Summary of the Tokyo 2020 Games Network

SAITO Wataru SHIGECHIKA Noriyuki

Abstract

This artiele provides an overview of the "Telecommunication platform" and the various "Network services" prepared and provided by the organising committee for the Olympic and Paralympic Games Tokyo 2020, and summarizes the achievements and challenges in providing them by considering problems that arose during preparation and Games-time operation.

Keywords : Games Data Network, Telecommunication platform, Systems and Network services for the Games

1. Introduction

The communication network is indispensable for the operation of the Games for those involved in the Games, including the organising committee staff. It was installed and operated by the organising committee from its establishment to its liquidation, while changing its function and size. In particular, the communication network used during the Games was called Games Data Network. This section mainly introduces the "Telecommunication platform" and "Network services" of Games Data Network.

The "Telecommunication platform" was a network that connected the two data centres in Japan as hubs to competition-related systems in cloud data centres in Europe, and approximately 70 major centres and facilities that included 43 Olympic and Paralympic Games venues. The network could be said to be one of the largest telecommunication network in the history of the Games, due to the large number and distributed locations of competition venues throughout the country from Hokkaido to Kanto, and Tokai (Table 1).

In addition to the competition-related system, the other systems used at the competition venues and facilities were, in principle, also based on this "communications infrastructure". Naturally, "Network services" were no exception, with the Internet access and fixed-line telephones also being provided over this network.

Starting with the Tokyo 2020 Olympic and Paralympic Games (hereinafter referred to as "Tokyo 2020 Games"), the organising committee has also provided a network of video-material transferring for broadcasting (Broadcast Contribution Network). The role of the Broadcast Contribution Network is to provide dark fiber or leased lines to the video transmission system prepared by Olympic Broadcast Services (OBS). This is the relay transmission part for collecting 4K video materials shot at each venue to International Broadcast Centre (IBC) in real time, so in principle, the physical conditions were strict : complete redundancy and undergrounding. In fact, some competition venues had to deal with issues such as, "There is an underground route but no second route, and what to do about the underground conduit for the second route," etc. Depending on the competition schedule and the facilities available to the venues, new underground conduits were installed, backup for the aboveground section was added as third or fourth cabling route, or other countermeasures and mitigation measures were taken. Although the organising committee and the partners had lots of challenges for the provision, this report would not deal with those in detail because we basically focus on the bandwidths between

SAITO Wataru
Technology Services, The Tokyo Organising Committee of the Olympic and Paralympic Games
SHIGECHIKA Noriyuki
RCA Co.Ltd. (Telecom Advisor of Technology Services)
The Journal of The Institute of Electronics, Information and Communication Engineers, Vol.105, No.8, Supplement, pp.13-21, August 2022

Table 1　43 Games Venues across 9 Prefectures

Region	Number of Venues	Remarks
23 Tokyo wards (cities)	22	
Outside 23 wards	3	
Kanto area except Tokyo	11	Chiba 4, Saitama 3, Kanagawa 3, Ibaraki 1
Outside of Kanto	7	Shizuoka 3, Fukushima 1, Miyagi 1, Hokkaido 2

