of this use case is to use 5G to transmit 4K video from a drone during an event or disaster. Preliminary studies, evaluations, and selection of issues when using 4G were done in FY2017.

4 Trial results

4.1 Connected car

Trials were conducted in Shinjuku Ward, Tokyo, and Ichinomiya City, Aichi Prefecture (Figures 4, 5).

The results of 4.5 GHz transmission tests conducted in Ichinomiya City are shown in Figure 6. The downlink throughput using a bandwidth of 100 MHz and a 1:1 ratio for up and down-link time intervals was almost 300 Mbps. In the environmental conditions for these tests, the median value for one-way delay on the radio segment was 0.935 ms, which is less that the 1 ms target value.

The results of 28 GHz measurements are shown in Figure 7. The median delay value was 0.915 ms, confirming low latency communication similar to the 4.5 GHz case. A comparison of the 4.5 GHz and 28 GHz cases is shown in Figure 8. In the driving routes shown in Figure 9, the Section 2 driving area is the same for both bands. The sections indicated in red in Figure 8 show that 4.5 GHz is more resistant to degradation of throughput due to the environment.

4.2 ICT Construction

To compare working efficiency when using Wi-Fi and 5G, the time required to stack three blocks was measured using various systems. (See Figures 10, 11, and 12)

Figure 3: Drone aerial photography application

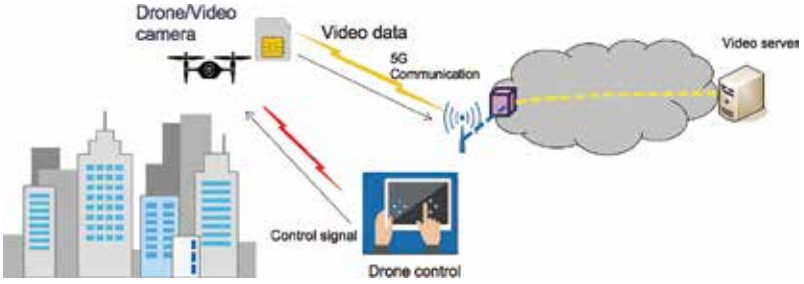
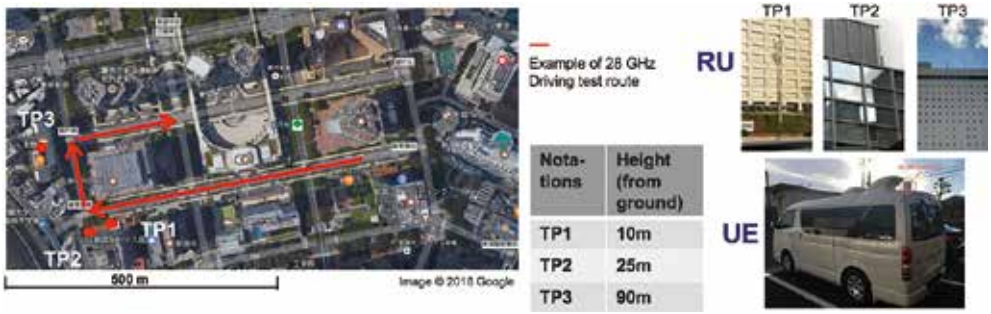
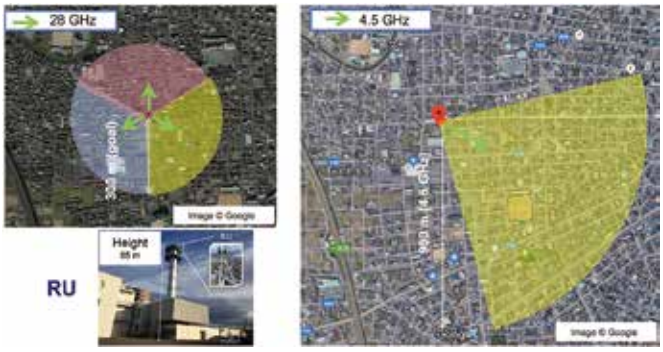


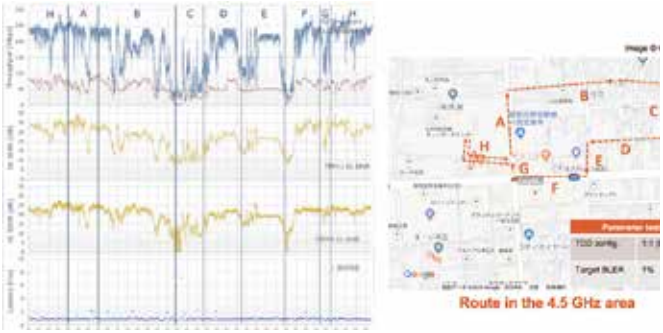
Figure 4: Test area in Shinjuku Ward, Tokyo



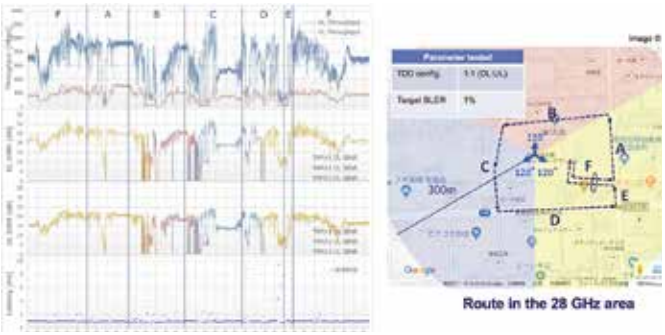
■ Figure 5: Test area in Ichinomiya City, Aichi Prefecture



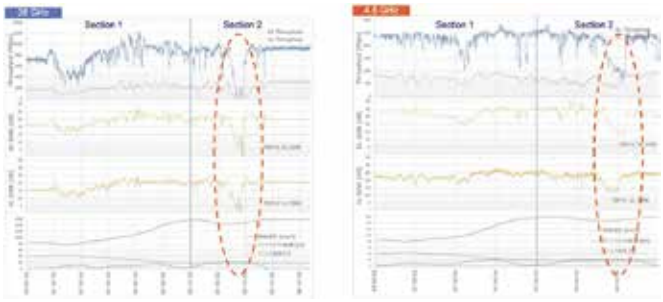
■ Figure 6: 4.5 GHz transmission test results (Ichinomiya area)



■ Figure 7: 28 GHz transmission test results (Ichinomiya area)

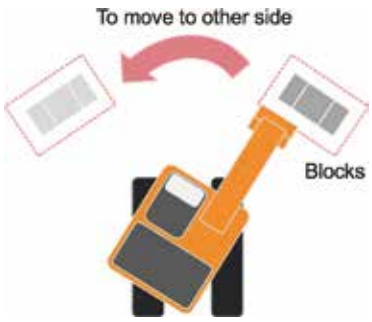


■ Figure 8: Comparison of 4.5 GHz and 28 GHz (Shinjuku area)



■ Figure 9: Driving routes

■ Figure 10: Block stacking test overview



■ Figure 11: Block stacking test photograph

■ Figure 12: Machinery configurations

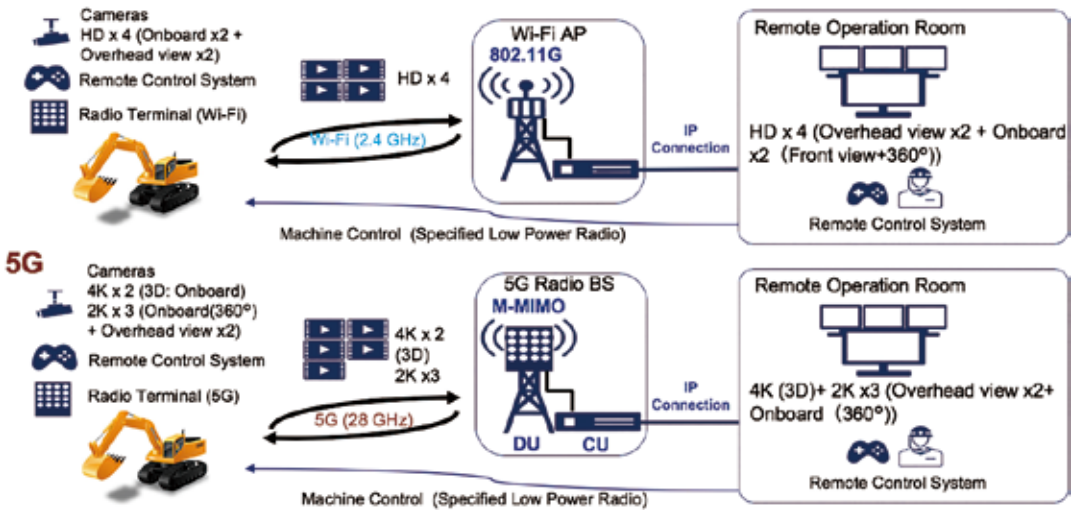


Figure 13: Block stacking test results

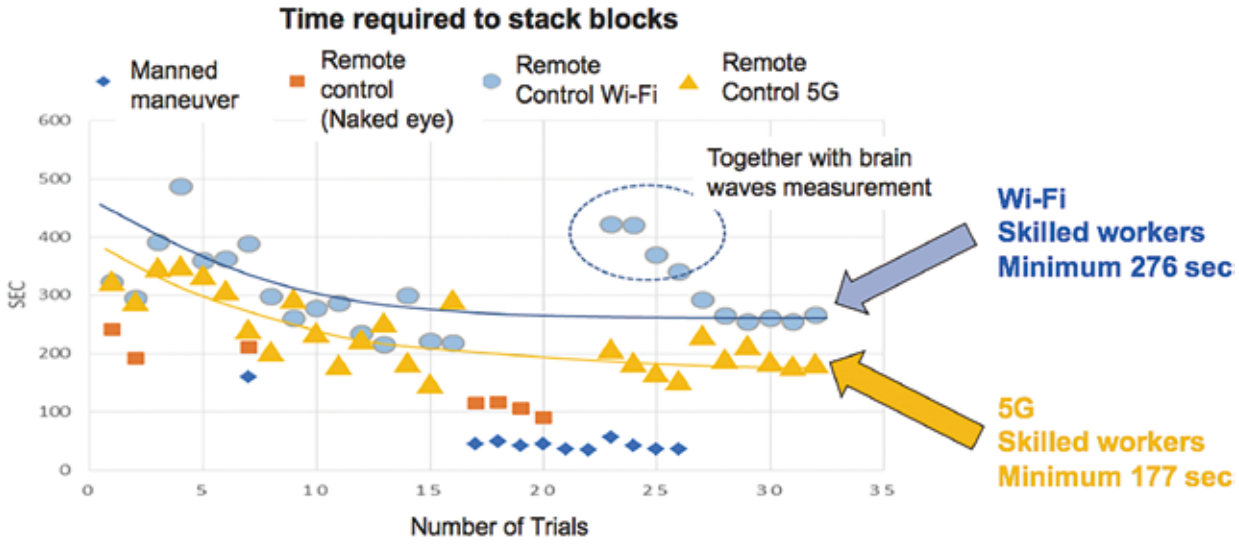
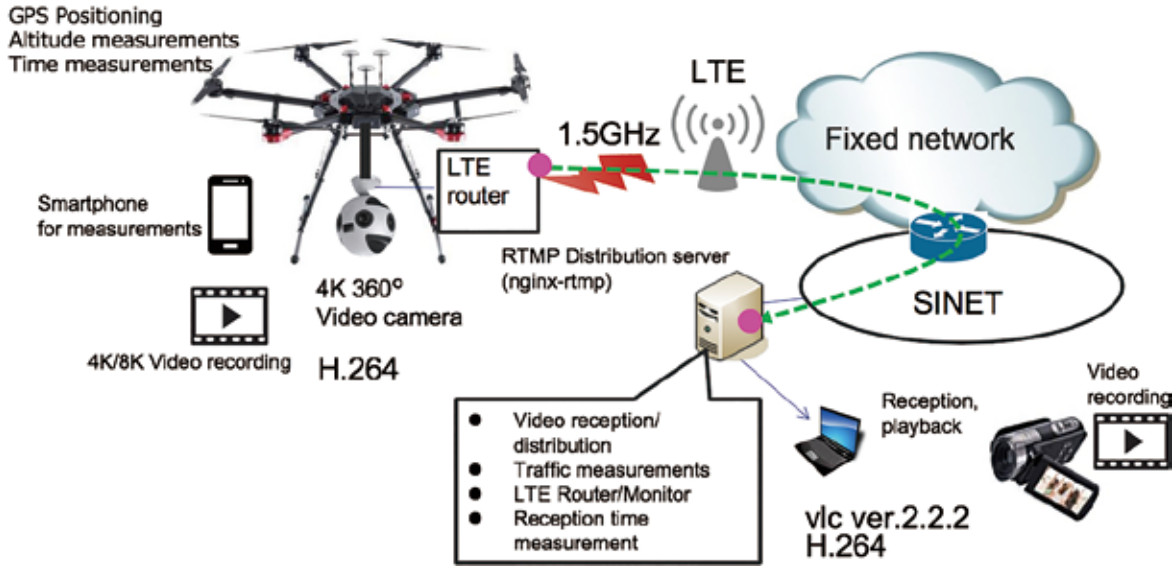


Figure 14: Drone aerial photography test configuration



Configurations using the conventional method (Wi-Fi) and 5G are shown in Figure 12. To reduce differences between the environments, the number of cameras and distance to the remote control room was the same. The conventional system used 2K video, while the 5G system used naked-eye 3D 4K video, comparing based on image quality. The remote control system used Specified Low-power Radio.

In the experiments, the same operator alternated between the two test environments and compared them with consideration for how work time decreased as they gained practice. Assuming an exponential approximation, the expected time for an experienced user would be 276 s on the Wi-Fi system, and 177 s on the 5G system, reducing work time by a third (Figure 13).

