NTT WEST's Efforts in Providing APN Services

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Abstract

With the declared purpose of "'Connecting' then 'opening' the door to the new world," NTT WEST seeks to contribute to the further development of communities and address a variety of challenges posed by changes in society by refining its technologies and wisdom and co-create new value. The entire NTT Group has been working to actualize the Innovative Optical and Wireless Network (IOWN) concept. In this article, we introduce NTT WEST's efforts toward this end, especially related to the development of the All-Photonics Network (APN) in creating use cases and providing the APN commercial service in the form of IOWN1.0.

Keywords: optical transport network (OTN), real-time remote control, remote live

1. Introduction

As society changes drastically, NTT WEST aims to contribute to the revitalization of communities and creation of new value through co-creation with local customers and partners. To address a variety of challenges affecting communities, NTT WEST is using its networks, services, and solutions.

Challenges in a community are becoming more complex. They include the lack of workers in local industries due to declining birthrate and an aging population and the need to maintain transportation systems for the community. To achieve both economic development and solutions to social challenges, lifestyles will need to change drastically. These changes will include the incorporation of information and communication technology systems and other digital technologies that use data, artificial intelligence, and Internet of Things into many aspects of daily life.

The NTT Group has been studying the Innovative Optical and Wireless Network (IOWN) as a technological platform that supports such social transformation and developing specific IOWN solutions and services. An example of such efforts is that NTT WEST is engaged in conducting demonstrations of use cases to connect IOWN's innovative technologies to solutions for various social issues. We are also developing commercial services using IOWN technologies. Some of these services are being rolled out as the first applications of IOWN.

In the following sections, we introduce NTT WEST's co-creation efforts with a variety of partners using the All-Photonics Network (APN) as examples of applying the IOWN concept to solutions for communities. The APN is an element of IOWN and achieves low-power consumption and high-capacity and low-latency communication. We also introduce the features of the APN service in IOWN1.0, launched in March 2023, as the first social implementation of the IOWN concept as well as examples of collaborative enterprises with partners using this service.

2. Remote live event using APN-related technologies

The live-entertainment field is exploring new types

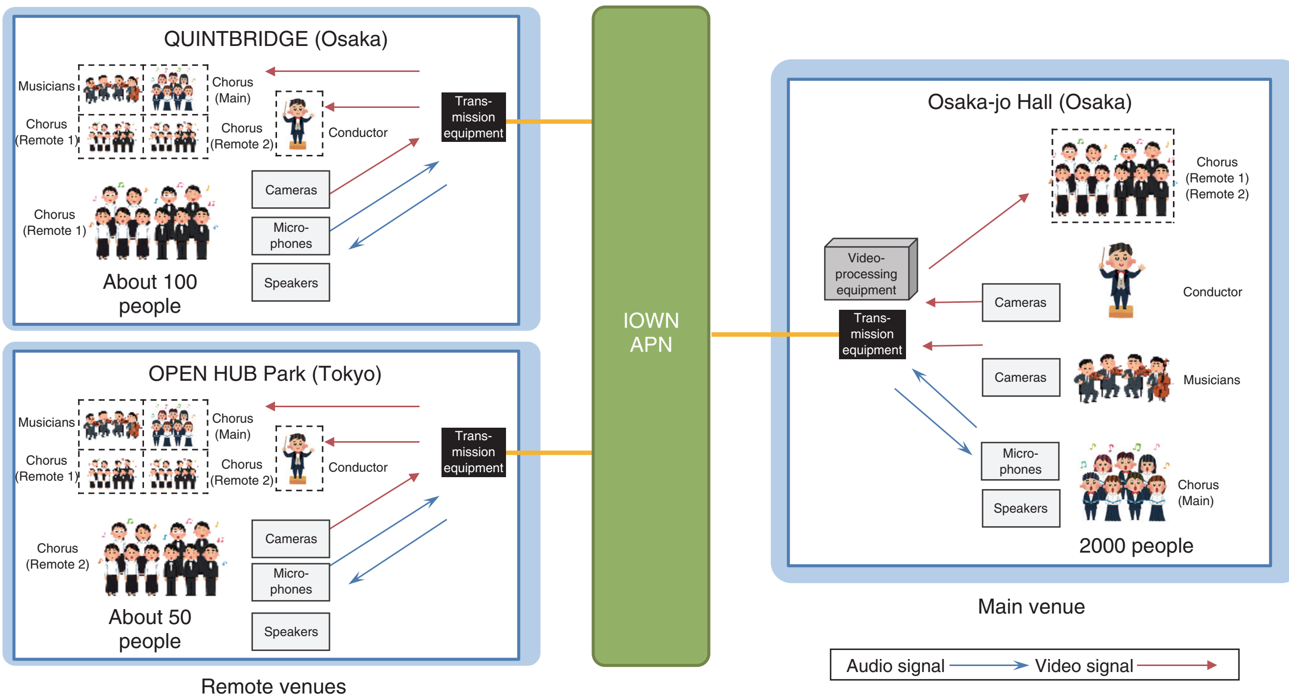

Fig. 1. Demonstration of real-time remote choral performance.