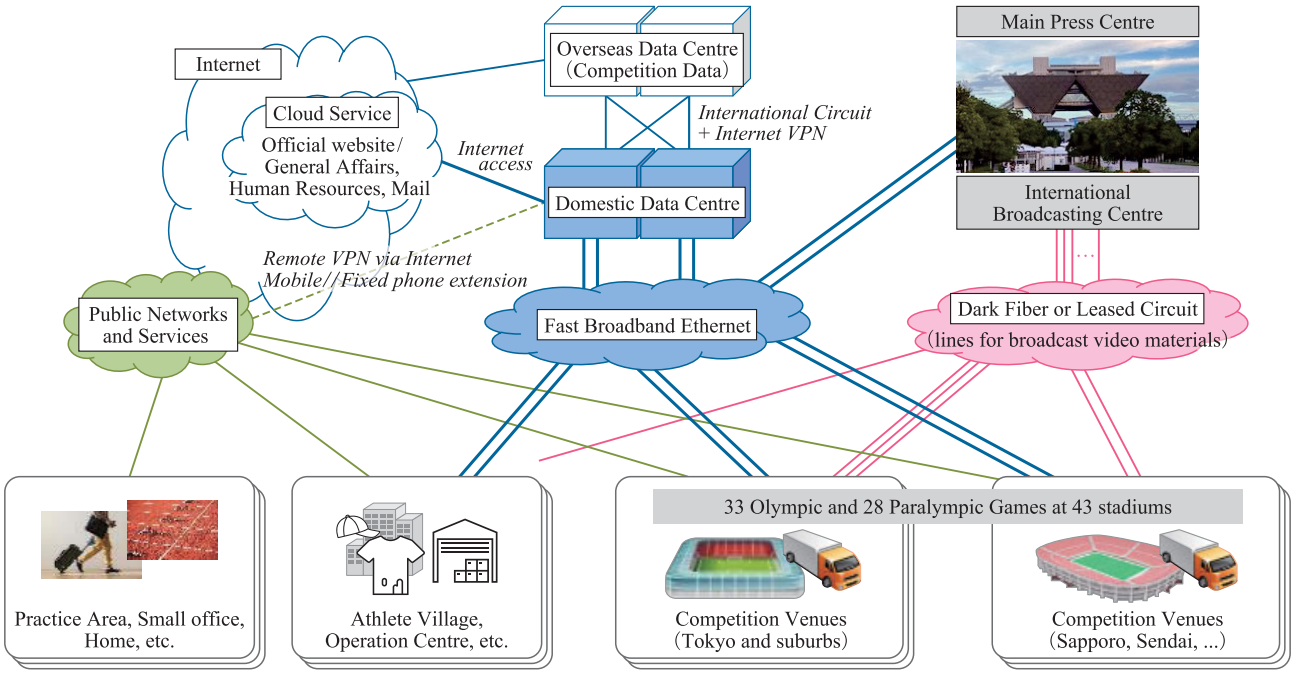

Figure 1　Physical Configuration of the Network for Conventions (overview)　The data network for the Games (blue in the figure) is connected to the Domestic Data Centre and other venues in a star configuration using high-speed broadband Ethernet, etc. The broadcasting network is connected to the International Broadcasting Centre using dark fiber and leased circuits.

the competition venues and IBC. The physical configuration of Games data network and Broadcast Contribution Network is shown in Figures 1.

2. "Telecommunication Platform" for the Tokyo 2020 Games

2.1 Consideration of Architecture and Requirements

Since not all requirements for "Telecommunication platform" were given, we started by understanding the network requirements and design concepts of past Games, and finally, after confirming the requirements from the top partner that operates the competition-related system, we attempted to decide the requirements in consideration of the domestic situation.

For example, the design of the WAN bandwidth between the venue and the data centre and the Internet connection bandwidth was determined, based on the configuration and the bandwidth used in the Rio de Janeiro Games, taking into account the expected bandwidth required by each service system, the number of expected visitors to Japan, the growth in Internet use after the Rio de Janeiro Games, and the like. The capacity of "Telecommunication platform" thus set up did not get saturated during the Games in Summer, 2021. However, a very brief Internet congestion occurred during the peak traffic period of the Olympics, but this did not affect the operation of the Games. This would be the result of a balance between the increase in general Internet use due to the one-year postponement of the Games and the decrease in the number of visitors due to the restriction of entry to Japan, since the capacity was originally designed for use in the summer of 2020.

The Tokyo 2020 Games used commercial network services provided by partner companies for communication between venues and facilities, which was an example of the domestic situation. In many past Games

such as Rio de Janeiro, dark fiber was mainly used for transmission, and actual network control was performed only by network equipment provided by the organising committee. This is thought to have been in conjunction with a policy to install optical fibers in the region on the occasion of the Games. However, Japan has a high fiber penetration rate, in other words, the demand for new fiber installation was small, and if new cables were needed, it would be a burden on the Organising Committee, and there were many distant venues that could not be configured with only dark fiber. Therefore, we chose to use commercial network services.

2.2 Functional Classification of Networks ("Telecommunication Platform")

Games Data Network as "Telecommunication platform" for the competition can be broadly classified into the following three networks : the Competition Network (CPN), which housed the competition results distribution system ; the Back Office Network (BON), which was used by the Organising Committee staff for preparation and operation before/during the Games period ; and the OCOG Technology Network (OTN), which provided VLANs dedicated for the various systems and services provided by each Functional Area (internal organization of the Organising Committee, hereinafter referred to as "FA") and each stakeholder involved in the Games (Table 2).

