Technology of Personal Mobile Radio, Introduction of PS-LTE and its Challenges

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Abstract

At the Olympic and Paralympic Games Tokyo 2020, PS-LTE was introduced for the first time in the history of the Olympic and Paralympic Games as one of the technologies for providing Personal Mobile Radio (PMR) service used for communication among the Games management personnel, and PS-significantly contributed to the smooth operation of the Games. This article outlines the structure of the PS-LTE system and its construction process for the Olympic and Paralympic Games Tokyo 2020. It provides an overview of the use of PS-LTE during the Olympic and Paralympic Games Tokyo 2020, including the preparation period. The post-Games utilization of the PS-LTE system is also discussed.

Keywords : Personal Mobile Radio (PMR), First time in the history of the Olympic and Paralympic Games, PS-LTE, Post-Games utilization

1. Introduction

Personal Mobile Radio (PMR) service is a "communication service to support the smooth operation of the Games" used for communication among the parties involved in managing the Games to support venue management, competition management, medical care, security, and other event support. PMR service provides an immediate communication means by radio devices to target devices within a defined area.

NEC provided PMR service for the Olympic and Paralympic Games Tokyo 2020 (hereinafter referred to as Tokyo 2020 Games) using three technologies : PS-LTE (Terminology), direct communication radio and IP radio. The areas where PMR service was provided are shown in Table 1.

In addition to these three technologies, airport MCA radios serviced by the respective airport radio companies were provided at Haneda and Narita airports.

This article describes PS-LTE introduced as a PMR service for the first time in the history of the Olympic and Paralympic Games.

2. PS-LTE in the Tokyo 2020 Games

PS-LTE is a wireless network built on an LTE system intended for public use.

NEC proposed PS-LTE as a technology for providing PMR service, and after evaluation by the Tokyo 2020 Organising Committee, it was decided to introduce PS-LTE as a PMR service.

This section describes the PS-LTE system for the

Table 1 PMR Service Coverage Area

Technology	Service area
PS-LTE	Tokyo area (within a 10-km radius of the Olympic and Paralympic Villages), Musashino Forest Sports Plaza, Tokyo Stadium
Direct Communication Radio	Venues outside and surrounding the PS-LTE coverage area
IP Radio	Venues outside and surrounding the PS-LTE coverage area

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Tokyo 2020 Games.

2.1 System Overview

The PS-LTE system constructed for the Tokyo 2020 Games consisted of a control station, base stations, mobile stations, and a supervisory and control centre, as shown in Figure 1. There were two types of base stations : wide-area stations that covered the area outside the venues and venue stations that covered the area in and around the venues. Seven wide-area stations and 22 venue stations were installed.

A redundant backhaul connected the control station and base stations.

The equipment used to configure the control station and base stations was duplicated to provide sufficient redundancy. Even if a failure occurred, the PS-LTE system would continue to operate and would not interfere with the operations of the Games.

The equipment making up the PS-LTE system for the Tokyo 2020 Games was the same as that provided to customers who require continued communication even during a disaster.

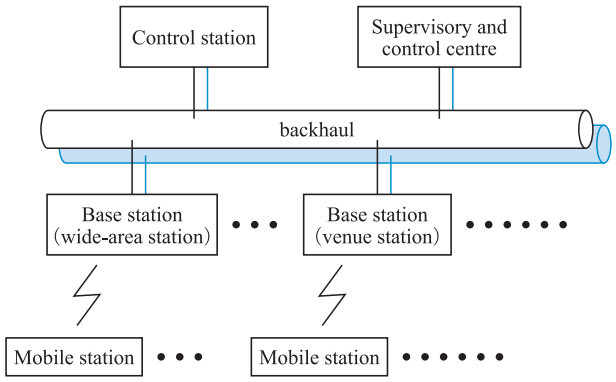

Figure 1 The PS-LTE system configuration The system consists of a control station, base stations, mobile stations, and a supervisory and control centre.

2.1.1 Control Station

The control station consists of core network equipment called EPC (Evolved Packet Core), which has the function of managing communications for the entire PS-LTE system and controls LTE-based communications, a PTT (Push To Talk) server, which controls the PTT function, in which a call is made by pressing a button on a mobile station ; and routers to control communication with the base stations. All of these devices have a redundant configuration of active and standby systems.