4.3 Drone aerial photography

As shown in Figure 14, video captured with 4K and 720p cameras mounted on a drone was transmitted to a server using a 4G terminal mounted on the drone, and the transmission delay and throughput were measured. 4K video resulted in delay of approximately 30 s, confirming that transmission would be difficult using 4G.

5 Conclusion

This article has described 5G performance evaluations for application use cases in 5G trials conducted by the MIC.

Trials of 5th Generation Mobile Communication Systems in Indoor Environments

Masaya Yamada
Assistant Director
Adaptive Communications research Laboratories
Advanced Telecommunications Research Institute International (ATR)

Nobuo Suzuki
Head
Dept. of Broadband Wireless Communications, Adaptive Communications research Laboratories
Advanced Telecommunications Research Institute International (ATR)

Hiroyuki Yokoyama
Director
Adaptive Communications research Laboratories
Advanced Telecommunications Research Institute International (ATR)

1. Introduction

In anticipation of the realization of 5th generation (5G) mobile communication systems and new markets created using them, the Ministry of Internal Affairs and Communications (MIC) began conducting 5G system trials starting in FY2017. In these trials, the communications industry providing 5G and various other industries that will use 5G have cooperated, conducting tests in six groups to ensure that the many and diverse applications and features of 5G (high speed, many-connections, very low latency) are all covered.

The authors participated in the fourth group (G IV), collaborating with other agencies in 5G testing related to ultra-high speed communication in indoor and enclosed environments. This article reports on performance tests of 5G radio propagation characteristics using the 28 GHz band and with 5G applications.

2. Evaluation test locations

The following three types of environment were selected for evaluation in indoor and enclosed environments.

Environment	Location	Region
Stadium	Okinawa Cellular Stadium Naha	Naha City, Okinawa Prefecture
Inside train station	Keikyu Railway, Haneda Airport International Terminal Station	Ota Ward, Tokyo
School	Maehara Elementary School	Koganei City, Tokyo

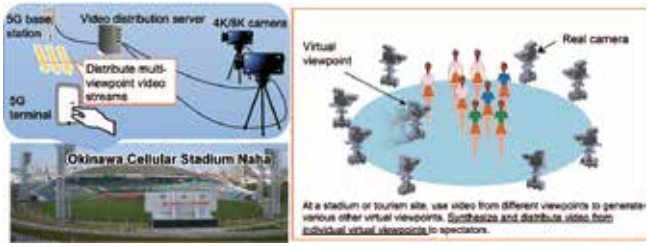
3. Application concepts and evaluation details

In these tests, 5G performance was evaluated in anticipated use cases for various services and applications. The application concepts at each of the test locations are described below.

(1) Stadium

Distribution of free-viewpoint video is being studied as an application to develop entertainment in a stadium further, utilizing the ultra-high-speed and high capacity of 5G. In FY2017, 28 GHz reception characteristics at spectator seats in a stadium were studied, and multiplexed high-resolution video distribution tests were conducted.

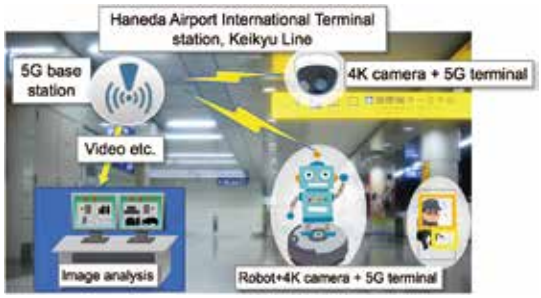
Figure 1: Stadium application concept



(2) Train station

To ensure much greater safety and security in train stations, a system is being studied, which transmits 4K or other high definition video using 5G features, processes it with an image analysis application to detect dangerous articles or behavior that needs attention, and deals with it quickly and effectively. In FY2017, preliminary studies and evaluation were done on the basic performance of an image analysis application for high-definition video (2K and 4K class).

Figure 2: Train station application concept



(3) School

Use cases requiring the high-speed and high-capacity of 5G are being studied as applications that can stimulate classroom activity in an elementary school, such as simultaneously accessing high-volume content using multiple terminals. In FY2017, preliminary studies and evaluations were done, examining the performance of simultaneous access to high-volume content using existing 4G networks.

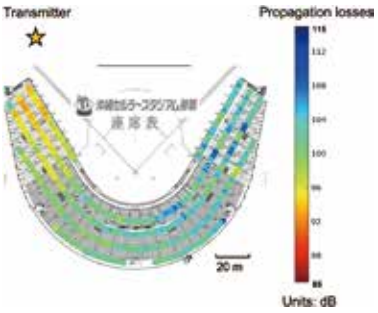
■ Figure 3: School application concept

4. Test results

(1) Stadium

The reception characteristics in the spectator seating at Okinawa Cellular Stadium were studied when transmitting in the 28 GHz band from the lighting tower near the third-base side. 28 GHz band propagation losses at spectator seats in the stadium were measured as shown in Figure 4, generally demonstrating good reception conditions.

■ Figure 4: Map of propagation losses in the stadium



Then, antennas transmitting 28 GHz band 5G signals were mounted on the third-base side lighting tower (Figure 5), and 25 5G terminals each were positioned in the spectator seats on both the first-base and third-base sides. High-definition video (2K and 4K class video) was distributed simultaneously from the transmitter, and all 50 5G terminals were able to receive the video normally (Figure 6).

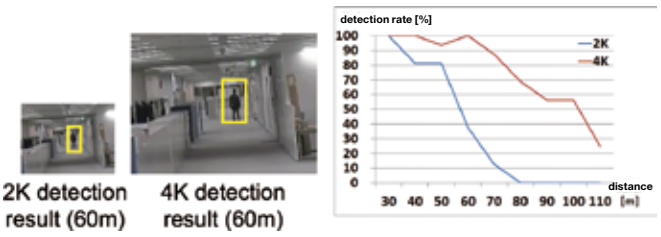
■ Figure 5: View of stadium and transmitter antenna location

■ Figure 6: High definition video reception tests using 5G terminals

(2) Train station

In FY2017, the basic system for an application to detect people by analyzing 2K and 4K-class high-definition video was built and evaluated. The evaluations compared performance in detecting people when using 2K class and 4K class video. As shown in Figure 7, people could be detected at approximately twice the distance when analyzing 4K class video, relative to 2K class video, demonstrating the utility of high-speed 5G transmission and its ability to transmit 4K class high-definition video.

■ Figure 7: Detection performance of high-resolution image analysis application



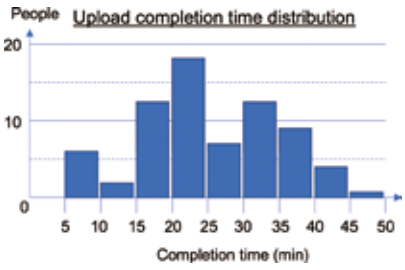
(3) School

In FY2017, to study the requirements for accessing high-volume content simultaneously from many terminals in an elementary school, we evaluated the performance of tasks such as simultaneously uploading large content using multiple 4G terminals.

■ Figure 8: Performance evaluation system using 4G

In the performance tests, two classes of grade four students (36 children/class) uploaded video and watched streaming video all at once. As shown in Figure 9, up to 45 minutes was needed to upload a video. In separate discussion with the elementary school teachers, they stated that ability to upload videos within one minute during class would be desirable, so there is a clear need for the high-speed, high-capacity transmission capabilities of 5G.

■ Figure 9: Distribution of time required for video upload (using 4G)



5. Conclusion

This article describes performance evaluation tests conducted in FY2017 using applications anticipated to utilize the ultra-high-speed characteristics of 5G in the 28 GHz band, for indoor and enclosed environments. We plan to conduct further tests with 5G in train stations and schools in the future.

Acknowledgements

These tests were conducted through a technical examination service by MIC in FY2017 called "Contract of a service to study technical requirements for 5th generation mobile communication over 10 Gbps in indoor environments"

References

[1]MIC, "5G Integration Testing Begins", http://www.soumu.go.jp/menu_news/s-news/01kiban14_02000297.html, May 2017.

[2]Okumura et al., "System Trials toward Actualization of 5th Generation Mobile Communication System 5G," MWE2017 Draft proceedings, 2017

[3]Yamada et al., "Trials of 5th Generation Mobile Communication Systems in Indoor Environments", Proc. IEICE 2018 General Conference.

5G Overall System Trial

— *An application of 5G Ultra-Low-Latency Communication to Truck Platooning* —

Hitoshi Yoshino
Advanced Technology Research Department
SoftBank Corporation

Ryo Yamaguchi
Advanced Technology Research Department
SoftBank Corporation

Manabu Mikami
Advanced Technology Research Department
SoftBank Corporation

1. Introduction

Research and development is underway toward the commercialization of 5th generation mobile communication systems (5G) in 2020. In addition to extending the capabilities of 4G networks with enhanced Mobile Broadband (eMBB), 5G will provide capabilities in the new domains of Ultra Reliable and Low Latency Communication (URLLC) and massive Machine Type Communication (m-MTC), and is highly anticipated as social infrastructure for our advanced information society. URLLC and m-MTC in particular have potential for developing new markets, and establishing concrete 5G applications for these is an urgent matter.

The Ministry of Internal Affairs and Communications (MIC) began 5G system trials in Japan in FY2017[1]. These trials request evaluation of 5G wireless system technologies for commercial use, as well as trials of 5G in collaboration with other vertical sectors, meaning use of 5G in sectors other than mobile communications.

The trials discussed here belong to the 5G URLLC test group (Group V, or GV) led by SoftBank, and deal with a use case applying 5G to truck platooning. This article reports on these activities in GV.

2. Application of 5G to truck platooning

Truck platooning involves multiple trucks driving together in a convoy. The truck platoon is controlled as a unit by using inter-vehicle communication. Development to implement truck platooning is currently underway in several countries around the world.

Several social issues can be resolved through use of truck platooning. Platooning can enable trucks to drive closer together to reduce wind resistance, which can reduce fuel consumption and reduce CO2 emissions. It has been shown that a platoon of three trucks travelling 4 m apart at 80 km/h consume 15% less fuel[2]. If the distance between trucks is reduced to 2 m, the fuel consumption would be reduced by 25%. Reducing the distance between vehicles can also increase the traffic capacity of roads, mitigating congestion. This could further reduce CO2 emissions. In Japan, an aging driver population and driver overwork are also social issues, so truck platooning can reduce the burden on drivers and increase safety.

Adaptive Cruise Control (ACC) measures the distance between a lead vehicle and following vehicle using radar or other technology and maintains a safe separation between vehicles according to their cruising speed. ACC has been implemented and many vehicles are already equipped with it. However, when controlling based only on the measured distance between vehicles, there is a significant delay between when the lead truck begins to slow down and when the following distance changes. There is further delay until the following truck begins to slow down. For this reason, if only ACC is used, a longer following distance must be maintained to prevent collisions.

On the other hand, Cooperative ACC (CACC) controls speed based on speed and acceleration information sent from the lead truck to the following truck by inter-vehicle communication, which can greatly improve control of the following distance when the lead truck needs to brake suddenly. This also enables stable operation with less fluctuation in following distance (hunting oscillation) due to control delay. Fuel consumption can be further reduced and traffic capacity of roads increased while maintaining safety by further reducing the following distance and increasing the number of platooned trucks, so using 5G URLLC, which realizes low latency and high reliability, in this field is very promising.

3. Trial description

In the GV trials, the ultra-low latency radio capabilities of 5G were used in the transport field for two use cases: (1) Communication between vehicles involved in platooning, and (2) Remote monitoring and operation of the entire truck platoon. These use cases are shown in Figures 1 and 2.

There are two main communication requirements for these use cases. The first is low-volume, low-latency communication needed for the vehicle control systems (speed, acceleration, vehicle positions, etc.). The other is high-volume, low latency communication needed for the video monitoring system, to monitor the whole platoon (monitoring the truck surroundings, etc.). The former must also be highly reliable.

Figure 3 shows the forms of communication for platooning, including (1) Vehicle-to-Network-to-Vehicle communication (V2N2V), (2) direct vehicle-to-vehicle communication (V2V Direct, Sidelink), and (3) vehicle-to-network communication (V2N). Communication with (1) above is between vehicles through a base station, and can provide relatively stable and low-latency communication with the help of the base station. With

Figure 1: Use case 1: Inter-vehicle communication for truck platooning (Vehicle control and video monitoring around following truck)

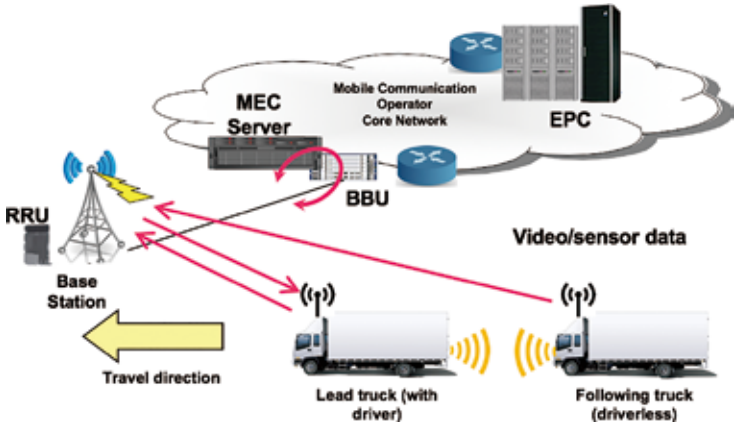
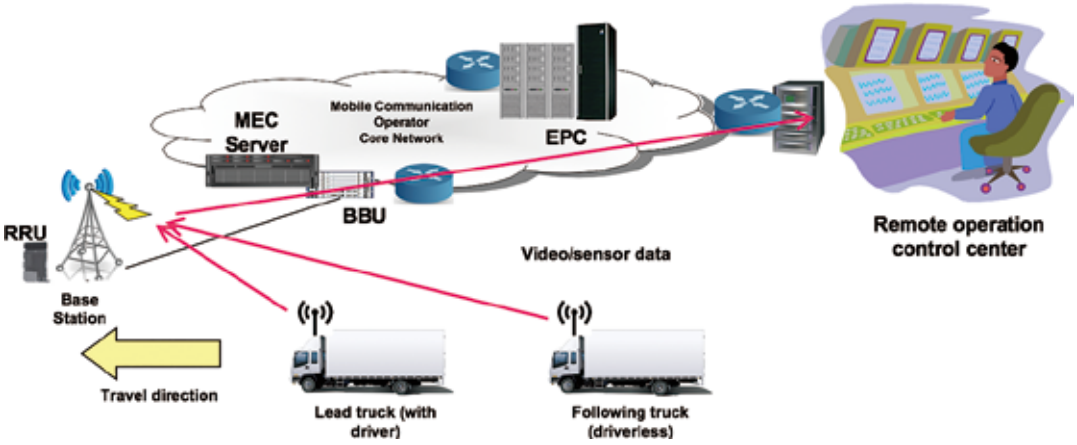


Figure 2: Use case 2: Remote monitoring, remote operation(Communication between platooned trucks and remote operation control center)



(2), there is a possibility that signals become blocked by other vehicles coming between the platooned trucks, so it could become less reliable than (1), but it can achieve lower latency than (1). With (3), delays within the network dominate vehicle-to-network communication, but it is needed for remote monitoring and operation of the vehicles.