Needless to say, competition-related matters were primary in the Games operation. In other words, in terms of networks, CPN had the highest priority and required a high level of monitoring and operation. BON handled all information related to the preparation and operation of the Organising Committee, and thus required a high level of monitoring and operation over a long period of time. OTN might be responsible for FA services indispensable for their operation in some cases, and also provided the connectivity for the Wi-Fi Internet services to office visitors in other cases. That is to say, OTN's purposes and usage methods varied. For this reason, the common network functions were kept to a minimum, and the necessary functions and operations were to be provided by the individual systems and services.

Table 2 Classification of Games Data Network

CPN	Network for distribution system of competition results
BON	Network for organising committee operations
OTN	Others used for Network services, FA systems, etc.

Remark : Here, "Games Data Network" is used to collectively refer to "Telecommunication platform" and "Network services" provided responsibly by the Technology Services bureau of the Organising Committee. In terms of "Telecommunication platform", "Games Data Network" was divided into the above three categories.

CPN were logically divided into several networks (VLANs) according to the systems that handled the goal-scoring photographs, the progress of the Games, or the competition results data such as scores and measurement times. BON were also divided into several networks according to the devices used, such as the network to which the staff PCs were connected and the network to which the staff smartphones were connected via Wi-Fi. OTN was divided into VLANs according to the services and systems to be accommodated, resulting in a large number of VLANs being set up and operated. CPN, BON and OTN had common policies such as the total prohibition of Lateral Movement between terminals such as PCs to prevent the propagation of malware infection, and the independence of VLANs (no inter-VLANs communication) to prevent the propagation to other services. On the other hand, CPN and BON required physical security of the usage location, network authentication, and monitoring by proxies, while OTN, in principle, left the operation of each VLAN to each service or system policy.

3. "Network Services" Provided in Tokyo 2020 Games

3.1 Main Network Services

The Network services described here were studied and prepared, in parallel with "Telecommunication platform", based on the requirements of the past Games. The following is a list of representative services :

Internet for stakeholders (wired and Wi-Fi connections)
VLAN service for the press (Press Plus)
CATV (Community Access Television) service
IP fixed-line telephone and FMC services
VLAN for TV conference service
IOC staff network
VLAN Connect (intra-and inter-venue VPN connectivity)
Internet with a global IP address, etc.

In addition to these services, remote access VPN can also be listed as one of the services provided to the staff.

The remote access VPN was installed with the expectation that staff members would use it for business purposes at venues under construction. However, since Tokyo 2020 Games was postponed for one year soon after its installation, it actually became the main tool for staff to work remotely at home, with a maximum of approximately 3,500 users at one time.

Except for the last one, Remote Access, the above-mentioned were basically the similar services provided for stakeholders at the past Games, but the Press Plus dynamic VLAN connection function, the distribution of cell phones to all staff members, and the Fixed Mobile Communication (FMC) function for internal calls based on the distribution of cell phones were newly added at this time. In principle, "Network services" were provided using stable and well-proven technologies, but some advanced technologies such as "Local5G" were also incorporated on a limited basis.

The details of the functions and construction/operation of the Wi-Fi connection service will be left for another article, but the connection service was unstable someplace when the press-related personnel and others were concentrated in certain locations. There, even when connected, each connection speed was much slow. This was caused by a sharp increase in Wi-Fi usage in the press area a few days before the opening ceremony, but it was an opportunity to realize the difficulty of "short-term intensive use" and the importance of "responsiveness" during the Games.

CATV was provided in two types : In-Venue CATV (3,200 units), which was provided using the RF system because significant signal delays were not allowed, and Inter-Venue CATV (3,700 units in total, including the number of units re-deployed at the Paralympics) using the IP multicast system, which was designed for viewing over a wide area. Since this service required coordination with projects other than our telecommunication, the delays in procurement of monitors, the delays in installation work to receive images from OBS and the necessity of additional frame synchronization equipment at some venues to stabilize In-Venue CATV images were consecutively found in the last-minute delivery period of May to July. These made us keenly aware of the need to keep proactively track of the progress of related others in this kind of short-term projects ; others cannot afford to think about the impact on us.