The control station was located in a data centre managed by NEC, had its independent power supply and was connected to a commercial power supply, ensuring 24-hour operation 365 days a year.

2.1.2 Base Station

The base station has the function of capturing radio signals and connecting them to the control station that manages communications. The base station consists of a Base Band Unit (BBU) (Terminology) that controls the entire base station, and monitors call control protocols, and a Remote Radio Head (RRH) (Terminology) that processes signals exchanged through the backhaul and signals to be placed on the radio, routers that control communication with the control station, and antennas. The equipment of the base station, excluding the antennas, has a redundant configuration of active and standby systems.

At the Tokyo 2020 Games, the base stations were of two types : wide-area stations and venue stations. The wide-area stations were set up to cover the outdoor area within a 10-km radius around the Olympic and Paralympic Villages. The venue stations were set up to cover the indoor and surrounding areas of the venues.

(1) Wide-area Station

Radio propagation simulations were conducted in advance to efficiently cover a 10-km radius around the Olympic and Paralympic Villages, and suitable facilities were selected for installation. As a result of the simulation, it was decided to install seven base stations. The number of RRHs per base station ranged from 2 to 4. Figure 2 and Figure 3 show a wide-area station's

Terminology

PS-LTE Public-Safety LTE. A radio system built on an LTE system for public use (for example, for use by public safety organizations at disaster sites). At the Tokyo 2020 Games, PS-LTE was built as a dedicated radio system.

BBU Base Band Unit. A device performing digital baseband signal processing, connection and termination processing with control stations, call processing, and monitoring and control processing. It converts signals received from control stations into baseband signals and transmits them to RRH. It also transmits the reverse direction.

RRH Remote Radio Head. A device that transmits and receives radio signals, converts and amplifies the processed baseband signals from the BBU into radio signals and transmits them to the mobile station, and vice versa. It also transmits in the reverse direction.

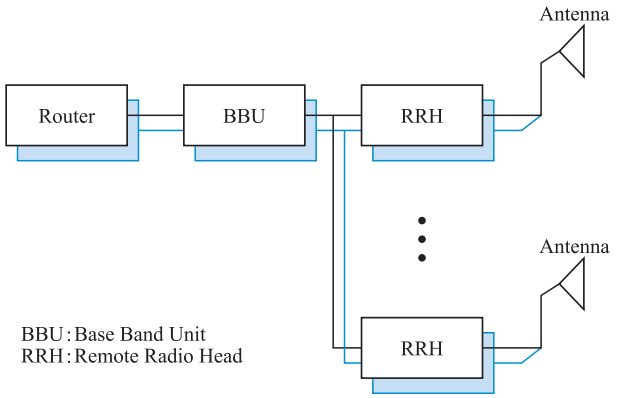

Figure 2　Base Station Equipment Configuration　The system consists of a BBU, RRHs, antennas, and routers. The number of RRHs was 2 to 4, depending on the station.

Figure 3　Appearance of the Wide-area Station　The BBU and routers are installed inside the building.

equipment configuration and appearance.

（2） Venue Station

Venue stations are base stations used to cover indoor and surrounding areas of venues and have the same equipment configuration as that of wide-area stations. The difference from wide-area stations was that a configuration in which the antennas were partially branched to arrange many antennas for covering complicated indoor areas and the shape of the antennas. While wide-area stations used large antennas installed on steel towers to cover a wide area, venue stations used small antennas that could be easily installed. The small antennas were adopted for the venue stations because of the less duration required for the installation and removal, and the broadcast cameras would not capture them.

The number of RRHs varied significantly depending on the size of the venues and the complexity of their structures. RRHs were 2 for the Canoe Slalom Centre, a simple structure, and 14 for the Olympic Stadium, a large-scale and complex structure.

Figure 4　Mobile station　A Smartphone-type Radio was Used.

2.1.3　Mobile Station

The mobile station is a device that users hold in their hands to make and receive calls.

The mobile station adopted for the Tokyo 2020 Games was a smartphone-type radio shown in Figure 4, unlike the transceiver-type radio used in past Games.