In FY2017, application of 5G communication to self-driving of following trucks in a platoon is being studied, so the basic performance of communication necessary for vehicle control and video monitoring of the surroundings of following truck was evaluated. Specifically, the communication types (1) and (2) above were tested. The specifications of test equipment are shown in Table 1.

4. Trial results

A truck platoon driving environment using large trucks was set up on the Tsukuba City test course to evaluate 5G communications equipment (Figure 4).

(1) Latency characteristics

The latency characteristics of 5G communication equipment were measured in tests, with consideration for use in vehicle control for platoon driving. The 4.7 GHz band was used in the tests, and the evaluation was done in a test environment with vehicle-to-vehicle communication via base station. The tests were done assuming truck speeds up to 90 km/h. An example of over-the-air latency measurement is shown in Figure 5. It shows that at a speed of 87 km/h, the transmission delay on the air was 0.58 ms.

(2) Throughput characteristics

While platoon driving, the surroundings of the following vehicles must be monitored at the lead truck for safety. The feasibility of low-latency, high-volume communication for video monitor-

Table 1: Test equipment specifications

No.	Item	4.7 GHz band equipment	28 GHz band equipment
1.	Center frequency	4.74 GHz	27.9 GHz
2.	Bandwidth	100 MHz	700 MHz
3.	Duplex scheme	TDD	
4.	Radio access scheme	Downlink: OFDMA, Uplink: OFDMA	
5.	Subcarrier interval	60 kHz	120 kHz
6.	Radio subframe length	0.125 ms	
7.	Data modulation schemes	Downlink: QPSK, 16QAM, 64QAM, 256QAM Uplink: QPSK, 16QAM, 64QAM	
8.	Transceiver antenna configuration	Base station: 64Tx/64Rx Mobile terminal: 4Tx/8Rx	Base station: 4Tx/4Rx Mobile terminal: 2Tx/4Rx

Figure 3: Forms of communication for platooning

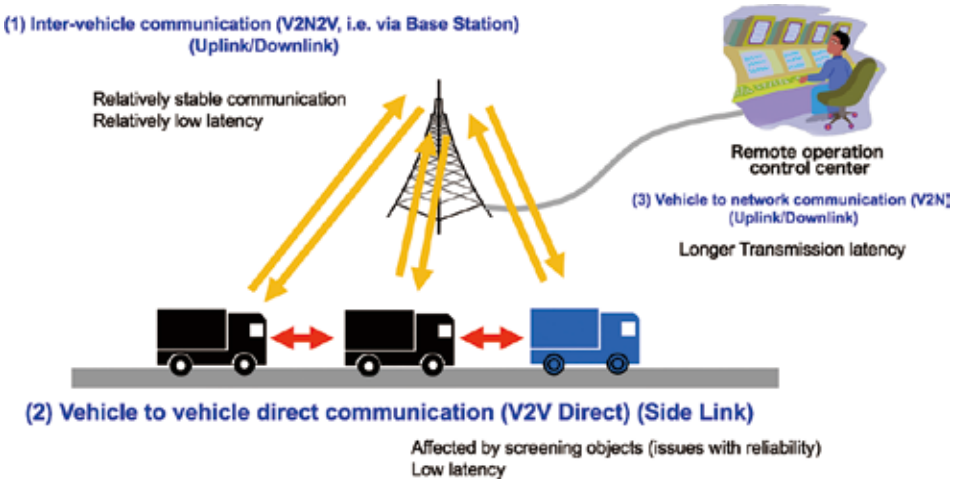
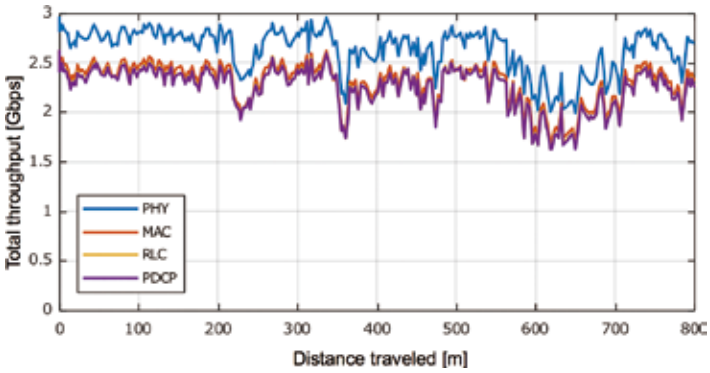


Figure 4: Real truck platooning test

Figure 5: V2N low latency communication performance assuming vehicle remote monitoring and control (4.7 GHz band)

Figure 6: Throughput characteristics (28 GHz band)



ing was tested. The test environment involved vehicle-to-vehicle direct communication with vehicles separated by approximately 10 m. The 28 GHz band was used to ensure wide bandwidth. Figure 6 shows the relationship between distance traveled and throughput. The figure shows that throughput of approximately 2 Gbps was achieved. This shows that video transmission is possible without increasing the delay due to video encoding, thanks to such high throughput.

5. Conclusion

We conducted basic performance evaluations applying 5G to truck platooning on a real test course. We studied two cases of communication: low-volume, low-latency communication needed for platooning (for truck control), and high-volume, low-latency communication (for monitoring the following vehicles). The test results confirmed that the communication requirements for advanced truck platooning were met.

In the future, we will conduct integration testing for a platooning control system as well as testing to ensure reliability.

References
[1] Ministry of Internal Affairs and Communications, "5G System Trial Begin," Press Release, http://www.soumu.go.jp/menu_news/s-news/01kiban14_02000297.html, May 2017.
[2] K. Aoki, "Current Activities of Development on the Automated Truck Platoon," pp.303-309, IPSJ Journal, Vol.54 No.4, Apr. 2013.

Demonstration of Disaster-proof Warehouse and Smart Office Applications Using the Multiple Simultaneous Connectivity of 5G

Kentaro Ishizu, Homare Murakami, Hirokazu Sawada, Kazuo Ibuka, Takashi Matsuda, Fumihide Kojima
Wireless Networks Research Center,
National Institute of Information and Communications Technology

1. Introduction

One of the advantages of the 5th generation (5G) mobile communication system is the ability to achieve a significantly larger number of simultaneous connections. In the IoT (Internet of Things) era, the number of mobile connected things will increase and all sorts of things will be connected to the Internet. Mobile communication systems will therefore have to provide a social infrastructure that achieves larger numbers of simultaneous connections.

It is expected that the simultaneous connection capabilities of 5G will allow it to accommodate a million terminals per square kilometer[1]. This goal needs to be evaluated together with realistic assumed applications in order to clarify the usage scenarios that can be implemented with 5G. Therefore, in this article we report on the results of demonstrations based on two different use cases: the use of 5G in disaster-proof warehouses during disaster situations, and the use of 5G in smart offices to support future working styles [2].

2. Disaster-proof warehouse use case

In a disaster, it is important to manage very large numbers of resources and ascertain the circumstances of many people. The purpose of a disaster-proof warehouse is to stockpile reserves in normal situations so they can be used or consumed in the event of an emergency. However, considering the circumstances that arose during disasters in recent years, it can be seen that it was not possible to accurately ascertain the positions of warehouses with a surplus of goods and warehouses where problems had arisen due to

Figure 1: Demonstration of a disaster-proof warehouse use case

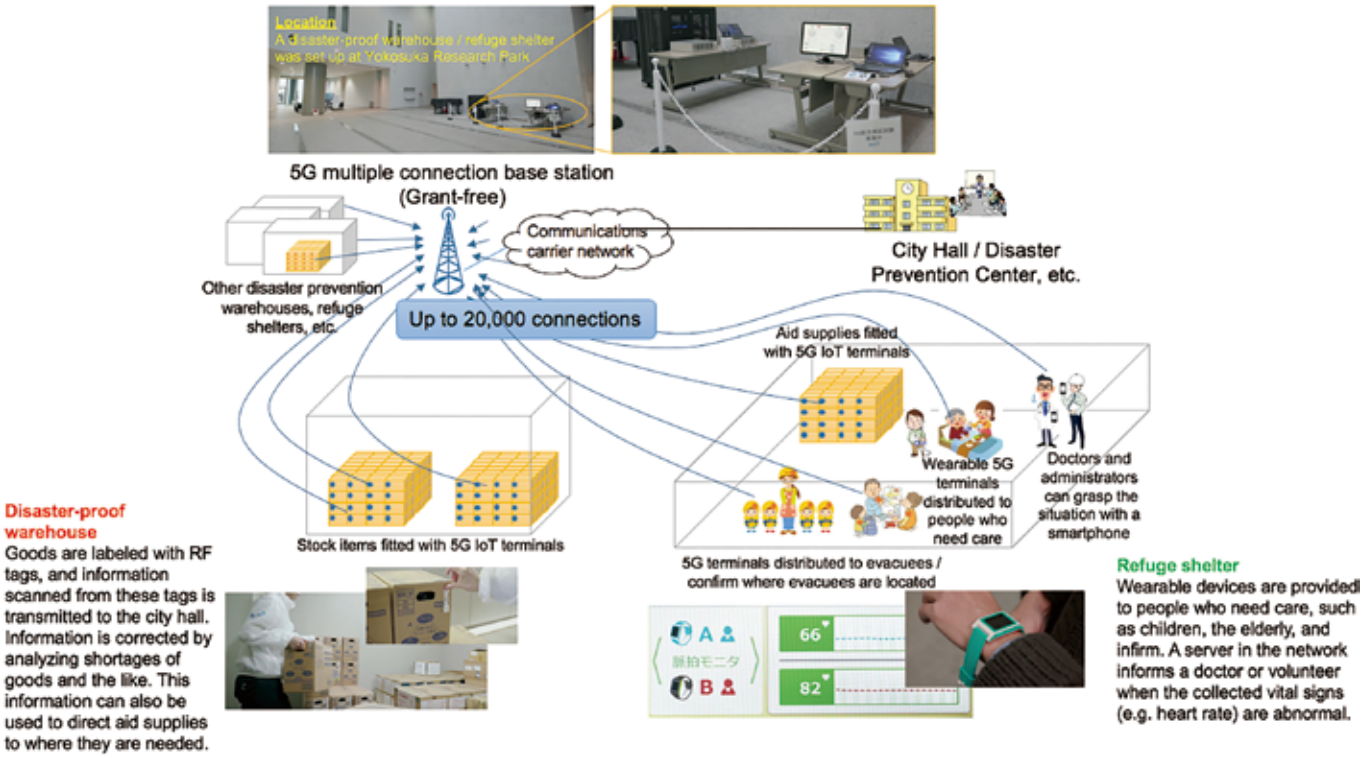


Figure 2: Demonstration of a smart office use case

shortages. In addition, it may be unrealistic to expect that accurate warehouse records will continue to be kept when accepting and dispensing aid during an emergency. Efforts are therefore being made to implement a system whereby goods are labeled with RF tags that can be scanned to generate information that is sent via 5G to a city hall or the like, where it can be centrally analyzed to identify shortages and ensure that aid supplies are directed to where they are most needed. Furthermore, wearable devices that can measure the wearer's position and vital signs would be provided to people who need particular care, such as children, the elderly and infirm. This information can be collected via 5G and used to request the assistance of doctors or volunteers when abnormal values are detected (Figure 1).

The wireless communication needed to implement this system is realized using a Grant-Free system that is being studied for 5G [3,4]. In conventional communication systems like LTE, a communication channel must be established before any data communication starts. This process places a heavy load on the communication system, and gives rise to limitations on the number of terminals that can be connected. However, in the Grant-Free system, data can be transmitted straight away without having to set up a communication channel. This system is suitable for situations where small quantities of data such as sensor outputs are sporadically transmitted from large numbers of terminals. For this demonstration, we developed a prototype device that implements this method. We also developed a test device capable of simulating 20,000 terminals and generating wireless communication connections in the same way. By combining these devices, we constructed a demonstration environment where up to 20,000 terminals are transmitting signals in the Grant-Free system while transmitting information from wearable devices to a base station.