For the telephone service, each staff member was given a smartphone and used the extension service function of a Network services partner before the Games, but we added a stable quality fixed-line telephone service for use at the management and operation centres of each FA to create an integrated telephone system. In the end, 2,600 fixed-line phones and 15,000 extension smart phones were used at the Games time.

3.2 Identification of Service Requirements and Quantities

The basic functions were determined based on the specified requirements and advice from IOC, OBS, and others who were familiar with the requirements of the past Games, while the quantity was determined by the number of requests received from each FA and the number of rate card orders for paid services for stakeholders.

Requests from FAs were identified through a process called TEAP (Technology Equipment Allocation Plan), which was conducted every year or half a year or every quarter including minor updates, starting three years prior to the Games, in which the Technology Services bureau of the Organising Committee asked all FAs about the quantity required and collected their requests. However, the requests from other bureaus and FAs generally tended to be excessive, as the services were not covered by their own budgets, and the room allocation in the venue was not decided until one year before the convention, so there were many duplicate requests, which made the scrutiny a challenging task. For example, even in case that several FAs requested Wi-Fi Internet, we could find one AP sufficient for them if those requests in the same room in the final room assignment.

On the other hand, rate card orders are subject to stakeholders, and even the number of advanced orders would not be known until about six months before the start of the Games. Therefore, we had to prepare equipment, etc. based on the quantities of the past Games and to respond to the actual number of orders. Orders were closed three months prior to the start of the Games, and we provided the service for the rest of the time, including during the Games period, if the provision was possible in terms of facilities and lead-time. In fact, CATV could not provide the service during the Paralympic Games due to lack of STBs (Set Top Boxes) in stock, even when we received orders.

4. "Telecommunication Platform" (i.e. network) Provided to FA

4.1 Major FA Systems Provided with "Telecommunication Platform"

In addition to our "Network services", there were cases in which FAs and others organized functional requirements based on their own business designs and requested the network/capacities necessary for their systems. In such cases, the network was mainly provided as sub-network of OTN. As shown in the following list, the network was provided for various systems ; for example, Internet connection for payment terminals used in shops at the venue.

Security systems including surveillance cameras (Closed Circuit Television, CCTV)
Medical systems
UPS (uninterruptible power supply) monitoring systems
Energy management systems
Simultaneous interpretation and distribution systems for medalist interviews
Video board image and information systems
Temperature control system for venue data centres
Internet connection for specific FA information terminals
Internet connection for payment terminals, etc.

The network to accommodate the Closed Circuit Television (CCTV) system had been provided physically separately from the data network for the past Games. But for Tokyo 2020 Games, it was superimposed on OTN from the viewpoint of efficiency (decided in 2018). Based on this early decision to superimpose, because of the expected fact that it was a special network that would transmit and receive a large number of video images by IP multicast, regarding this CCTV network, under the supervisory of Security Bureau of the Organising Committee, the digital camera partner, the Network services partner and Technology Services Bureau were to start working closely together to understand the requirements and to proceed design and verification.

Rather, our telecommunication team did work for and coordinate with the CCTV system so that it could be thought as if one of "Network services" in terms of the way the actual consideration and design proceeded. However, the FA systems that were able to make such detailed preparations were rather exceptional.

4.2 Understanding Network Requirements and Quantities from FAs and Others

The system administrator or network user from the viewpoint of Technology Services Bureau was each FA, and we obtained the requirements from the staff of the relevant FA, their system integrators, or IOC organization, and examined the configuration and functions. Then we decided the configuration and allocation of the bandwidth for inter-venue communication, Internet connection and the like on the assumption that Games Data Network, especially OTN, be provided to them. However, except for the previously-mentioned CCTV, no concrete discussions could be made until less than 12 months before the Games.

In order to avoid any discrepancies or omissions in the construction and provision of these services, specific locations and quantities were collected and organized in the same way as for "Network services", by establishing service codes for the newly applicable FA systems. Namely, in principle we had the recent requests collected in the same TEAP process.

4.3 Common Issues and Responses That Emerged in the Last Period

Many of FA systems started operation in June or July of 2021, and most of them began actual use and operation without a trial in a production environment. Because of the large communication loss in the complex system and the small number of engineers who could see from the undercarriage to the service, the survey from early 2021, just before the operation start, found a number of system projects that raised concerns about implementations of the operational level that had been previously aligned and promised. Although there were no major problems at the communication, some were concerned about the security operation. Since the Games was already approaching, it was decided that common measures independently from each system should be implemented in OTN network as well, in order to raise the overall level of security.