NEC adopted a smartphone-type model with excellent shock resistance, water resistance, and dust resistance and provided approximately 6,300 units.

2.1.4　Supervisory and Control Centre

The operation status of the PS-LTE system was monitored and remotely controlled in the event of failures, etc. The centre was located at NEC's office, and a 24-hour monitoring and control system was established.

The PS-LTE system was operated in close cooperation with Technology Operation Centre (TOC) during the Games period.

2.1.5　System Performance

Core network equipment (e.g., EPC) with sufficient processing capacity was installed to handle the approximately PS-LTE 6,300 mobile stations.

The performance of the core network equipment is equivalent to that of the equipment used in telecommunication carriers and was sufficient to handle all 6,300 units, even if they were all used simultaneously.

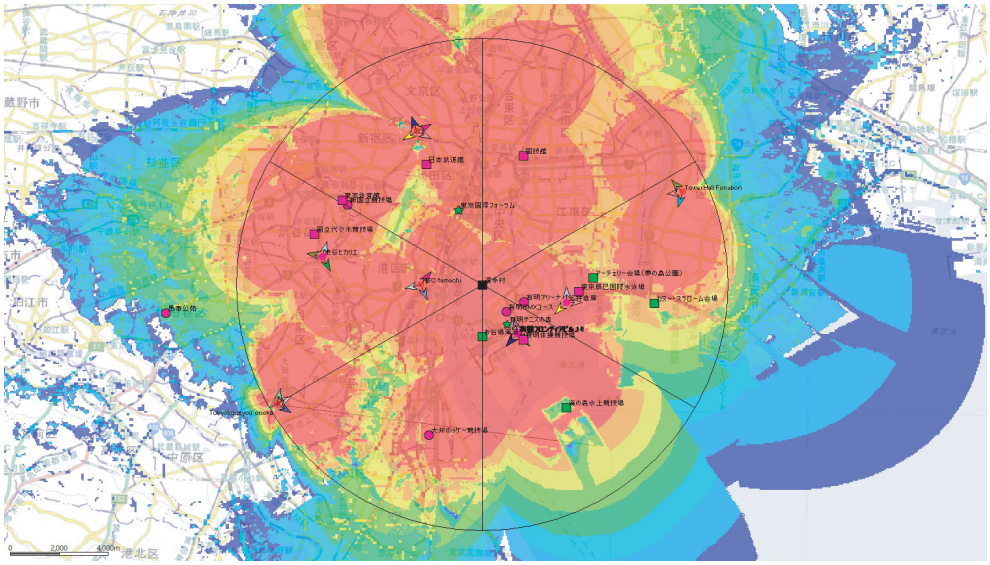

Figure 5　PS-LTE Coverage Area　This is a simulation result for an area within a 10-km radius of the Olympic and Paralympic Villages. Prepared by NEC based on the Geographical Survey Institute map (https://maps.gsi.go.jp/#12/35.647951/139.766693/&base=std&ls=std&disp=1&vs=c1j0h0k0l0u0t0z0r0s0m0f1).

2.2　Service Area

The areas covered by the PS-LTE system included outdoor areas such as road event courses (marathons and triathlons) within a 10-km radius around the Olympic and Paralympic Villages, 20 venues such as the Olympic Stadium and the Olympic and Paralympic Villages within a 10-km radius, and Musashino Forest Sports Plaza and Tokyo Stadium outside the 10-km radius.

(1)　Outdoor Areas within a 10-km Radius of the Olympic and Paralympic Villages

Figure 5 shows the results of radio propagation simulation within a 10-km radius around the Olympic and Paralympic Villages.

The locations of the wide-area stations were determined based on these simulations. In practice, even if the simulation results showed efficient coverage, the selection of the installation site had to be performed several times due to the inability to secure (rent) a facility.

(2)　Venues

Simulations were also conducted in advance for venues such as the Olympic Stadium, Olympic and Paralympic Villages, and outdoors over a 10-km radius of the Olympic and Paralympic Villages.

The number of devices installed at each of the 22 stations was determined by repeating the simulation with antenna positions as a parameter.

