APN Service-provision Activities

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Abstract

In March 2023, NTT EAST and NTT WEST launched APN IOWN1.0, the first-version service of the All-Photonics Network (APN), which is one of the major technology areas that comprise the Innovative Optical and Wireless Network (IOWN). APN IOWN1.0 provides ultra-low latency and enables the visualization and adjustment of latency with microsecond granularity. This article describes the position of the newly introduced APN service within the IOWN concept and the value the service provides. It also presents typical use cases and an overview of the service.

Keywords: APN IOWN1.0, ultra-low latency, visualization and adjustment of latency

1. Introduction

On March 16, 2023, NTT EAST and NTT WEST launched APN IOWN1.0, the first-version service of the All-Photonics Network (APN) of the Innovative Optical and Wireless Network (IOWN) [1].

The APN is one of the major technology areas comprising IOWN. It implements photonics-based technology everywhere from terminals to the network, thereby providing end-to-end optical wavelength paths. Its aim is to achieve unparalleled low-power-consumption, high-quality, high-capacity, and low-latency transmission.

With this capability, the APN will address network issues, such as ever-growing traffic volume, network complexity, and latency due to congestion. It will also address energy-consumption issues, such as increases in power consumption at datacenters. The APN will make it possible to provide customers with new experiences and value, such as the fusion of real and online activities that will be required in response to changing lifestyles.

Although the target year for implementing IOWN is 2030, we decided that the value of ultra-low latency can be provided by combining technologies and products currently available. Thus, we studied the possibility of launching the APN service in March 2023, ahead of 2030. The intention was that the early introduction of the APN service would enable us to work with customers to accelerate the creation of new use cases and new value.

The efforts to implement APN IOWN1.0 were led by NTT EAST and NTT WEST in collaboration with the Innovative Technology Office under the NTT Technology Planning Department, whose mission is to commercialize IOWN-related technologies, the IOWN Development Office under the NTT Research and Development Planning Department, which is responsible for promoting research and development of IOWN-related technologies, and NTT laboratories (NTT IOWN Product Design Center, NTT Network Innovation Laboratories, and NTT Network Innovation Center), which are researching and developing APN-related technologies and products (see **Table 1**).

2. APN IOWN1.0 provides ultra-low latency

Of the three performance targets of the APN [2], APN IOWN1.0 offers the value of ultra-low latency with end-to-end latency being 1/200[*1] that of the conventional network. It also features a commercial implementation of “OTN Anywhere,” an optical transport network (OTN) terminal device developed by NTT laboratories that visualizes and adjusts latency with microsecond granularity.

The performance targets of the APN for 2030 are as follows.

(1) 100-times higher power efficiency: We aim to achieve low power consumption by implementing technology that transmits signals all

*1 End-to-end latency being 1/200: Target latency for intra-prefecture video traffic that does not require compression.

Table 1. Organizations involved in the implementation of APN IOWN1.0.

Organization	Role
NTT EAST/NTT WEST	Install equipment and provide service
NTT Technology Planning Department	Promote commercialization of IOWN technology
NTT Research and Development Planning Department	Promote research and development of IOWN technology
NTT IOWN Product Design Center	Promote the implementation of products that adopt IOWN technology
NTT Network Innovation Laboratories	Undertake APN-related research and development
NTT Network Innovation Center	Develop APN-related products

the way through the network to the terminal in optical form as well as by implementing technology of photonics-electronics convergence.

(2) 125-times higher transmission capacity: This will be achieved through the use of new multi-core optical fibers, implementation of high-capacity transceivers, and adoption of high-capacity optical-transmission-system technology.

(3) End-to-end latency being 1/200 that of the conventional network: We seek to achieve ultra-low latency by transmitting information in units of wavelengths, eliminating the need for encoding and compression.