Specifically, as one of measures, a firewall with an IPS function was decided to be installed at the Internet entrance and exit of OTN to monitor every network in it at all times and block certain packets if deemed necessary. The decision was made in May, and the equipment was installed at the end of June, when the athlete village was already opened and the Games-time

operation was started. Thus, this firewall was operated during the Games while continued to be tuned.

While the introduction of this functionality and equipment had the advantage of adding new security functions, from the perspective of network operation, it also brought the disadvantages such as insufficient maturity of the equipment operation, insufficient coordination with the existing operations, addition of operational flows, potential reduction of availability, etc. In the end, no major problems were encountered, but the actual workload on the site was significant.

5. Movements and Preparations Leading up to the Games

5.1 Progress from the Time the Organization was Established

Soon after the Organising Committee was established, the back-office network necessary for the operation of the committee began operating in 2015, albeit on a small scale. As for the network for the Games, after the Rio de Janeiro Games in the summer of 2016, the architecture was studied and designed in earnest, and Games Data Network began operation in March 2019. The back-office network prior to the Games Data Network was a network for staff use only, with no concepts such as CPN, BON, or OTN, and connection restrictions based on the Deny-list. In Games Data Network, only necessary communication was allowed, and the operation based on the "Allow-list" was thoroughly implemented, including internal communication. At the time of the switchover, interviews were conducted with the FA staff in charge of each system, their contractors, and other service providers, but many settings were omitted due to misunderstanding or oblivion. Conducting reconfirmation, we spent nearly two months to provide the necessary services in a stable manner. After this, we spent a year and a half as planned, actually two and a half years due to the postponement of the Games, so as to build up a strong network through daily operations and audits, additional service installations, and changes in the network configuration. These two and a half years also served as a period for accumulating the organization know-how and training more than 1,000 persons who were engaged in communication operations at TOC (Technology Operation Centre) and venues/facilities.

Preparations proceeded relatively smoothly, but a request from IOC led to a decision to change the venue to Sapporo Odori Park in November 2019, which required new tasks from venue design to construction within a period of about six months. In particular, the biggest concern was the underground redundancy requirements for BCN that would transmit the broadcast video materials, but we were able to overcome this with minimal changes by utilizing the facilities used for the Sapporo Dome and the like.

Then, the postponement of the Games was decided in March 2020. Since the venues to be used in summer of 2021 had not yet been determined, telecommunication work at each venue was to be suspended, and from this point on, our team had become busy with additional adjustments for extending each service for one year and resuming next year. In principle, the policy was to provide the same level of services planned for the Games on a one-year sliding. However, it was not easy to review the technical conditions on the process of about "temporarily suspending or reducing the level of services that had already been started or constructed, and then resuming them one year after, without significantly increasing costs". In addition, it was hard to parallelly change the numerous contracts of multiple partner suppliers in alignment with those conditions.

Fall in 2020, after the technology issues of the postponement had been settled, the discussions on requirements for "countermeasures against Coronavirus disease 2019 (COVID-19) infection" began. Though responding to requests from FAs and others, we narrowed down requirements that were feasible with minimal impact on Games Data Network ; as a result, preparing small telecom facilities at some venues, adding the existing "Network services" and recommending the commercial telecom services, and so on.

After this period, in early spring of 2021, we restarted to expand and deploy Games Data Network to all venues. From this time, several requirements that had not been communicated as network requirements and therefore had not yet been implemented were discovered by the users who arrived at the venues. For example, due to missing requirement for switch redundancy, we set new switches at several venues. We had needed to work for this kind of "unknown" requirements till the Game started. We could overcome such reviews/changes because of our "certain degree of flexibility," which will be discussed later (Table 3).