2.3　System Construction

The PS-LTE system construction started in FY2018 and was carried out with preliminary coordination, installation, and verification steps.

Since the wide-area stations were constructed outside the venues, the facilities could be rented earlier, and adequate time could be ensured for the construction period.

On the other hand, the renting period of facilities at the venues was set at a minimum, and construction work had to be carried out in multiple venues within a few months immediately before the Games, allocating construction resources a challenge. However, the construction plan was carefully coordinated with the Tokyo 2020 Organising Committee steps and business operators in charge of the maintenance at each venue. The construction was completed before the Games staff arrived at the venues and started using the PMR.

During the construction of the PS-LTE system, adjustments were made for interference from radio to ensure that the operation of communication carriers and other wireless systems would not be affected. As a result, the location of the PS-LTE antennas had to be changed, and additional filters had to be installed at the base stations of communication carriers to avoid

interference.

After installing the base station, radio wave measurements and call tests were conducted on and around major roads and venues in Tokyo, such as road event courses and highways designated as Olympic routes. The results confirmed that Reference Signal Received Power (RSRP) could provide stable calls in all areas except tunnels and that PMR service could be provided as expected.

3. PMR Service Operation

NEC was responsible for constructing the PS-LTE system and for operational tasks such as setting up the mobile stations, delivering to users, and responding to user inquiries.

NEC handled the PS-LTE system and other PMR systems (direct communication radio and IP radio). Although there were differences in mobile station setup work depending on the radio technology, the operational tasks were the same.

This section describes the operation of the PS-LTE system.

3.1 Mobile Station Setup

The PS-LTE system supported approximately 6,300 mobile stations or about 6,300 users. Users gave instructions through PMRs in units of operational groups such as venue management, security, and medical services. Groups ranged from 20 to 45 people, depending on the size of the venues, and the total number of groups in the entire PS-LTE system was 700.

These groups were defined in a fleet map, and the mobile stations were configured for these groups based on the fleet map (the configured groups were called "Talk Groups") and distributed to users.

3.2 Operational Structure

Positions were assigned to TOC and venues to carry out the operational tasks (Figure 6). The supervisory and control centre was also staffed 24 hours a day.

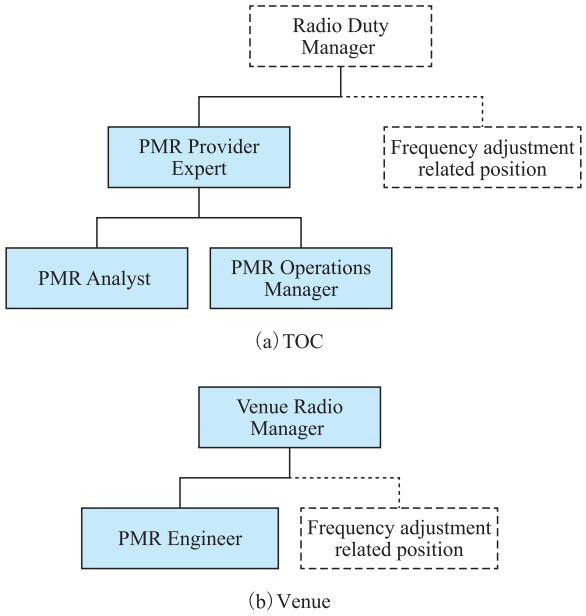

Figure 6 PMR-related Operational Positions NEC deployed 3 positions in TOC and 2 positions at venues.