Take video transmission as an example. In a current mainstream Internet protocol (IP) network, it is general practice for a video captured with a camera to be encoded and compressed for transmission over the IP network with the data being decompressed and decoded at the destination before the video is displayed on a monitor. In the APN, however, the OTN*2 protocol is used for high-speed layer 1 communication paths, making optical-wavelength spans end-to-end paths. This eliminates packet queuing at routers and switches in the paths, enabling jitter-free communication with ultra-low latency. Since the APN has high capacity, video can be transmitted without encoding or compression. Thus, the APN reduces latency currently caused by encoding and compression and eliminates jitter that is currently produced by fluctuations in packet forwarding. By using low-latency cameras and monitors, we can minimize latency throughout the entire system.

We provide the capability to visualize and adjust latency with microsecond granularity by connecting OTN Anywhere (**Fig. 1**). This device makes it possible to equalize delays across different locations. This capability is effective and valuable for use cases that require fair timing between different locations, such as e-sports.

3. APN IOWN1.0 use cases

The ultra-low latency provided by APN IOWN1.0 is beneficial not only for e-sports but also for a variety of use cases not achievable with conventional networks, such as the remote operation of surgical robots in areas where doctors are in short supply, remote operation of devices in vast factories and of facilities located high above ground, and remote production in the broadcasting industry through real-time video transmission.

The availability of a network with high performance means that applications in various business fields that have been conventionally processed on-premises can be processed over the network. This will help produce solutions that overturn the conventional way of business (**Fig. 2**).

A typical benefit of ultra-low latency is the ability to perform precise operations and tasks even from a distance (**Fig. 3**). Typical use cases that demonstrate this ability are described below.

3.1 Telemedicine using surgical-support robots

There are concerns over the shortage of surgeons in rural areas and too great a concentration of medical specialists and supervising doctors in urban areas. These concerns have given rise to expectations for telemedicine. Connecting a surgical robot with a remote operator via the APN makes information transmission between them fast and jitter free, facilitating high-quality remote surgical support through stable robot teleoperation. It is also important to provide an environment in which medical personnel at a remote location can feel as if they are in the same room as the patient. Bi-directional communication over the APN enables medical personnel to conduct

*2 OTN: A communication standard for optical transmission networks specified by ITU-T (International Telecommunication Union - Telecommunication Standardization Sector), an international standardization organization.

