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

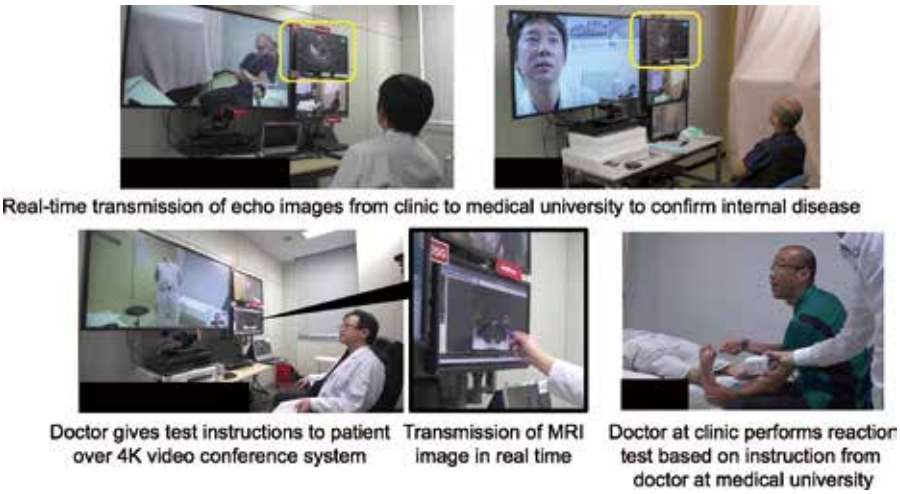
Figure 2: Trials at Tokyo Skytree Town

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!