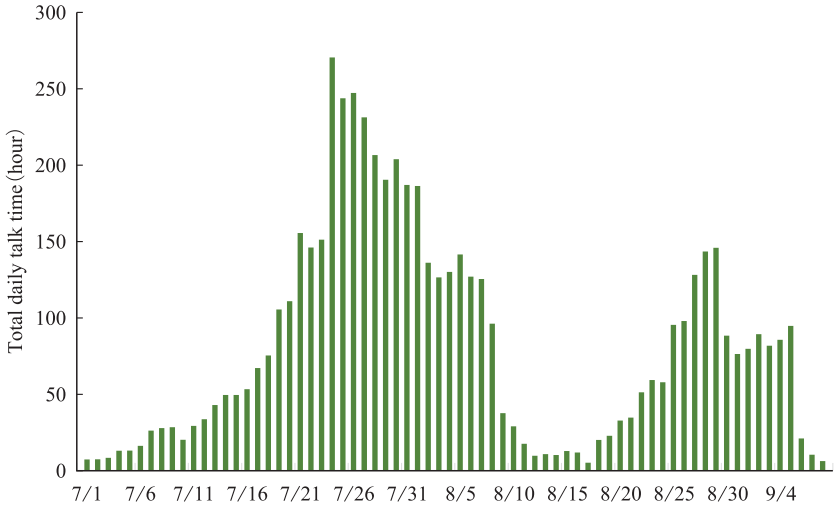

Figure 7 PS-LTE traffic The total daily talk time of the Talk Group is shown in the figure.

During the Tokyo 2020 Games, more than 300 personnel were mobilized.

In principle, TOC was staffed 24 hours a day during the Olympic Games and 19 hours a day during the Paralympic Games, while the venues were staffed for competition hours and several hours before and after.

3.3 Operational Status

The PMR service was provided stably during the Games period, including the preparation period, with no system outages or other problems.

The traffic generated during the Tokyo 2020 Games was also within the performance range of the PS-LTE system.

Figure 7 shows the total talk time for each Talk Group from July 1 to September 8, 2021, organized per day. The horizontal axis is the date, and the vertical axis is the total talk time in each Talk Group. If Person A speaks for 5 seconds in one Talk Group to call Person B, and then Person B responds for 3 seconds, the call duration is recorded as 8 seconds.

The traffic generated (Talk Group calls) tended to be similar to past Games.

Traffic increased from the time when preparations for the Games began in earnest and reached their maximum on the day after the opening ceremony of the Olympic Games. The day after the opening ceremony was the first day of the competitions in many venues. There were many interactions between personnel, which stimulated the use of radios. Subsequently, the number of calls decreased, and it is assumed that users got used to their work.

Traffic decreased during the transition period, but traffic increased as the Paralympic Games approached, and preparations began in earnest.

Traffic during the Paralympic Games was less than during the Olympics Games due to the smaller scale (number of venues, etc.) and fewer users.

Figure 8 shows the transition of the utilization rate of the wireless band, where the utilization rate was the highest on July 24, 2021, when traffic was at its maximum. The utilization rate of the wireless band was 34% at the maximum, and there was enough capacity.

The PMR service could be provided without the restriction of low-priority Talk Groups, which had been considered in advance.

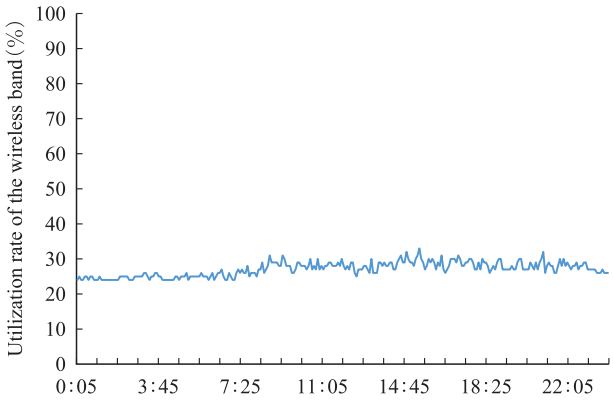

Figure 8 Utilization Rate of the Wireless Band over Time on July 24, 2021 The figure shows the utilization rate of the wireless band over time when the utilization rate was the highest.

4. Utilization of the PS-LTE System after the Games

NEC worked to utilize the PS-LTE system introduced at the Tokyo 2020 Games as a legacy after the Games.

NEC proposed that the PS-LTE system be used as part of MCA Advance provided by MRC (Mobile Radio Center, Inc.), and after the Tokyo 2020 Games, the used equipment was diverted to be used to build MCA Advance.

5. Conclusion

NEC was able to provide a stable PMR service on a large scale. Thanks to the efforts of NEC and the Tokyo 2020 Organising Committee, and all related organizations, institutions, business operators, and volunteers. I want to take this opportunity to express my gratitude.

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