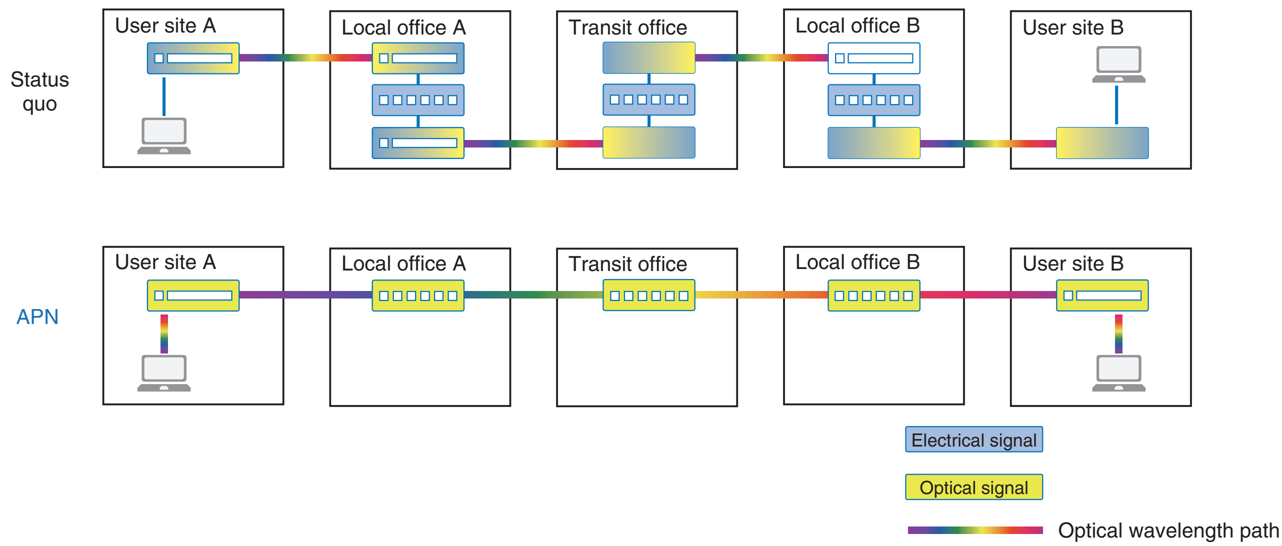
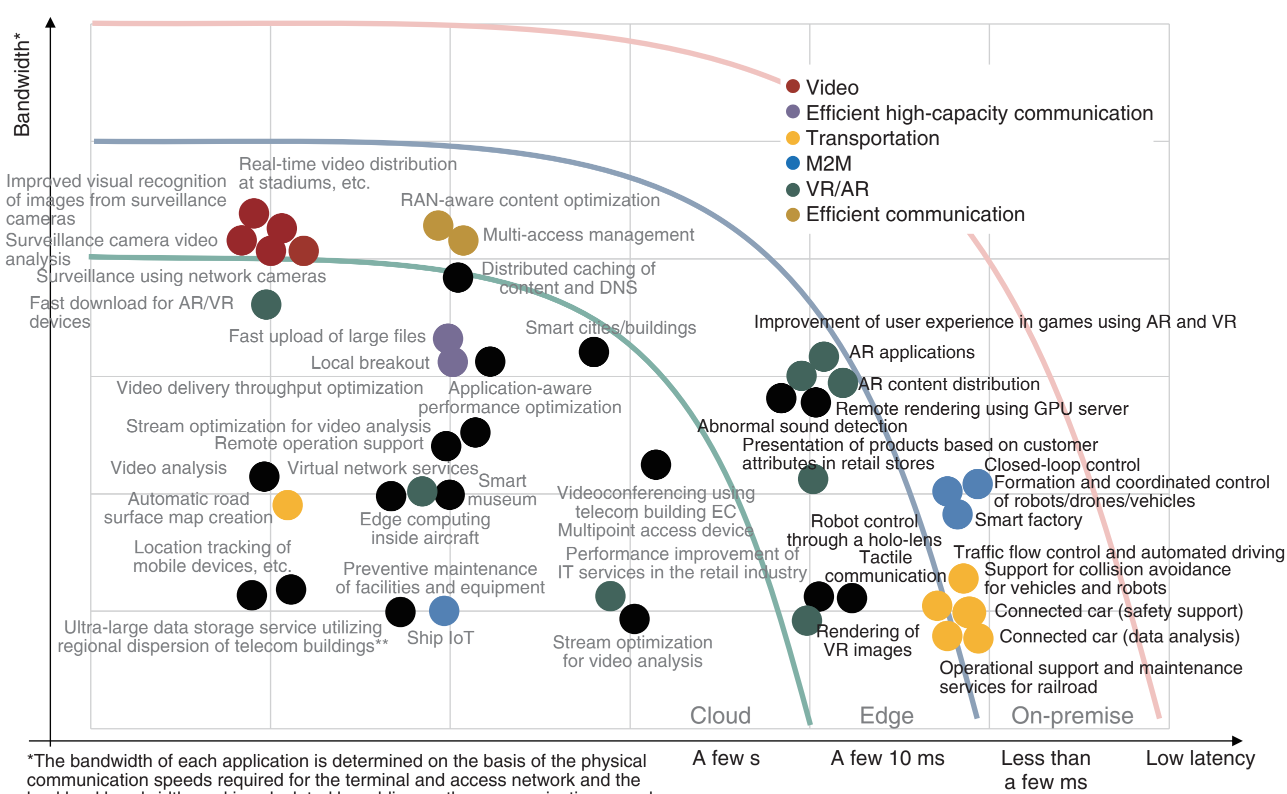


Fig. 1. APN provides ultra-low latency.



*The bandwidth of each application is determined on the basis of the physical communication speeds required for the terminal and access network and the backhaul bandwidth, and is calculated by adding up the communication speed of each terminal multiplied by the number of terminals accessing the edge site.
**The required bandwidth is narrow because storage units are physically delivered.