Incidentally, after the conclusion of the Games (October 2021 onward), the network configuration has been simplified and the operations such as failure response time has been lowered back to the pre-Games

Table 3 Major Events and Their Impact on Games Data Network

	Telecom-related major events	Preparation and operation of "Communication"
Initial stage to Mar. 2018	・The committee established, FAs launched ・BCN requirements (fully redundant & underground)	・Primary data centre & back office network operation started (Apr. 2015) ・Determined specifications and ordered constructions for broadcast conduits at each venue
Preparation Apr. 2018 to Mar. 2020	・Venue Space Outline decided (Jun. 2019) ・Decided to relocate Marathon's venue to Sapporo Odori Park (Nov. 2019) ・Service quanties semi-finalized (Feb. 2020)	・Games Data Network operation started (Mar. 2019) ・Started designing telecom facilities for comp venues (Jun. 2019) ・Finalized BCN conduit & venue design for Odori Park (Mar. 2020) ・Construction of telecom facilities at comp venues began (Jan. 2020)
Postponement Apr. 2020 to Mar. 2021	・Decided to postpone by one year (Mar. 2020) ・Cost reduction request (Apr. 2020) ・Additional study of COVID-19 countermeasure requirements (Dec. 2020) ・Number of RTC advance orders of stakeholders decided (Apr. 2021)	・Construction at venues/facilities suspended (Apr. 2020) and equipment partially removed & evacuated (-Dec. 2020) ・Services/functions made degraded and interrupted (Jun. 2020-) ・Reviewed service quantities and venue designs (-Dec. 2020) ・Second data centre operation and venue constructions resumed (Jan. 2021-) ・Realized additional requirements of COVID-19 (Apr. 2021-)
Last minute to Games to Sep. 2021	・Decided to strengthen FA network monitoring (May. 2021) ・FA's & Telecom services started (Jun. 2021-) ・Start of the Games (Jul. 2021)	・Infrastructure design change=FW (IPS) added (Jun. 2021) ・Troubleshooting during installation (Jun. -Jul. 2021) ・Reviewed and started of operation (Jul. 2021-)

Periods in parentheses are for reminder purposes; if deleted, the text will be slightly larger.

level.

5.2 Ensuring the Flexibility of the "Telecommunication Platform"—Its Importance and Limitation

From the standpoint of those who create the "Telecommunication platform", it is desirable to define the business requirements including services and venues/facilities/offices, and then determine the requirements and design of the "Telecommunication platform" that handles them in an integrated manner. In reality, however, the only way was to construct and operate the "Telecommunication platform" in parallel while studying or hearing the requirements for services, office venue design and the like with reference to the past Games, and then to determine the detailed requirements such as each service function. Furthermore, since the venues and the rooms to be used in the venues were not finalized until about a year before the Games, the quantity of services was not decided until the final stage of the Games.

This meant that the "Telecommunication platform" had to be flexible to a certain degree. For example, at design phase, we envisioned several patterns according to the services and scales to provided according to the characteristics of the venues and facilities; the patterns were applied for about 70 major locations. After the pattern selection, though the basic structure was not changed, the number of components and ports were determined sequentially for each venue according to the arrangement of rooms in the venue. For ease of operation, we also predetermined network equipment such as those to be used as the core of the venue and those to be used at the edges, and ordered and prepared in a tightrope walk based on the actual venue design, while watching the leveling-out of equipment productions and deadlines of procurement.

When the flexibility of the architecture did not compensate for the additional requirement, we sometimes customized services to some extent. For example, the design was basically based on the premise of business usage of the event stakeholders and the organising committee, and if it had been applied to the accommodation rooms in the athletes' village, the business-use advanced Wi-Fi access point (AP) would have been used. Naturally, we decided not to do this, but to procure and install APs for small offices from a Network services partner as "service" and have them operate as part of Games Data Network.

It is impossible to complete a multi-year project, which involves many parties and changes requirements frequently, only in a waterfall fashion. So, we treated some changes or new requests with a certain-level of flexibility in the above-mentioned fashion. In most of such cases, these treatments led to a review of the requirements and construction/operation, which required coordination with the IOC, technology partners, and other stakeholders, including those within the organising committee, to a greater or lesser degree. However, the lack of time made such coordination insufficient. The most symbolic example would be the

