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

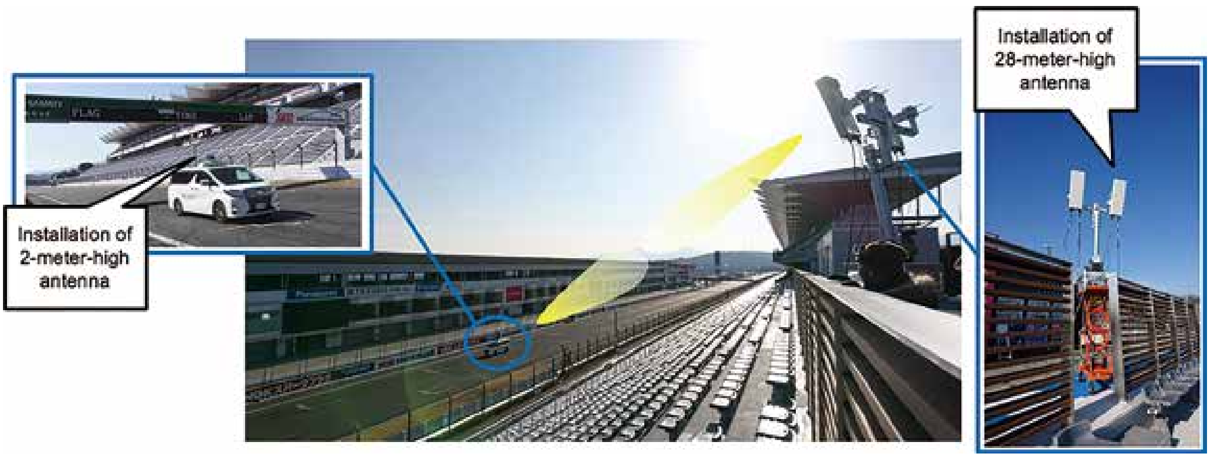
The vehicle trials were conducted on February 7-9, 2018 at Fuji Speedway (in Shizuoka Prefecture) by constructing a 5G transmission zone near the grand stand and transmitting 5G wireless content to vehicles driving around the track at high speed (Figure 1).

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.

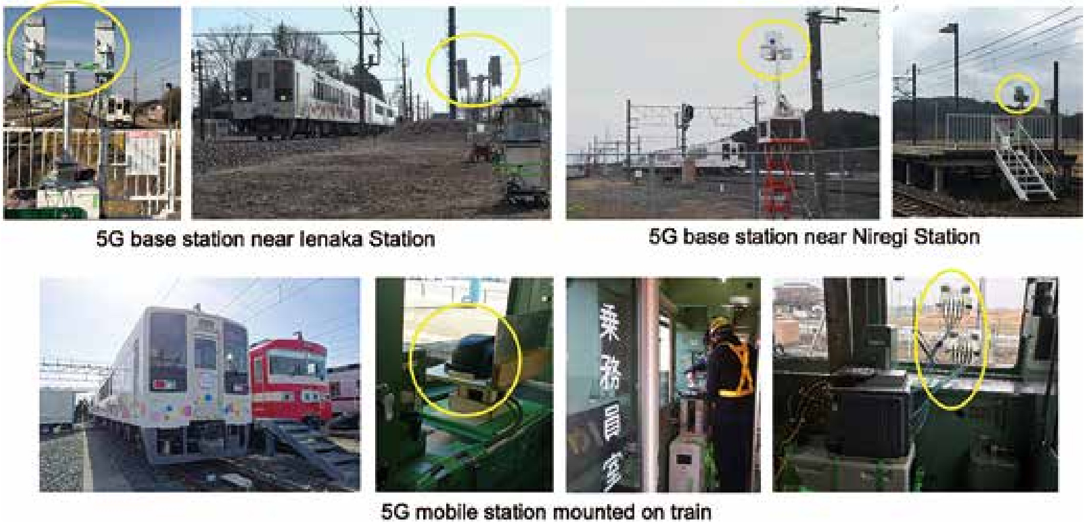
2.2 Train transmission trials on Tobu Railway Nikko Line

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

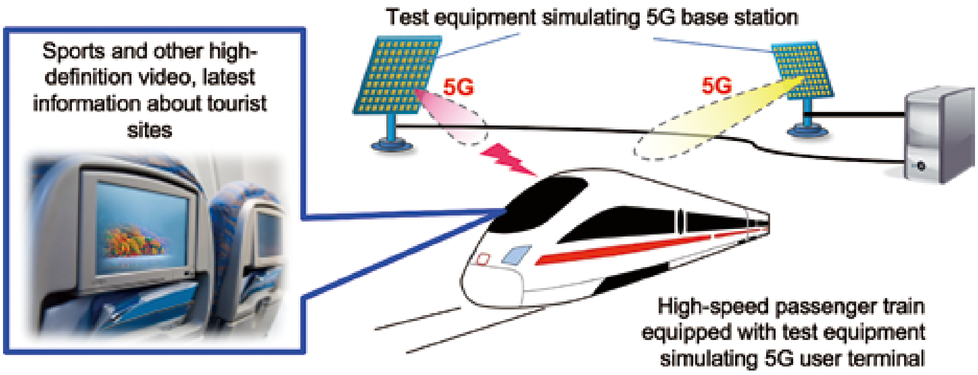
■ Figure 1: Wireless transmission trials for high-speed vehicles at Fuji Speedway



■ **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.

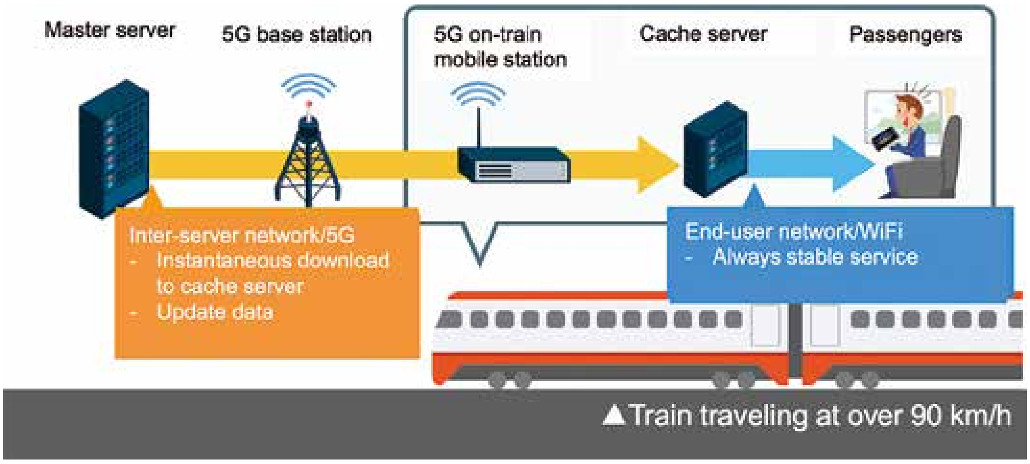
The two antenna units subordinate to the base station base band unit installed near Niregi Station were deployed in a distributed configuration. Specifications of the transmitting equipment were as follows: center frequency of 27.900 GHz, bandwidth of 730.5 MHz, and number of antenna elements (base station: 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