of events that integrate the real world and cyber world, such as audience-less live shows and virtual festivals. Through the development of IOWN APN-related technologies for achieving high-capacity and low-latency communication, the NTT Group is also seeking to create such integration in a variety of fields, including live entertainment. The NTT Group's technologies make it possible to connect multiple locations and enable users to experience them as one space.

With such background, NTT WEST conducted a field demonstration of a real-time remote choral performance connecting Tokyo and Osaka using technologies related to the APN (**Fig. 1**). For the 40th anniversary of the choral concert "SUNTORY Presents Beethoven's 9th with a Cast of 10,000," held in the Osaka-jo Hall and broadcast annually by Mainichi Broadcasting System (MBS) since 1983, NTT WEST connected three locations: Osaka-jo Hall, QUINTBRIDGE (Kyobashi district in Osaka), and OPEN HUB Park (Tokyo), all separated by a total of 700 km of optical fiber. APN-related technologies connected the three different locations, each with a conductor, orchestra musicians, and choral performers. Video latency was kept to 15 ms one way (propagation time of less than 1 video frame at 60 fps), resulting in an experience where video delay was not felt. Audio latency was approximately 4 ms one way. This is the same it takes for sound to travel 3 m in the same space, meaning that this is the same latency musicians experience if they are 3 m apart on the same stage. Thus, with NTT's APN technology, audio from remote locations and audio from 3 m apart at the same space could be received simultaneously, creating a new experience that transcends distance.

Latencies are not just due to data transmission but also internal processing of data in equipment such as cameras and displays. Because the latter has a major impact on latencies, it is important to choose equipment with the shortest internal-processing time possible to achieve low latency. To share the excitement and sensation of you-are-there realism, it is necessary to enhance the experience in remote locations so the audience there can have the same experience as they would at the main venue. There is thus still much research to be done in providing a richer experience.

The benefits of the APN are not just limited to this type of field demonstration. Because there are many cases in which it can contribute to addressing social challenges by bringing people together so they feel they are side-by-side even when separated, we will use the knowledge gained from remote live event to

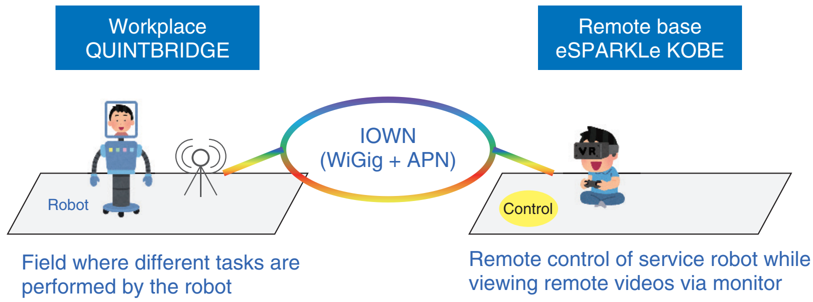

Fig. 2. Real-time remote robot control.

develop applications for the APN.

3. Remote robot control using the APN and high-frequency band radio

In regions with a growing aging population and declining birthrate, the decrease in the working population is a major issue to sustain the local economy. The development of remotely operated robots that can perform necessary tasks anywhere without being limited by physical location or physical characteristics of the operator can be effective for addressing such an issue. However, such development faces the challenge of ensuring sufficient communication bandwidth and low-latency communication, which are necessary for high-resolution video communication and real-time signal exchanges during remote operation. With this background, NTT WEST collaborated with ADAWARP, which provides a platform for remote operation of robots, in a demonstration of real-time remote robot control (**Fig. 2**).

In the demonstration, a service robot in QUINTBRIDGE was controlled remotely from eSPARKLe KOBE, a facility within the NTT WEST's Hyogo branch office, via an APN line. By viewing video from multiple cameras attached to the robot, the robot's operator remotely performed tasks that required detailed operations, such as pressing buttons and opening and closing doors.

Because QUINTBRIDGE is where many workers constantly carry out digital communication exchanges, using a 2.4- or 5-GHz wireless local area network to connect to the robot may lead to operational issues such as throughput degradation due to network-traffic congestion in the facility. Wireless Gigabit (WiGig), which uses the 60-GHz band was thus used to avoid interference with the 2.4- and 5-GHz bands.