For this demonstration, we used a wireless system with a bandwidth of 10 MHz, with each terminal transmitting information at five second intervals. The base station regards a terminal as having communicated successfully if it receives information within ten seconds. The results of this test confirmed that the 5G system is capable of receiving data from all 20,000 terminals in 70 seconds when the terminals are set up to transmit data every 5 seconds. We also confirmed that in an environment with 20,000 wireless terminals, it is still possible for the server management screen to produce a graphical display of stock tag information and pulse information from wearable terminals.

3. Smart office use case

In the future it is expected flexible work patterns will become more commonplace, increasing the demand for office environments that are customized to individual needs. People also expect to have greater opportunities to work efficiently in remote businesses anywhere using a nearby shared office. We will therefore implement smart office environments by developing office tools that combine not only the multiple simultaneous connection capabilities of 5G, but also other desirable performance attributes such as ultra-high speed and ultra-low latency (Figure 2).

As examples of tools, the smart table incorporates a planar

antenna in the desktop for near-field communication, and is connected to a base station operating in the 3.7 GHz band. For this demonstration, we used an LTE base station with a bandwidth of 20 MHz, and we aimed to conduct an evaluation in terms of the system configuration and radio wave interference. This planar antenna only allows terminals to communicate when they are on the desk, and suppresses radio wave interference to the space further away from the desktop surface. Therefore, even if there are several smart tables installed in the same conference room, they can use radio waves of the same frequency band without causing interference between desks. This facilitates effective use of frequency resources, and makes it possible to achieve a large overall network communication capacity. Video from an omnidirectional camera and audio from a microphone capable of estimating direction of audio sources are communicated by smart tables to a server, which automatically creates the minutes of the meeting by recognizing what is being said and by who. In addition, when the system estimates that the discussion has stalled (e.g., at a break in the conversation), the system searches for current news relating to keywords extracted from the most recent spoken content, and displays it on a large-sized wall-mounted display to contribute ideas for brainstorming.

The smart chair has six pressure sensors on the seat and back panel. Information from these sensors is transmitted to the server via multiple simultaneous connections so that the posture of the person sitting on the chair can be identified (e.g., leaning forward, leaning back, or shifted to one side). In the future, by gathering information from every chair in the room, the system could recommend breaks or control the air conditioning to prevent fatigue and drowsiness among the conference participants. In this demonstration, these chair pressure sensors are powered entirely by photovoltaic panels installed on the rear side, so there is no need to replace batteries. Other forms of chair sensor that are being developed can detect a person's heart rate and/or breathing when a person simply sits down, and in the future this can be expected to be used for health management and fine-grained control of the office environment. Since the 5G wireless system for chairs is still on the drawing board, we used existing Bluetooth Low Energy equipment for connections of wireless sensors.

The electronic whiteboard uses ultra-low latency communication in the 28 GHz band to provide a real-time display that updates in synchronization with other whiteboards at remote locations. Most current videoconferencing systems share only video and audio signals, but by also sharing the pen strokes drawn on a whiteboard in real time, it is possible to share the same whiteboard between multiple conference rooms, resulting in greater work efficiency and smoother discussions. Here, the writing on the electronic whiteboard from multiple locations is managed by a 5G edge server directly connected to the base station. This not only reduces the radio access latency, but can also reduce the latency in higher layers.

4. Summary

We have presented the results of a demonstration to examine the performance of 5G simultaneous multiple connections in two usage scenarios. This demonstration confirmed that it is possible to improve the terminal connectivity required in disaster situations, and to develop a new office environment. The function and performance of 5G are being strongly led from the viewpoint of services, and we hope that the results of this verification will be useful for future 5G applications and 3GPP standard reviews. In addition, we are studying methods for distributed micro-cell technologies in mobile communication systems [5], and we expect this can be effectively applied to smart offices where there is limited communication range.

Acknowledgments

This study was commissioned by the Ministry of Internal Affairs and Communications as part of an initiative to investigate the technical criteria of 5th generation mobile communication systems where 20,000 devices at a single venue can communicate simultaneously (FY2017). The disaster-proof warehouse demonstration was performed jointly with Softbank Corporation and Abit Corporation, and the smart office demonstration was performed jointly with Itoki Corporation and Sharp Corporation.

References

[1] Recommendation ITU-R M.2083-0, "IMT Vision — Framework and overall objectives of the future development of IMT for 2020 and beyond," Sep. 2015.
[2] NICT press release, "Simultaneous connection of 20,000 terminals confirmed in 5G verification test — Demonstration of effectiveness in disaster-proof warehouse and smart office use cases", March 2018. http://www.nict.go.jp/press/2018/03/29-1.html.
[3] 3GPP R1-166403,"Grant-free Multiple Access Schemes for mMTC".
[4] 3GPP R1-1609398,"Uplink grant-free access for 5G mMTC".
[5] Ishizu et al., "A study of base station sharing methods for 5th generation mobile communication systems", IEICE Technical Reports, Vol. 117, no. 246, RCS2017-182, pp. 81–86, October 2017.

Cover Art

Onoe Kikugoro (Picture of kabuki actor Onoe Kikugoro III. It is said that he is playing the role of Ushiwakamaru (1838).)

Utagawa Kunisada (1786–1865)

Collection of the Art Research Center (ARC)
Ritsumeikan University
Object number: arcUY0215

Smoothing the Transition from the Fixed Telephone Network to the IP Network

Takayoshi Kagei
Deputy Director
Telecommunications Policy Division, Telecommunications Business Department
Telecommunications Bureau, Ministry of Internal Affairs and Communication

1. Introduction

In November 2015, due to declining numbers of subscriber telephone contracts and the expectation that transit exchanges and other such systems will reach their maintenance limits in or around 2025, we announced our intention to migrate from a public switched telephone network (PSTN[*1]) to an IP network. Under NTT's vision:

- The core network (relay network) parts will be migrated to IP networks (NGN[*2]) operated by NTT East and NTT West.
- The access lines leading to user premises will continue to use existing metal lines after the transition to IP networks, and existing subscriber exchange equipment will be used as access points for metal lines.
- While allowing users to continue using their existing phones, we will also put forward the idea of providing new metal IP phones.

Since the fixed communication networks of NTT East and NTT West form Japan's basic communication infrastructure, we are obliged to follow the various systems currently prescribed by the Telecommunications Business Act. For this reason, we consulted with the Information and Communications Council in February 2016 on the subject of how to achieve a smooth transition in fixed telephone networks. Following this consultation, discussions were held at the Smooth Telephone Network Transition Committee[*3] across a wide range of issues while conducting interviews with service providers and related organizations. This committee compiled two reports, which were published in March 2017 ("The post-transition IP network") and September 2017 ("Planning for a smooth transition").

Based on these council reports, the Ministry of Internal Affairs and Communications is developing a system to realize a smooth transition to the IP network of the fixed telephone network.

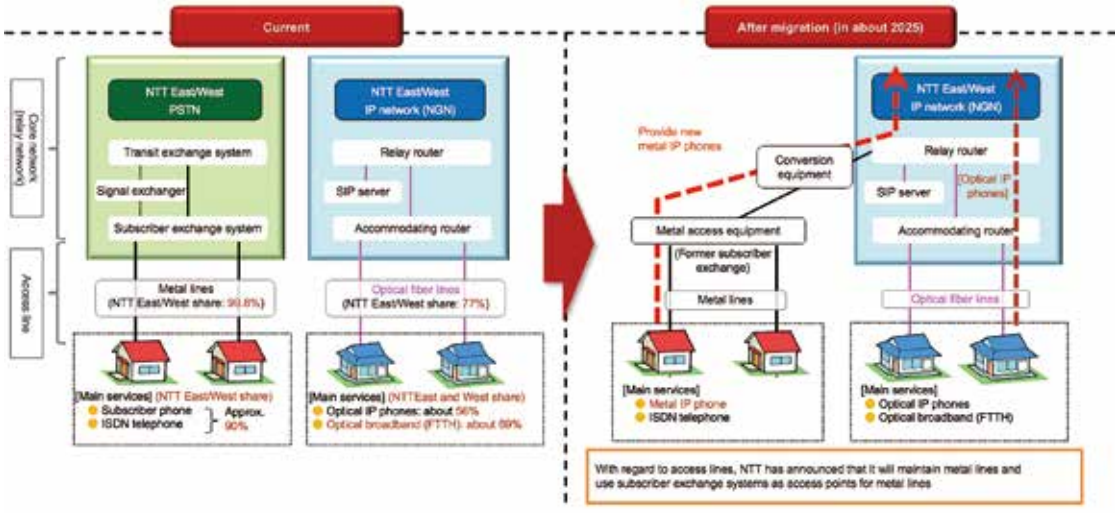
This article presents an overview of the main points of these reports and the systems and facilities that will be affected, with a particular focus on efforts related to the migration of facilities.

2. Key points of the Information and Communications Council report

2.1 Basic philosophy concerning fixed telephones

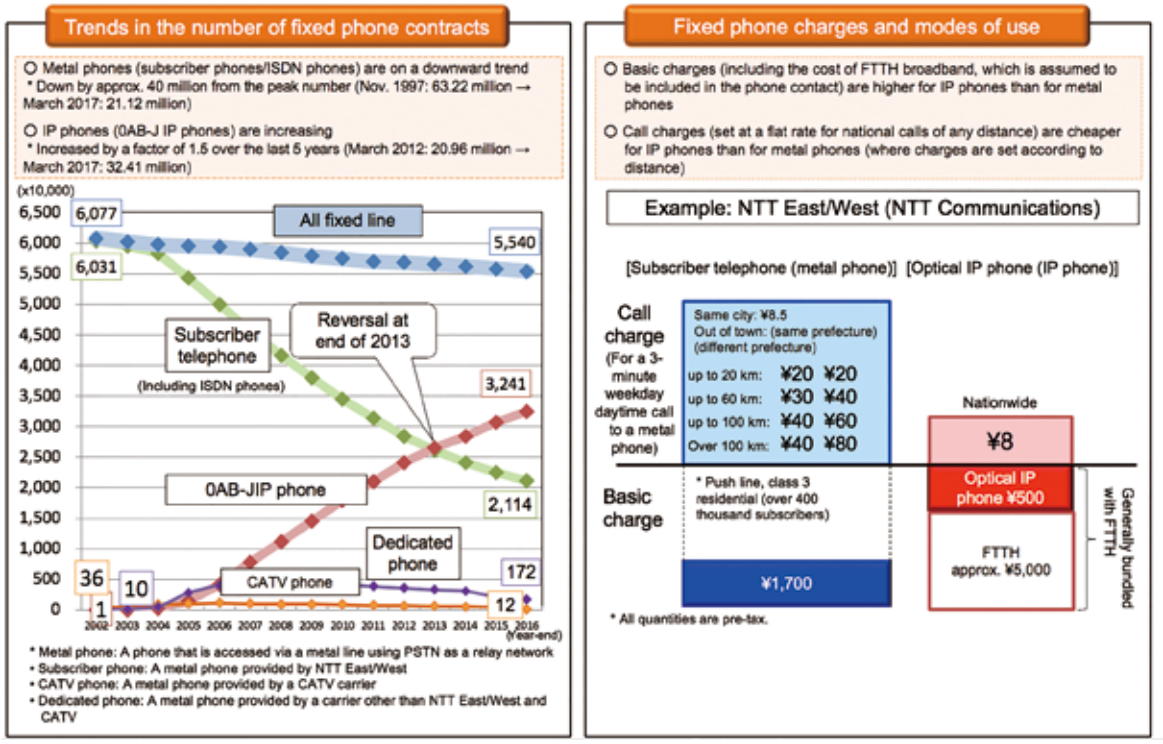
In recent years, the number of metal phone (subscriber phone and ISDN) subscribers[*4] has been on a downward trend, but if

Figure 1: Transition of fixed telephone network to IP network



*1: Public Switched Telephone Network.
*2: Next Generation Network.
*3: The committee is chaired by professor Hirotaka Yamauchi of the Graduate School of Commerce at Hitotsubashi University. This committee set up two working groups — one to study telephone connection functions (headed by Professor Hitoshi Aida of the University of Tokyo Graduate School of Engineering), and another to study user protection (headed by Yoshinori Sakai Professor Emeritus of Tokyo Institute of Technology and Associate Professor at the Open University of Japan) — and also conducted technical and special investigations.
*4: Number of subscriber phone contracts (including ISDN): 21.14 million (as of March 2017).

Figure 2: Current status of fixed telephones (number of contracts and charges)



these are added to the growing number of IP phone (0AB–J IP phone) subscribers,[*5] then the total number of fixed telephone subscribers in Japan is still over 55 million.

Today, a wide variety of means of communication are in an advanced state of use, including mobile phones and broadband. However, the fixed telephone network is available in every part of the country and provides a basic means of communication to people's homes, businesses, public buildings and the like, and therefore plays an important role as part of the essential infrastructure of social and economic activity. This important role will remain unchanged even after migrating to an IP network.

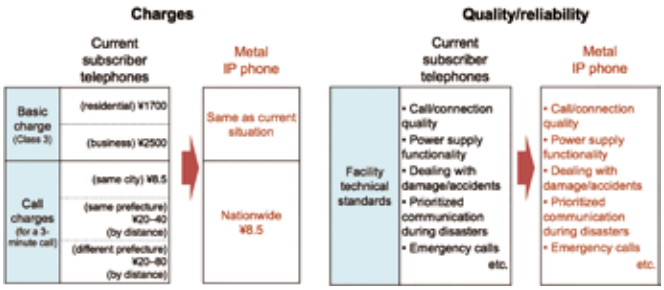
Furthermore, once fixed telephone services have transitioned over to an IP network, it will be possible to charge a low tariff[*6] for calls of any distance within Japan while ensuring that the communication quality is at least as good as what is currently available, and it is expected that a range of new services will also be made available to users by exploiting the characteristics of IP networks such as their ability to perform data communication as well as voice communication.