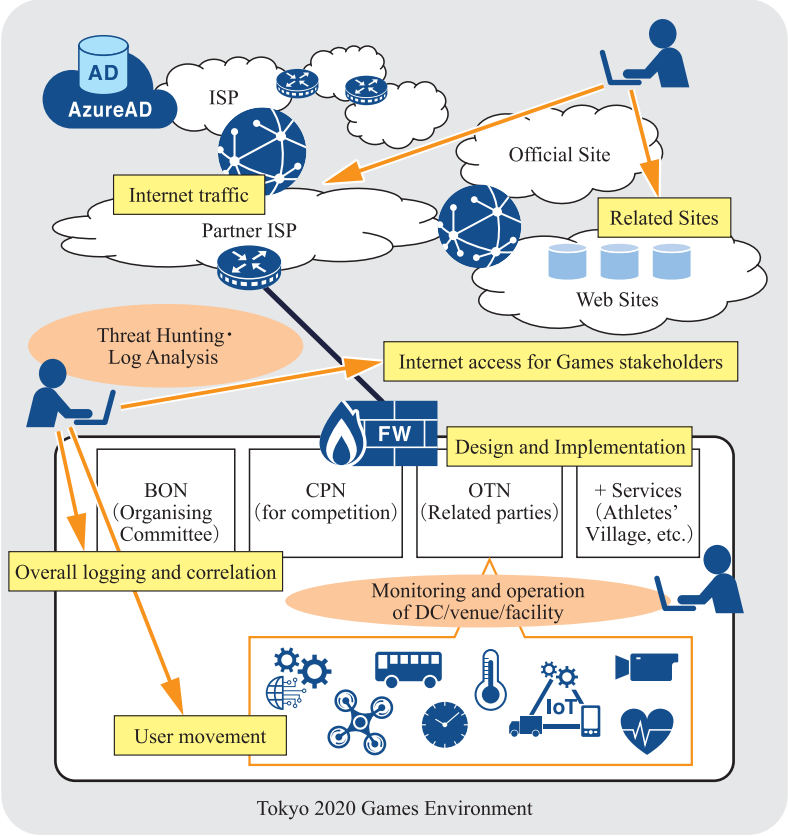

Figure 2　Overview Image of Operation and Monitoring

earlier-mentioned implementation of the firewall in the period just prior to the start of the Games (May-June).

6. Monitoring and Operation during the Games

The monitoring and operation of Games Data Network was basically based on the status and logs of the devices constituting the network (in a broad sense, including related servers other than network devices), and was conducted under the supervision of the TOC's Telecom and in cooperation with the venue teams.

However, the total number of devices and their logs could be so large we could have fell into the status that we only watched each tree but did not see the woods. Therefore, in addition to this kind of service layer and device-by-device operation, efforts were also made to get general correlations, and overall user movements based on the whole information.

In addition to operation of the organising committee, the Internet usage of stakeholders was monitored and analyzed on the Network services partner (ISP) side. Also, some public organizations and the Network services partner monitored Games-related sites, including those not directly used by the organising committee, and observed the impact of the progress of the conventions on Internet traffic (Figure 2). These are also presented here in separate articles.

7. Summary

While maintaining the basic architecture of the "Telecommunication platform", we were able to respond to the long-term sequential determination of requirements by providing several configuration patterns and other flexibility. In addition, the operational training period of more than two years from the spring of 2018 including a postponement period, greatly contributed to the accumulation of organizational knowledge, from process maturation with other organizations to human resource development. These were the main reasons why there were fewer problems than in past competitions and why we were able to respond quickly to any problems that did occur.

On the other hand, problems tended to occur in FA systems and a part of Network services immediately before and during the event as a result of inadequate

testing and advance preparation in the production environment. This is a proof of the importance of preparation and testing, especially for large-scale and short-term competitions. The flexible and sequential decision-making mechanism agreed upon with the Network services partners was useful in the events of trouble.

Even with this preparation period and a certain degree of flexibility, there were still some things that could not be handled. The security enhancement of OTN that was implemented immediately prior to the Games was a case in point. Although there are points to be regretted, I believe that it is a great achievement that the Games were completed without any major problems, based on the agreement with the parties concerned.

(Received February 9, 2022 ; Revised March 4, 2022)

SAITO Wataru

Graduate School of Engineering, The University of Tokyo (M.S., 1993). Graduate School of Business, Carnegie Mellon University (MBA, 2001). Seconded by NTT to the Tokyo 2020 Organising Committee since 2018, as the Director of ICT solutions, Department, Technology Services Bureau. (Executive Officer, Sogo Security Services Co, Ltd.)

SHIGECHIKA Noriyuki

Ph.D. (Policy and Media), Telecom Advisor, Technology Services Bureau, Tokyo 2020 Organising Committee from 2018 to the end of the Games. (Representative Director of RCA Corporation.)