High-frequency radio bands, such as the 60-GHz band, cannot penetrate physical objects such as people, walls, and columns, so it is necessary to design base stations that ensure line-of-sight propagation within an area and develop technology to switch between different base stations instantly when a robot moves or rotates to maintain line-of-sight communication propagation with the robot. The first requirement was fulfilled using a direction-diversity scheme, which places multiple base stations along the edges of an area. The second requirement was achieved using NTT Access Network Service Systems Laboratories' site diversity control technology. Specifically, the robot was equipped with two WiGig wireless terminals, each connected to different base stations to ensure communication on two different wireless-transmission channels at all times.

By selecting the wireless terminal providing the best wireless quality for each data packet for transmission, the robot could switch between communication channels on the basis of dynamic monitoring of radio quality, resulting in lack of communication interruption even in an environment with obstructions. Therefore, the robot could transmit 4K-quality video and control signals without interruption caused by radio interference or base-station switching, even when moving within the facility. The robot's operator could thus successfully perform the demonstration's tasks. Even though the 4K video was compressed using the AV1 codec, end-to-end transmission and receiving took about 56 ms. This was less than 100 ms, which is considered the threshold above which latency can be perceived [1]. The demonstration also showed that an APN line can achieve sufficient communication capacity with a trivial amount of latency, even in an environment in which multiple cameras and robot sensors intermingle.

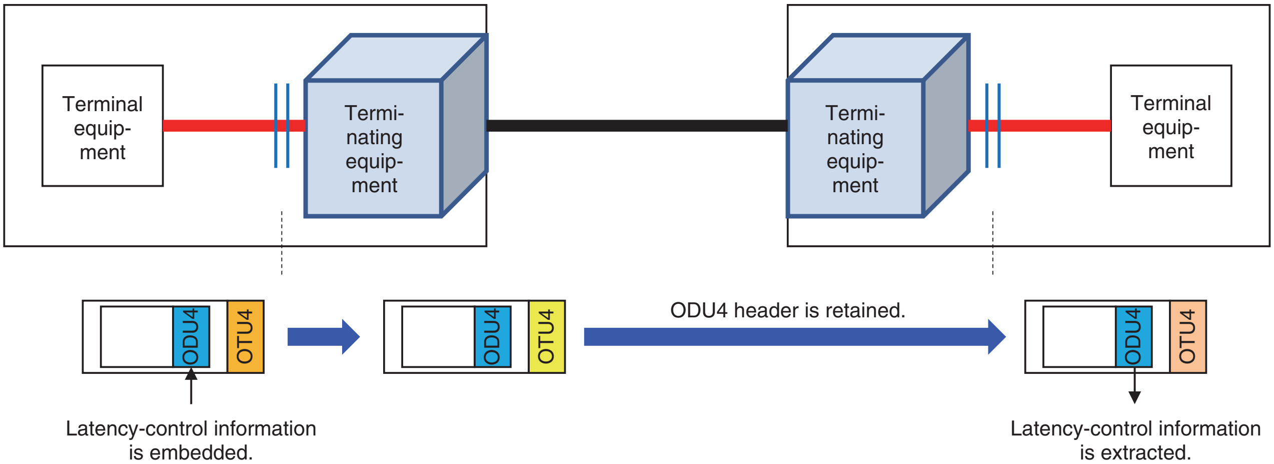

Fig. 3. Optical network service.

4. Launch of APN IOWN1.0 service

NTT is providing the commercial APN IOWN1.0 service with a network service (high-speed broadband access service powered by IOWN) and terminal equipment ("OTN Anywhere" powered by IOWN).

4.1 Network service

APN IOWN1.0's network service achieves low latency and zero signal fluctuations by eliminating data queuing and signal conversion. By using the optical transport unit 4 (OTU4) interface, a network that transparently transports Ethernet signals equivalent to 100 Gbit/s can be achieved (**Fig. 3**).

APN IOWN1.0's network uses the optical transport network (OTN) entirely for segments between user–network interfaces. The OTN provides an encapsulated optical path and transmits and receives data in units with maintenance overhead and error-correction codes assigned for each client signal. By supporting the OTN in all network-service segments, monitoring and control signals for path monitoring and performance monitoring can be propagated end-to-end.

4.2 Terminal equipment

For APN IOWN1.0, OTN Anywhere [2] is used as the terminal device equipped with latency visualization and adjustment functions. A distinctive function of OTN Anywhere is its assignment of latency-adjustment-related control signals to the maintenance-overhead domain, thus achieving end-to-end latency adjustment without network-communication interruption.