Based on this idea, NTT East and NTT West will start offering metal IP phones instead of ordinary metal phones. Like existing subscriber telephones, these metal IP phones are expected to provide a universal service, and we should aim to maintain the same standards of quality and reliability that people expect of existing metal phones.

2.2 Ensuring the quality and reliability of fixed telephones

Under the current system, communications carriers are obliged

Figure 3: Metal IP phone charges and quality/reliability



to ensure their facilities comply with technical standards so that users can be provided with reliable and stable telecommunications services.

With the transition from PSTN to an IP network, NTT East and NTT West will provide new metal IP phones by incorporating metal lines into NGN as well as optical lines, and the telephone networks of each communications carrier will be reconfigured so that their respective IP networks will be interconnected (IP-IP connection) without passing through the NTT East/West exchange system.

To adapt to these changes, we must ensure that the IP network is able to provide lifelines in emergency situations and a reliable and stable supply of fixed telephones to support everyday social and economic activities. It is therefore necessary to draw up technical standards for communication equipment to ensure that it can provide the same standard of quality and reliability as the existing telephone network.

*5: Number of 0AB–J IP phone contracts: 32.41 million (as of March 2017).
*6: NTT has announced plans for a flat rate of ¥8.5 per 3 minutes for metal IP phone calls to anywhere in Japan after the IP network transition. Currently, three-minute daytime calls to subscriber phones in NTT East and NTT West are charged according to distance: ¥8.5 for calls in the same city, ¥20–40 for calls in the same prefecture, and ¥20–80 for calls to a different prefecture.

2.3 Ensuring the ability of phones to connect

In the existing PSTN, the NTT East/West exchange system serves as a hub that connects between the telephone networks of each communications carrier at points of interface (POIs) in each of Japan's administrative divisions.

With the IP network transition, the NTT East/West exchange system will be abolished, the POIs will be consolidated, and in principle every communications carrier in Japan will establish IP-IP connections with either of two "connecting POIs", one in Tokyo and the other in Osaka. It has been confirmed that they will be allowed to share communication facilities (routers and SIP servers), which will require the implementation of new call connection functions.

It is expected that the connecting POIs used for IP-IP connections between communications carriers will have dual support for connections via L2 switches[*7] and without L2 switches (using a patch panel[*8] instead).

In addition to sorting out the role of these phone connection functions, their connection rules and technical standards, we are arranging a scheme[*9] whereby NTT East/West will maintain, manage and operate the communication facilities and L2 switches used by communications carriers inside connecting POI buildings.

2.4 Ensuring emergency call capabilities

Currently, in emergency calls, the PSTN line hold function ensures that calls from metal lines are held unless the emergency service disconnects, even if the caller drops the handset. On the other hand, a callback from the emergency service is required when reporting from a mobile phone.

Since it will be difficult to implement a line hold function after the IP network transition, NTT has proposed replacing it with a callback function. However, the emergency services have raised issues with the speed and reliability of existing callback functions, so NTT must adequately demonstrate how functions equivalent to those of current systems can be offered, or provide suitable alternatives.

To address this situation, the Smooth Telephone Network Transition Committee interviewed representatives from emergency services and business operators including NTT, and examined the functions of emergency calls after the IP network

Figure 4: Phone network configuration after the IP network transition

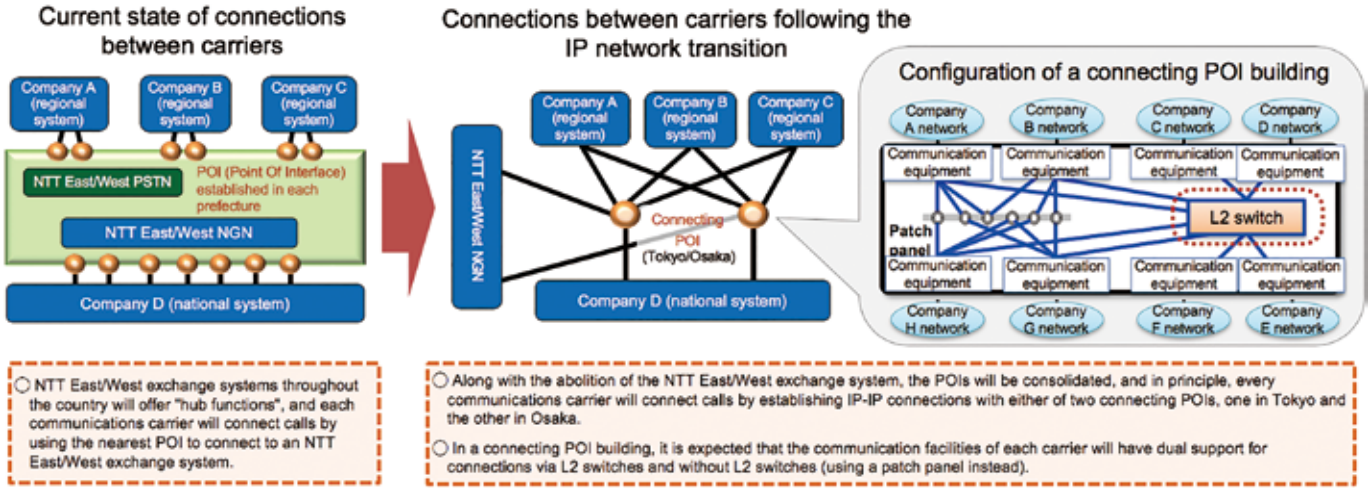
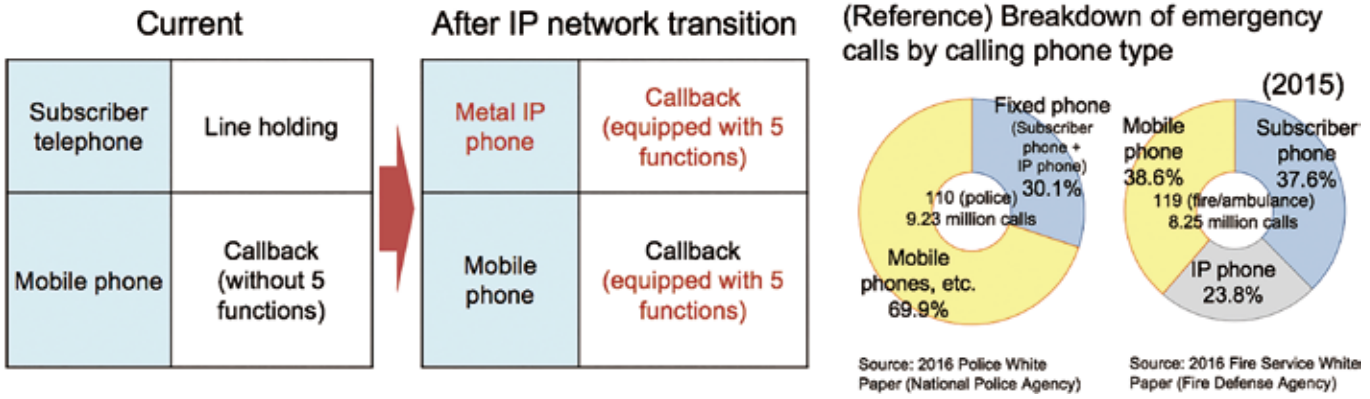


Figure 5: Emergency call functions compatible with the IP network transition



*7: A type of device that relays data on a network. Specifically, a switch that acts as a relay by forwarding packets to other relays based on the MAC addresses in the packet headers. (Called a Layer 2 switch because MAC addresses are handled by the second layer (data link layer) of the OSI reference model.)
*8: A panel used for accommodating and connecting a group of communication lines. Capable of selecting signal paths easily without using dedicated switching equipment.
*9: For L2 switches inside connecting POI buildings, communications carriers (consortiums) that want to use them enter into an IRU (indefeasible right of use) contract with NTT East/West, and NTT East/West maintains, manages and operates the L2 switches.

transition. As a result, it was concluded that the alternative functions for line holding should have the following properties:

- To facilitate callbacks from the emergency services to callers, it is realistic and rational to implement five functions: (a) emergency service number notification,[*10] (b) cancellation of call transfers,[*11] (c) cancellation of call barring,[*12] (d) restrictions on three-way calling,[*13] and (e) priority call handling in the event of a disaster.[*14]
- Based on the growing proportion of mobile phone usage in emergency calls, it makes sense to ensure that these five functions are also implemented for mobile phones.[*15]

2.5 How to manage the allocation of numbers to telecommunications lines

(1) Converting the number allocation mechanism for IP network migration (IP-IP connection)

In the current PSTN, when a telephone call is made to a number allocated to a user by NTT East/West, the call control signals from the caller's device (a metal telephone, optical IP phone, or mobile phone) must always be connected to the NTT East/West exchange system via the PSTN to provide a redirection mechanism whereby communication can take place with the call destination. However, this mechanism cannot deal with cases where connections between the telephone networks of each carrier are formed by IP-IP connections without involving the PSTN.

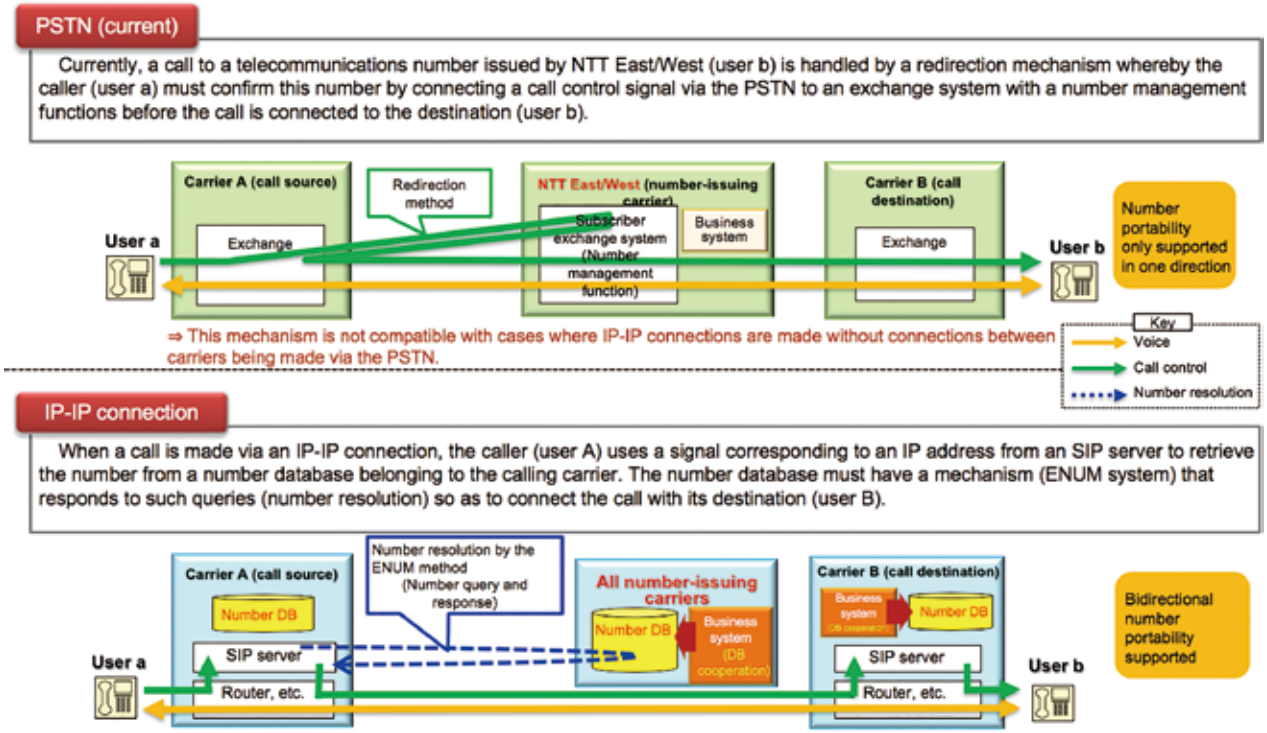
In an IP-IP connection, when a call is made to a number that all the carriers associate with a particular user, the calling equipment uses a signal corresponding to an IP address to retrieve the number from a number database belonging to the calling carrier. This number database must have a mechanism that performs a process called number resolution to connect the call with its destination (ENUM system[*16]).

For this reason, to support the phased introduction of IP-IP connections from January 2021, there is a need for the introduction of systems such as obliging all carriers that originate and/or receive calls to set up a proper number database for number management in IP-IP connections (including number resolution by the ENUM system).

(2) Providing bidirectional number portability for fixed phones

In the current fixed phone system, number portability (the ability to move telephone numbers) is only supported in "one way" when migrating from an NTT East/West metal phone to a fixed phone of another carrier by signing up for a new contract, and is not supported when migrating from an IP phone or from the fixed phone of another carrier besides NTT East/West.

Figure 6: Number management mechanism for IP-IP connections



*10: Japan's emergency services have so-called 1XY phone numbers (i.e., three digits starting with 1). This function reports the 1XY number of the corresponding emergency service back to the caller's phone.
*11: A function that cancels the forwarding of incoming calls to a caller's terminal, even if the caller is using a call forwarding function.
*12: A function that cancels the rejection of incoming calls to a caller's terminal, even if the caller is using a call barring function.
*13: A function that temporarily restricts calls between the caller and any third party other than the emergency service.
*14: Currently, calls to the emergency services are handled with higher priority in the event of a disaster, but this priority treatment is not extended to calls made by the emergency services back to the original callers.
*15: Since May 2017, with the aim of implementing these five functions in mobile phones, we have taken part in regular studies and discussions with a group of organizations including the emergency services (police, fire and coastguard), three mobile communication companies (NTT DOCOMO, KDI and Softbank), and the Ministry of Internal Affairs and Communications. A primary report detailing the results of these studies was reported to the Smooth Telephone Network Transition Committee on May 22, 2018.
*16: E.164 number mapping: a standard system that uses IP address query techniques to obtain information about the destinations to which phone numbers should be connected on the Internet.

The proportion of numbers in the fixed phone system (0AB–J) that cannot have number portability has been on an upward trend in recent years due to progress in the IP transition, and is currently at 16%.*17 This figure is expected to continue increasing in the future.

Following the IP network transition, all fixed-line users in the future will be using IP phones. For the convenience of these users, and in order to secure a competitive infrastructure for fixed phones, we plan to introduce bidirectional number portability by the end of the IP network transition (January 2025). This will require some systematic improvements.

(3) Ensuring fair and efficient use of number resources

Currently, the national allocation rate of mobile phone numbers starting with 090/080/070 and toll-free numbers starting with 0120 (i.e., the proportion of all numbers that have been made available) is in excess of 90%, and it is becoming difficult to deal with new allocation requests.

On the other hand, the actual number allocation rate of communications carriers (the proportion of available numbers that are currently in use) is about 70% for mobile phones and about 55% for toll-free numbers. At the national level, about 90% of available toll-free numbers have been assigned to a single carrier.

Under these circumstances, the current system allows carriers to voluntarily return numbers that have been allocated to them, regardless of whether or not these numbers are in use (voluntary notification). As a result, numbers that have remained unused for long periods of time are not being returned, leading to problems such as inability to manage or redistribute numbers flexibly.

To adapt to the different situation regarding number management brought about by the IP network transition (IP-IP connection), it will be necessary to set up systems for dealing with this shortage of numbers and the issues of unused numbers, and for implementing the fair and efficient usage and redistribution of finite and scarce number resources. These include:

- A mechanism for regularly confirming the state of use of telecommunications numbers and the discharge of obligations related to telecommunications numbers
- A mechanism that enables the disposal of numbers, such as the cancellation of telecommunications numbers that have been left unused for a certain period, or the cancellation of numbers when obligations relating to the handling of these numbers have not been not fulfilled

Figure 7: Current status of number portability in fixed phones

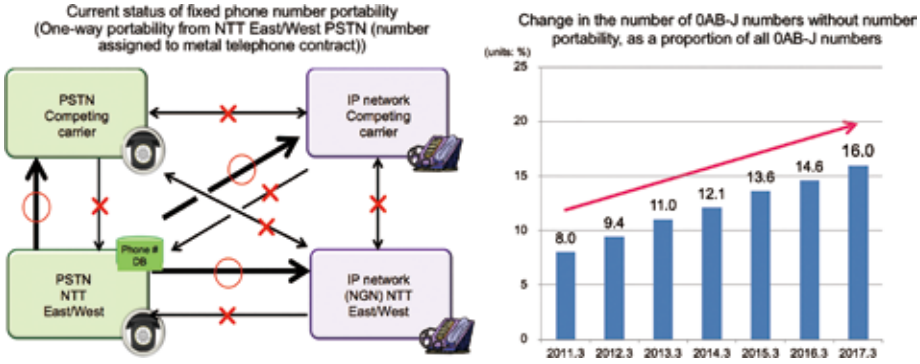


Figure 8: Principal forms of telecommunications number allocation and usage

Number	Use	No. of allocated carriers	Number capacity	Allocated	Allocation rate (number allocated/ number capacity)	In use	Usage rate (number in use/ allocation rate)
0AB-J	Fixed phones	23	419.92 million	238.33 million	56.8%*2	62.43 million	26.2%
090/080/070	Mobile phones/PHS	4	270 million	244.1 million	90.4%*3	171.7 million	70.3%
020	Exclusive numbers (M2M, etc.)	4	80 million	16.4 million	20.5%	0	0.0%
0204	Pagers	2	10 million	1.2 million	12.0%	20,000	1.9%
0600	FMC	0	10 million	0	0.0%	0	0.0%
050	IP phone	20	90 million	23.67 million	26.3%	9.43 million	39.8%
0120	Reverse charging (10 digits)	7	1million	990,000	99.2%	550,000	55.3%
0800	Reverse charging (11 digits)	7	10 million	3.03 million	30.3%	360,000	11.8%
0570	Unified number	3	1million	120,000	11.8%	10,000	11.7%

*1: As of the end of March 2017 (except 020 numbers, for which data was obtained at the end of May 2017)
*2: The area codes of fixed phones (0AB-J numbers) account for over 80% in 138 out of 582 regions nationwide (average rate: 18.6%)
*3: The allocation rate of mobile phones and PHS phones is 100% for 080/090 numbers, and 71.2% for 070 numbers.

2.6 Road map for facility migration

The migration from PSTN to IP networks is to proceed according to the following stages and schedule:

- Stage 1: Following preparatory work (development, verification, etc.) by communications carriers, establish a connecting POI building environment for IP-IP connections between carriers (by January 2021)
- Stage 2: Connect the subscriber exchange systems of NTT East/West to the IP network (NGN), and gradually implement IP-IP connections between optical IP phones and other carriers, and IP-IP connections between other carriers (from January 2021 to January 2024)
- Stage 3: Implement IP-IP connections between NTT East/West metal IP phones and other carriers (from January 2024 to the completion of transition in January 2025)

(Note: The migration of services from subscriber telephones to

*17: As of March 2017, there are currently 9.97 million fixed phone numbers that do not have number portability. This constitutes 16% of all phone numbers (62.43 million), a proportion that has been increasing in recent years.

Figure 9: Migration of facilities from PSTN to the IP network

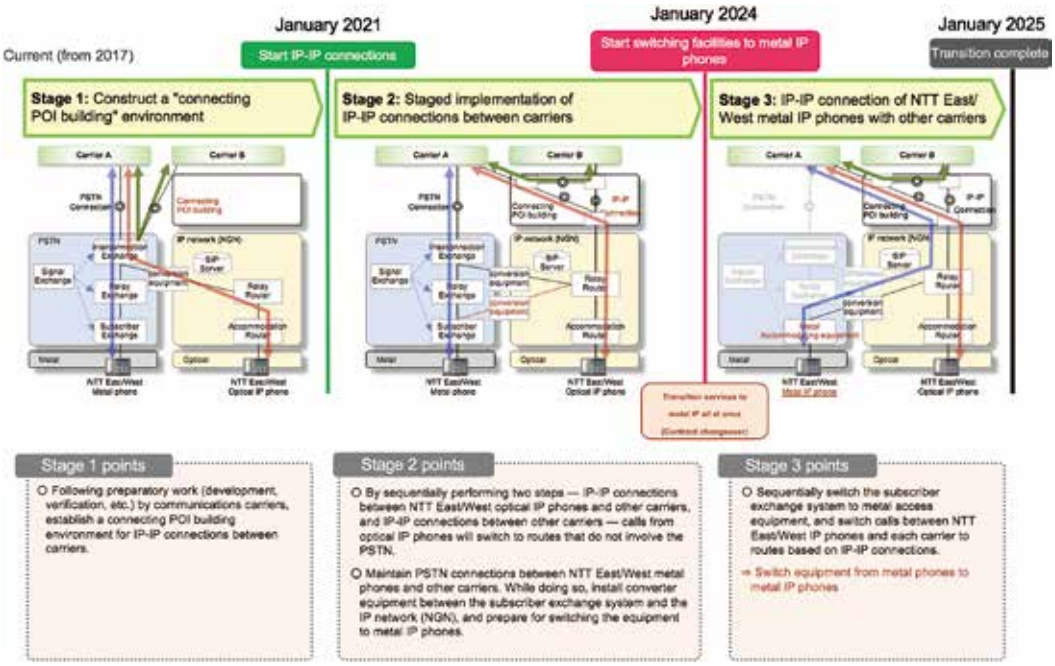
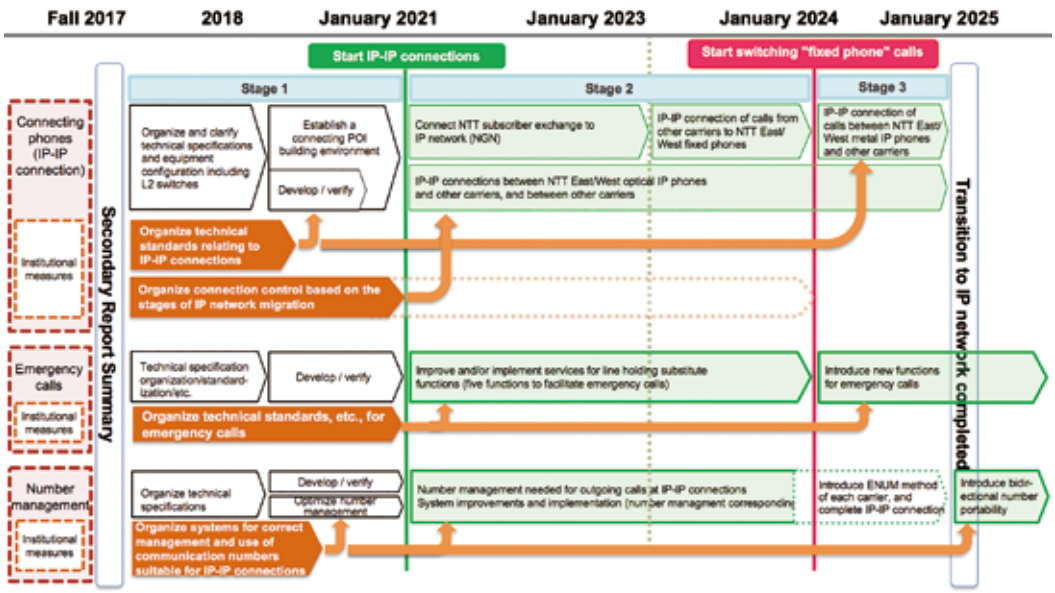


Figure 10: Facility migration road map



metal IP phones (with a simultaneous exchange of contracts) was conducted in January 2024)

To ensure that calls are handled properly during this transition process, it is necessary to establish a telecommunications number system and other such technical standards to ensure there is a functioning number management mechanism that is compatible with IP-IP connections.

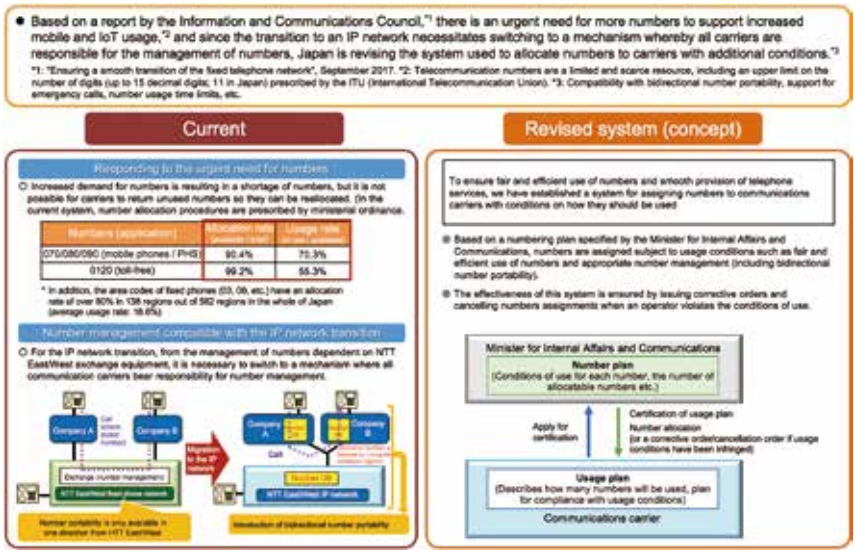
3. System revisions to promote the smooth migration of facilities (revision of the Telecommunications Business Act)

Based on a report by the Information and Communications Council, the Ministry of Internal Affairs and Communications has conducted a study of systematic measures. On March 6, 2018, a report on partial revision of the Telecommunications Business Act and the NICT Act was presented at the 186th Diet session, and was established in law on May 16th and promulgated on May 23rd of the same year.*18

According to this law, from the perspective of promoting a smooth migration of facilities from PSTN to the IP network, efforts are being made to switch to a mechanism where the responsibility for number management is borne by all carriers involved in the IP network transition, and to set up telecommunications number systems that address the urgent need for a larger pool of numbers to meet the needs of growth in the mobile and IoT sectors. The points that were changed in the

*18: The enforcement date of the Act is regarded as the day specified by a Cabinet Order within a period not exceeding one year from the date of promulgation.

Figure 11: Amendment of the Telecommunications Business Act (improvement of rules relating to telecommunication numbers)



revised items were as follows:

- The Minister for Internal Affairs and Communications shall draw up and publish a telecommunications number plan (hereinafter referred to as "number plan") including the contents of telecommunications duties to be provided for each type of telecommunications number, the conditions for using these numbers (handling important communications, supporting bidirectional number portability, expiration dates, etc.), and limits on how many numbers can be specified.
- Communications carriers who intend to use telecommunications numbers for the provision of telecommunications services must prepare a telecommunications number usage plan (hereinafter referred to as a "usage plan") and obtain certification from the Minister for Internal Affairs and Communications.
- The Minister for Internal Affairs and Communications shall examine the usage plans prepared by telecommunications carriers in terms of their suitability based on the number plan, etc., and shall allocate telecommunications numbers after approving the usage plan.*19
- Telecommunications carriers must use the telecommunications numbers designated by the Minister for Internal Affairs and Communications in accordance with the usage plan approved by the Minister for Internal Affairs and Communications. If a violation occurs and a communications carrier fails to comply with a compliance order from the Minister for Internal Affairs and Communications, this carrier's certification is liable to be revoked.

4. Conclusion

The NTT East/NTT West PSTN is a core communication infrastructure that acts as a hub to support phone calls and provides a competitive foundation for many businesses to develop their activities. Users and businesses will therefore be significantly affected by the form taken by the network after the IP network transition, and by the way in which this transition is achieved.