5. Creating use cases with partners through social implementation

As the first use case of NTT's commercial APN service (APN IOWN1.0) in western Japan, NTT WEST and Yoshimoto Kogyo carried out a remote entertainment event titled "Mirai no Owaraibu" (Future Comedy Live) on March 20, 2023 by connecting three locations in Osaka City—in Kyobashi (QUINTBRIDGE), Umeda (LINKSPARK), and Namba (Yoshimoto Manzai Theater) (**Fig. 4**).

By connecting the venues using APN IOWN1.0, not only was low-latency video transmission achieved, but the use of large, life-size video displays at two locations, QUINTBRIDGE and the Yoshimoto Manzai Theater, were made possible for this event. Audiences at the two locations could watch real performers at each location and virtual performers from the remote locations via the low-latency life-size video displays as if the performers were all in the same space at the same time.

Thanks to the technological achievements of APN IOWN1.0 in providing a realistic experience of remote performances, 97.3% of the audience at QUINTBRIDGE and the Yoshimoto Manzai Theatre said they "did not feel any latency at all," and 94.5% said they were "satisfied with the event." Through this effort, NTT WEST and Yoshimoto Kogyo succeeded in presenting a new form of entertainment.

6. Summary

We introduced NTT WEST's efforts in carrying out

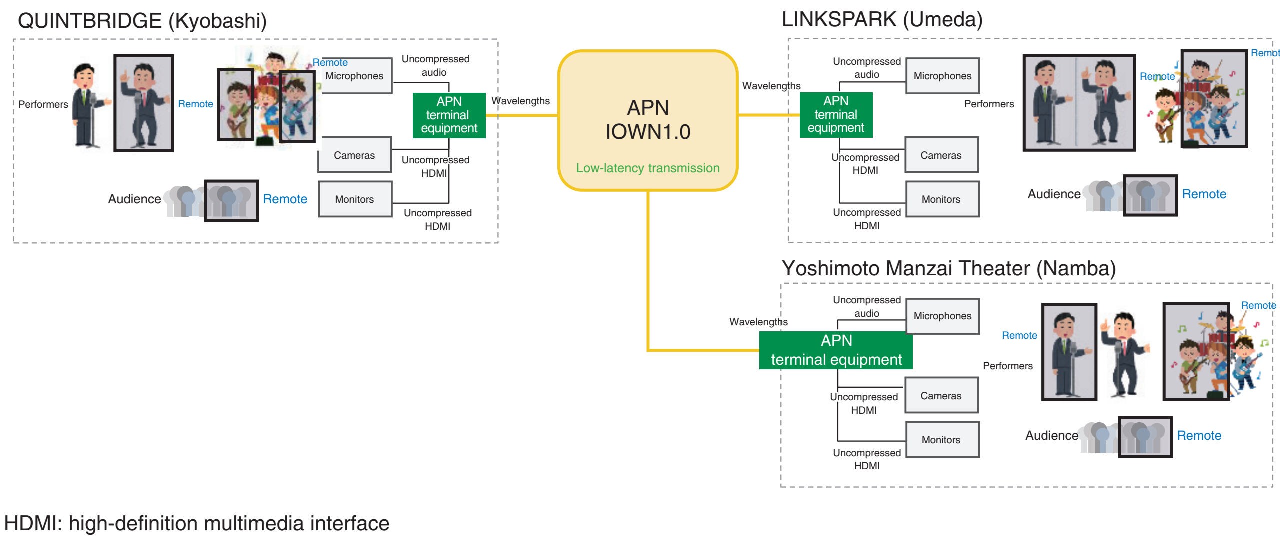

Fig. 4. First use case of commercial APN (APN IOWN1.0) in western Japan.

a remote live event and remote robot control as cases of using the APN to connect IOWN's innovative technologies to solutions for various social challenges. We also presented a summary of the APN service that NTT launched in March 2023 as the first offering of IOWN services along with examples of co-creation with partners using the APN service.

Beginning with the launch of this commercial service, we are also seeking to stimulate the creation of use cases with a variety of partners and apply IOWN to a variety of fields. For example, we expect the APN service to be applied to mobile fronthaul, which is planned as a social infrastructure in a wider range of fields, and to inter-datacenter connectivity. We are engaged in the development of services and technologies with the near-future goal of enabling visitors to the World Expo Osaka, Kansai, Japan to be held in 2025 to experience the value of IOWN through joint ventures with more customers and partners.

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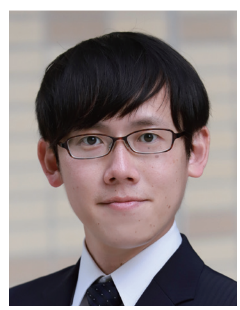

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