For this reason, prompted by the announcement of NTT's vision, we have spent about two and a half years actively engaged in concrete discussions and studies with business operators, enterprises and related organizations on a wide range of issues. The Ministry of Internal Affairs and Communications has also compiled a council report on how to implement the transition (together with a roadmap) based on about one and a half years of study, and has greatly accelerated the process by concentrating its efforts on achieving a smooth transition, including systematic improvements for greater effectiveness. Preparations for the migration of facilities (including development and verification) are now under way, and the actual transition process will start in 2021. This transition process and the efforts of related organizations will continue until we reach the milestones of service transition in 2024 and the completion of migration in 2025.

Now that we are approaching an important phase in the development of our communication infrastructure, we will continue to make every effort to support this initiative in our role as a policymaker. Above all, we would like to express our sincere gratitude for the great efforts and cooperation of everyone involved in this initiative.

(Source of figures)

- Figs. 1–10: Supplementary materials from reports by the Information and Communications Council ("Ensuring a smooth transition of the fixed telephone network", published March 28, 2017 and September 27, 2017)
- Fig. 11: Ministry of Internal Affairs and Communications

*19: However, telecommunications carriers (MVNO, FVNO etc.) that do not assign numbers to users upon designation of a telecommunications number have established the same usage plan as the standard telecommunications number usage plan stipulated by the Minister for Internal Affairs and Communications , It is deemed to have been accredited by the Minister of Internal Affairs and Communications.

Overview of the 2018 White Paper on Information and Communications in Japan

Economic Research Office, ICT Strategy Policy Division,
Information and Communications Bureau,
Ministry of Internal Affairs and Communications

1. Introduction

On July 3, 2018, the Ministry of Internal Affairs and Communications (MIC) published the *2018 White Paper on Information and Communications in Japan*. This year's white paper*1 focuses on the theme "Sustainable Growth by ICT in an Era of Population Decline."

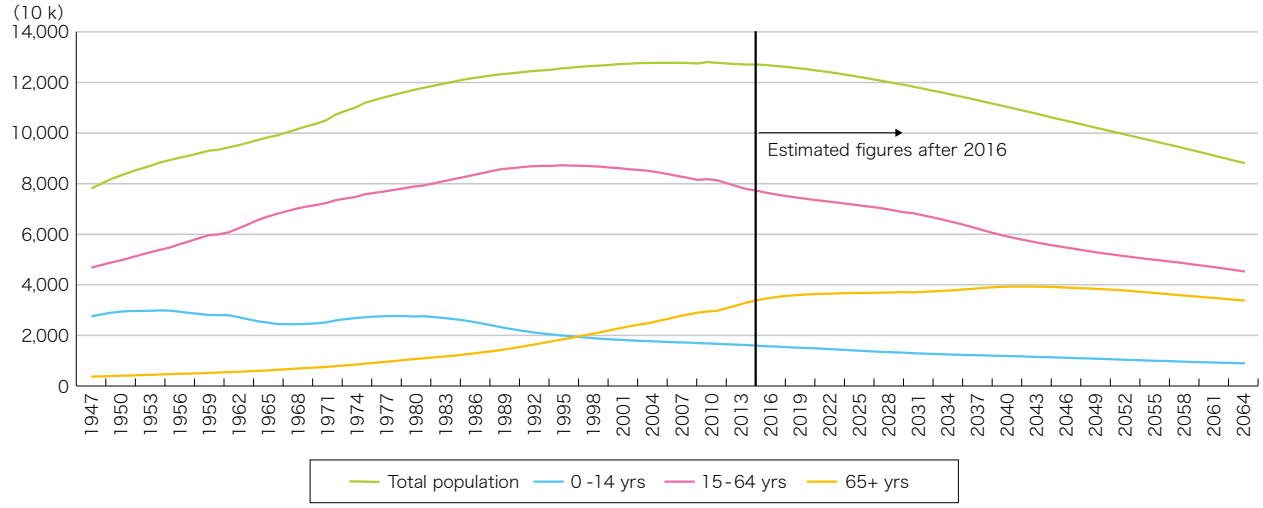
The population of Japan has been in decline since the tipping point in 2008, and the shrinking working-age population coupled with a growing elderly population could have profound socio-economic consequences as domestic demand and the scale of the economy contract and as labor shortages intensify (Figure 1). However, harnessing information communication technology (ICT) to create new value by interconnecting myriad things—people, objects, organizations, communities, and more—may offer a way to avoid the bleak consequences of this demographic trend. ICT can lead the way to sustainable economic growth even in the face of population decline by stimulating demand, by boosting productivity, and by promoting social and labor force participation.

The ever expanding use of the Internet and widespread penetration of the Internet of Things (IoT) is fueling massive growth in big data. Using artificial intelligence (AI) to analyze and interpret this data opens the way to the creation of new value.

A different view holds that we are in the era of a *digital transformation* in which society and the economy become driven by data. This transformation is set in motion when ICT—AI, IoT, etc.—began to be integrated into conventional socio-economic systems: infrastructures, institutions, organizations, production methods, and so on. These socio-economic systems will be reshaped to exploit ICT. We can also anticipate that, as the real world and cyberspace are seamlessly integrated, many partially optimized systems and institutions that until now have been shut away in particular sectors or organizations will emerge as fully optimized solutions that are available to society as a whole (Figure 2).

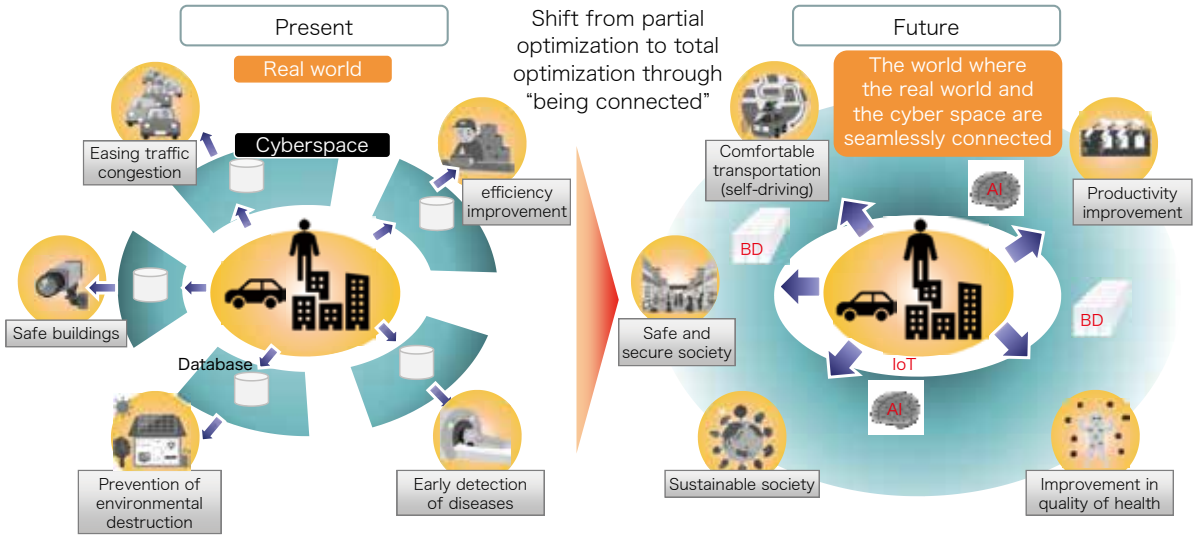
This paper will provide an overview of Chapters 2 to 4 of the white paper, which deal primarily with the creation of new value through ICT innovation.

Figure 1: Change of the population and population composition of Japan



*1 http://www.soumu.go.jp/johotsusintokei/whitepaper/index.html.
http://www.soumu.go.jp/johotsusintokei/whitepaper/eng/WP2018_outline.pdf

Figure 2: Digital transformation



2. Formation of New Economies through ICT (white paper chapter 2)

ICT is expected to contribute to sustainable growth of demand. Here we will highlight the potential role of ICT in the formation of new markets and economies, that transcend the barriers separating industries with several examples of X-Tech*2 and the sharing economy.

(1) Development of X-Tech

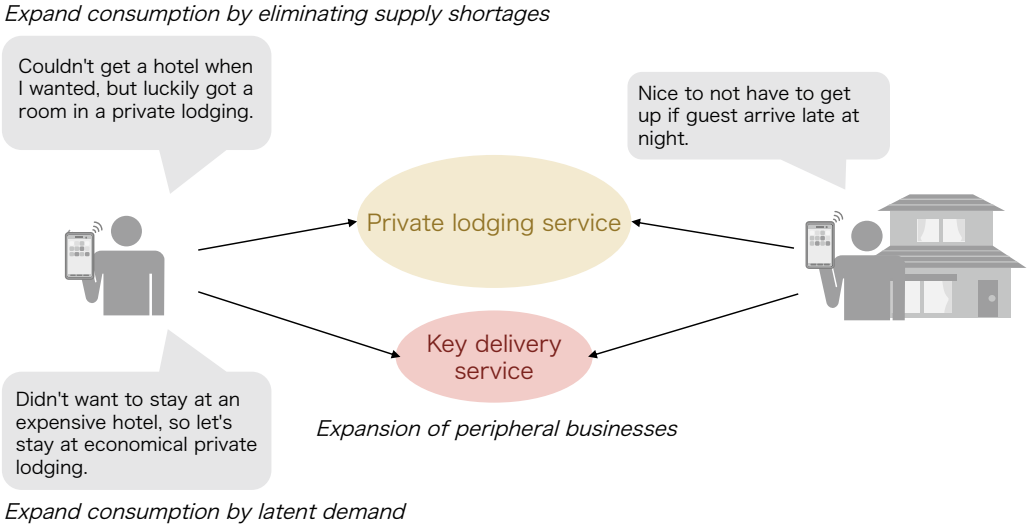
There has been significant movement in recent years to exploit digital technology and new ICT across a wide range of industries and types of businesses. Often described under the rubric of X-Tech, we now have FinTech in finance, EdTech in education, MedTech in medicine, and so on.

Taking just one example, FinTech opens the way for one-stop financial services encompassing household accounts and distribution of assets to different financial institutions, and AI-based optimal asset management for users and investment services involving relatively small amounts of money, which would help revitalize Japanese asset management.

(2) Sharing economy

By utilizing online ICT platforms, individuals are able to participate in the market as service providers. The typical example is that of a sharing economy. The sharing economy grows consumption by bringing latent demand to the surface and eliminating supply shortages, while markedly expanding the effects of peripheral businesses and services (Figure 3).

Figure 3: Image of sharing economy's contribution to economy (example of private lodging service)



*2 Pronounced "*x tech*" or "*cross tech*".

3. Productivity Improvement and Organizational Reform through ICT (white paper chapter 3)

A decline in national population is typically reflected in a decrease in gross domestic product (GDP), or total value of goods and services in the country. Improved productivity is essential to boost the additional value of products with limited human resources. Here we highlight the importance of implementing ICT together with organizational reform to boost productivity.

(1) Labor productivity in Japan

Japan ranked 21st in a comparison of labor productivity per man-hour of 35 OECD member countries, and had the lowest productivity among the G7 economies (per employee in 2016).

(2) Improving labor productivity

Labor productivity is defined as (amount of additional value)/(labor input); that is, the amount of additional value created by a worker in an hour. Productivity can be increased by either reducing the denominator or by increasing the numerator, but leveraging ICT to increase the numerator (*i.e.*, improving amount of additional value) side of the equation is generally more effective. A trial calculation was conducted based on the results of a questionnaire sent out to Japanese companies to determine whether improving the efficiency of labor input or increasing additional value was more effective in boosting the productivity of labor. We found that the productivity of labor could be enhanced 1.1 times by saving labor associated with the work, but productivity could be enhanced 4.0 times by adding value to existing products and services or by developing new products and services (Figure 4).

(3) Necessity of organizational reform

Japan's labor productivity growth lags behind the U.S. and other G7 nations. Measures for shoring up Japan's productivity can be divided into four types of innovations: organizational, process, marketing, and product.

In a survey comparing recent innovations by major American corporations versus Japanese corporations, it was found that U.S. corporations outperformed Japanese corporations across the board in all four types of innovations. In terms of organizational innovation, for example, the U.S. corporations completed corporate restructuring more than three years ago, while a good number of Japanese corporations were still struggling with restructuring over the past three years (Figure 5). Organizational reform is clearly essential to derive increased profits from ICT, and we can anticipate that Japanese corporations will step up their restructuring efforts in the years ahead.

4. Promoting Inclusion through ICT (white paper chapter 4)

As the population of Japan continues to shrink, metropolitan areas are expected to become more densely populated and the number of single-person households will continue to rise. This means that the population of socially isolated people may increase, since they lack trustworthy people such as family members to provide companionship and assistance in case of emergencies.

One strategy for augmenting the labor force as the population continues to decline will be to open the workforce to greater participation from various categories of people who until now have been marginalized or underemployed such as women, older adults, and people with disabilities.

(1) Communication through ICT to promote greater social participation

Social media has become immensely popular, which has made it much easier for people to connect and interact than was possible in the days before the spread of the Internet. Social media provides

Figure 4: Productivity and problem solving solutions through ICT

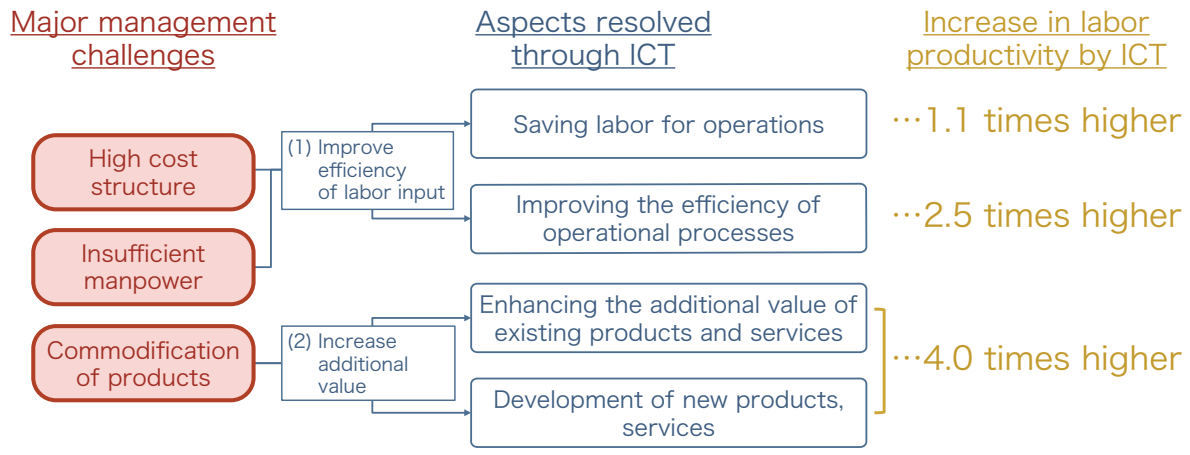
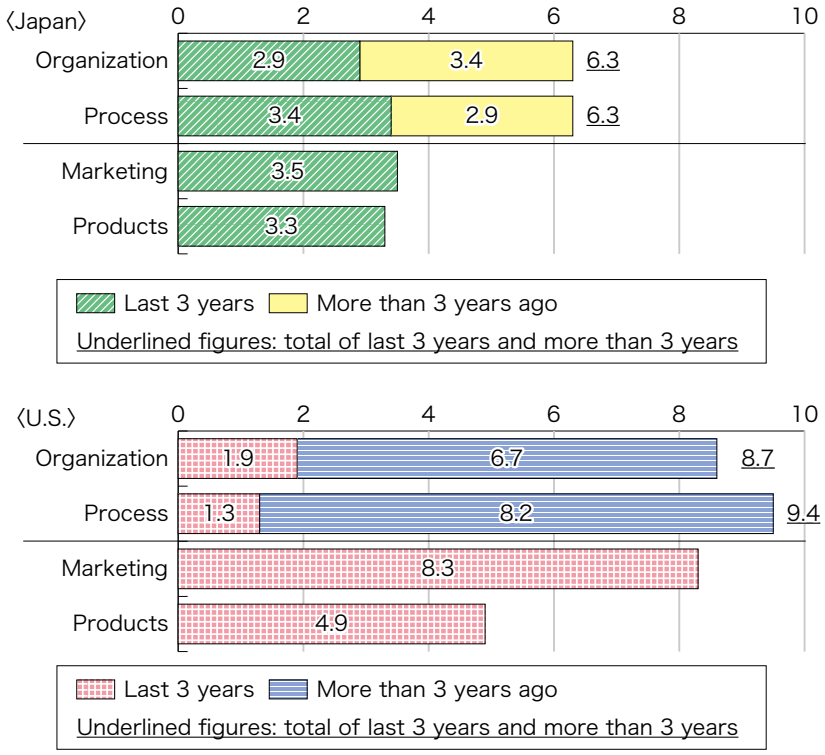


Figure 5: Innovation in Japan vs. U.S.



Based on a survey, we asked corporations to provide examples of each type of innovation. We then calculated averages for the total number of examples.

a way of gathering information, a way of making new friends, and a host of other beneficial uses. In surveying what Japanese users and foreign users like about social media, we found that far fewer Japanese users (compared with users in other countries) saw the benefits of social media for (a) building new relationships and (b) strengthening existing relationships.

Social media also offers a way to complement or supplement contacts in the real world. For example, visualization through ICT enables people who are in a position to help to reach out and assist communities that need help, it opens the way to community-based SNSs and sharing economy platforms that promote mutual aid and cooperation among local people in the community, and supports a wide range of initiatives all across the country.

(2) New ways of working supported by ICT

ICT supports diverse ways of working that enable people to closely communicate with colleagues in the office and to work without actually going to the workplace The *2018 White Paper on Information and Communications* discusses three types of ICT-supported work options is some detail: (1) business ICT tools, (2) telework, and (3) crowdsourcing.

(a) Business ICT tools

In recent years we have seen a vast increase in deployment and usage of tools facilitating communications, workforce management, and other administrative capabilities such as in-house SNS, chat, web conferencing, and other advanced features. A survey revealed that adoption of business ICT tools at an office or company did not have any discernable impact on ease of work for individual employees. Yet we also found that the employees who were most positive in their adoption and use of the ICT tools evaluated ease of work and working conditions more favorably. This would indicate that not only adoption of business ICT tools but positive use of the tools by employees is connected to the perception of ease of work or favorable working conditions.

(b) Telework

Telework is a flexible workstyle that exploits ICT to enable employees to make more efficient use of time and spaces. According to the *Communications Usage Trend Survey in 2017*, 13.9% of Japanese companies currently support telework in some form, and more widespread adoption of the practice is anticipated. Through an interview with employees who are not using but desiring to use telework, we discovered there are yet a number of sticking points in the corporate work environment and corporate rules that prevent telework schemes from being implemented. Most of the responses emphasized that "lack of relevant rules in the company" and "lack of social environment for telework."

(c) Crowdsourcing

A survey regarding crowdsourcing revealed that 30% of respondents had heard of the concept, but only 4.7% had actually used crowdsourcing in performing their work. We assume that crowdsourcing will achieve far greater name recognition and usage among independent teleworkers as they take on crowdsourcing-related contracts and assignments in the years ahead.

= A Serial Introduction Part 1= Winners of ITU-AJ Encouragement Awards 2018

In May every year, The ITU Association of Japan (ITU-AJ) proudly presents ITU-AJ Encouragement Awards to people who have made outstanding contributions in the field of international standardization and have helped in the ongoing development of ICT.
These Awards are also an embodiment of our sincere desire to encourage further contributions from these individuals in the future.
If you happen to run into these winners at another meeting in the future, please say hello to them.
But first, as part of the introductory series of Award Winners, allow us to introduce some of those remarkable winners.

Motohiro Abe
NTT DOCOMO, INC.
Motohiro.abe.cu@nttdocomo.com https://www.nttdocomo.co.jp/english/
Fields of activity: Standardization of the mobile core network

The world of standardization

I am delighted to have been selected to receive the ITU-AJ Encouragement Award, and thank the company for putting my name forward.

Here I would like to introduce something that we tend to take for granted—the world of *standardization*.

Standardization is the process of making a product conform to a standard. For example, consider the familiar dry cell battery. The size has been standardized, so we are able to purchase standard AAA batteries sold under countless brand names all over the world. The key here is interchangeability; for all practical purposes, any AAA battery is the same as any other AAA battery, and will power your device just the same.

My area of expertise is mobile network roaming—the ability to use your cell phone outside your home service area—and here too standardization is critically important. Without roaming, your cell phone would drop calls as soon as you got out of your home service area. We at 3GPP are currently working on a roaming architecture for Voice over LTE (VoLTE) called S8 Home Routing (S8HR). S8HR is simple to implement, and thus shortens the time to rollout.

Standardization is more complicated than just setting uniform characteristics of AAA batteries or other products. It also refers to the creation and use of common rules and guidelines in a particular industry. In the mobile industry, for example, the GSM (Groupe Spécial Mobile) Association orchestrates standardization activities. The GSMA does not actually create standards, but rather represents the interests of its members—mobile operators, manufacturers, and other interested parties—who develop common rules and regulations for the industry. These rules enable roaming and interoperability for new mobile technologies.

It will be apparent that the world of standardization is far from the techno-geek discipline that you might have imagined. It is essential for establishing uniform characteristics of products, as well as for establishing common rules and guidelines for different industries. If you are interested to jumping into this chaotic yet challenging world, I would encourage you to do so!

Atsuro Ichigaya
Shunsuke Iwamura
Shimpei Nemoto
NHK (Japan Broadcasting Corporation)
{ichigaya.a-go, iwamura.s-gc, nemoto.s-fy}@nhk.or.jp
https://www.nhk.or.jp/strl/index-e.html
Fields of activity: ITU-T SG16 WP3 Q.6(Video Coding)

International standardization of video coding

It is a great honor to receive the ITU-AJ Encouragement Award, and I would express my sincere appreciation to the ITU Association of Japan and to all those who helped us along the way.

On the Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 Q.6 (VCEG) and ISO/IEC JTC 1/SC 29/WG 11 (MPEG), we have been working on the High Efficiency Video Coding (H.265) standard and its extensions.

Around 2015, we saw a surge on interest among filmmakers, broadcasters, and other video industry players in High Dynamic Range (HDR) video, and in 2016 the JCT-VC began studying a supplement that would provide HDR coding guidelines for H.265 codecs. Interestingly, the HDR standard allows for two competing HDR workflows: Perceptual Quantization (PQ) developed in the U.S., and Hybrid-Log Gamma (HLG) developed in a collaborative effort by NHK and the BBC. PQ supports video services in well managed viewing

environments such as in movie theaters, while HLG is optimized for broadcasting where a wider range of viewing environments would be assumed. In developing guidelines for these two different formats, it was critically important that when we came up with an effective proposal for one, we had to scrutinize it very carefully to make sure that it did not adversely affect the other. We scrutinized and discussed the data of repeated verification experiments. The results of these deliberations were published in 2017 as Supplements 15 and 18 to ITU-T H-series Recommendations.

In 2018, we agree to create a new joint collaborative team between MPEG and VCEG called the Joint Video Experts Team (JVET) that immediately set to work on a next-generation video coding standard that will significantly improve the compression performance. We believe the deliberations made in JCT-VC will also be utilized in the development of the new standard that includes HDR coding with its scope.

Through active involvement in JVET, we are committed to developing a next-generation video coding standard that will support future broadcasting services.

Koichi Ichikawa

Nippon Telegraph and Telephone East - Minamikantou Corporation
kouichi.ichikawa@east.ntt.co.jp http://www.ntt-east.co.jp/en/
Fields of activity: Telecommunications

Activities in the United Republic of Tanzania and the Socialist Republic of Vietnam

It is a great honor to receive the ITU-AJ Encouragement Award. My first involvement in international cooperation was a two-year stint in Tanzania as a Japan Overseas Cooperation Volunteer (JOCV). I remember feeling a sense of elation and hope coupled with trepidation as the plane departed from Narita in December 1986 for the two-day trip to Dar es Salaam. A month later, I was assigned to serve as a telephone line engineer for the Dar es Salaam Telephone Company of Tanzania Posts and Telecommunications with responsibility for maintaining underground cable. Basically my job involved technology transfer working together Tanzanian telecom employees to troubleshoot and repair problems using special measurement gear and equipment. During the first year, we had over 80,000 repair requests for 24,000 subscriber lines, and I finished two full years of cooperative activity cleaning up Tanzania's poor telephony situation.

Then in 2007, I got involved in an optical access trial in Thang Long Industrial Park in Hanoi, Vietnam. This was a collaborative venture between NTT Group and Hanoi Telecom Group to install a Gigabit-Ethernet Passive Optical Network (GE-PON) in the Thang Long Industrial Park central office, to connect the GE-PON to the Hanoi Telecom network, then upgrade transmission speed and verify network stability through data transmissions to and from Japan. The role of our company, NTT-ME, was technology transfer in the broadest sense of the term. This involved preliminary investigation and design, drawing up a list of equipment to be procured, assemble trial equipment on time, prepare a manual, supervise on-the-job training, and ensure Hanoi Telecom operations and maintenance are running smoothly after the trial equipment is installed.

I experienced firsthand the high expectations of Vietnam through implementation of this optical access trial. Based on my experiences overseas, I think I will have other opportunities to help countries upgrade their telecom infrastructure in the years ahead.

Junichi Iwatani

Nippon Telegraph and Telephone Corporation
iwatani.junichi@lab.ntt.co.jp http://www.ntt.co.jp/index_e.html
Fields of activity: ITU-R SG5 WP5A, Wireless LAN

Activities to Improve Operational Conditions of Wireless LANs

It is a great honor to receive the ITU-AJ Encouragement Award. Starting in 2015, I was engaged in preparing and revising the draft standard of the next-generation high efficiency wireless LAN (802.11ax) in the IEEE 802.11 Task Group ax, and in 2017 I joined the Japanese delegation to ITU-R WP5A to work on revision of 5 GHz wireless LAN operational conditions (WRC-19 Agenda Item 1.16).

In ITU-R WP5A meetings, I am currently focusing on activities to relax restrictions on 5 GHz wireless LANs including expansion of outdoor use, and in the draft CPM text for the WRC-19 recently completed in May 2018 we have successfully reflected some of Japan's proposals to allow outdoor use and higher power transmission in the 5.2 GHz band as an option for revision of the Radio Regulations.

The immediate issue is whether the frequency band can be shared with other systems once the regulations are relaxed. While we have conducted technical studies and insisted that the frequency band can be shared under certain conditions so far, it is imperative that this should be reflected in an ITU-R Report on sharing and compatibility. Based on these technical studies, I would like to work on building a consensus at the ITU-R meetings on relaxing the conditions toward revision of the regulations at the WRC-19.

Based on my own experience working for both the IEEE and the ITU-R meetings, I would like to contribute over the long term to further upgrading operational conditions of wireless LANs and raising Japan's profile and influence in standardization meetings.

New Breeze
平成三十年十月十日発行（年四回一、四、七、十月の十日発行）第三十巻第四号（通巻百二〇号）

定価　一冊　一、六二〇円（本体価格 一、五〇〇円、消費税 一二〇円）　年間購読料　六、四八〇円（本体価格 六、〇〇〇円、消費税 四八〇円）

The ITU Association of Japan