AR: augmented reality
DNS: domain name system
EC: edge computing
GPU: graphics processing unit
IT: information technology
M2M: machine to machine
RAN: radio access network
VR: virtual reality

Fig. 2. Areas that are expected to benefit from low latency.

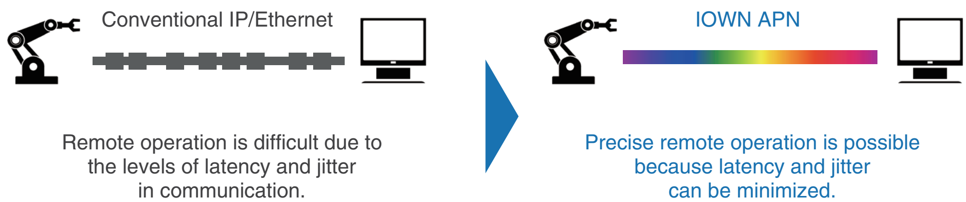


Fig. 3. Image of a use case that takes advantage of ultra-low latency.

surgery while viewing high-resolution images, such as 8K video, of the patient's condition, operating room, and other operational conditions. By supporting telemedicine, we are aiming for further development of regional medical care.

3.2 Smart factories

The low-latency, jitter-free APN makes remote operation possible for a wide range of tasks and maintenance work in vast environments, such as chemical plants and precision-equipment manufacturing plants. Remote fine operations, such as checking equipment and fine-tuning valves located high above ground or in explosion-proof areas, enable skilled personnel to gather in a room in factories and safely perform high-risk tasks. Implementing Internet of Things (IoT) in machines and systems at multiple locations and connecting them via the APN makes it possible to automate manufacturing lines and enables automated remote inspection of products before shipment.

3.3 Remote television production

The broadcasting industry is focusing on remote television (TV) production, a new method of live program production, by which video captured at an event site is transmitted to a program-production site in real time. The high-capacity, low-latency APN enables uncompressed transmission of video between an event site and program-production site. Conventionally, production equipment needs to be brought to the event site, and a program is produced on-site and distributed to broadcast stations. Remote TV production reduces the need to bring equipment and personnel to the event site.

Beyond the examples introduced above, we will endeavor to expand applicable use cases by combining the APN with other IOWN technologies and further evolving the APN. Such attempts include connecting datacenters with the high-capacity and low-latency APN to enable optical disaggregated computing[*3] and applying the APN to mobile fronthaul to rapidly expand the service area of Beyond fifth-generation mobile-communication system (5G)/6G.

4. Overview of APN IOWN1.0

The APN IOWN1.0 service achieves high-speed, high-capacity, low-latency, and jitter-free communication by providing dedicated optical wavelength in all sections of the network and using the optical transport unit 4 (OTU4)[*2], which accommodates multiple optical transmission networks, at APN interfaces. The combined use of OTN Anywhere, which is an APN terminal device, makes it possible to visualize and adjust latency (**Fig. 4**).

(1) Features of APN IOWN1.0

- High speed, high capacity: Dedicated point-to-point 100-Gbit/s paths.
- Low latency, jitter free: Latency 1/200 that of conventional networks, no jitter[*4], and no impact from other users' traffic thanks to the use of a dedicated optical wavelength for each path.

(2) Features of terminal device, OTN Anywhere

- Conversion of information format: The device receives 10-GbE or 100-GbE signals from customer devices, converts them to OTU4, and outputs them.
- Visualization and adjustment of latency: The device visualizes latency by outputting the results of measurements at certain points as an OTN Anywhere log, which can be used to adjust latency with microsecond granularity (8 µs to 20 ms).

*3 Optical disaggregated computing: In contrast to the conventional server-oriented concept in which computers are connected via a network, this concept takes advantage of the transmission characteristics of light by using optical fibers to directly connect computer resources, such as central processing units and memory units, and treats them as a single computer on a datacenter scale.

*4 Latency 1/200 that of conventional networks, no jitter: Time division multiplexing (distinguishing multiple traffic by fixing the time of transmission) is used to reduce traffic-dependent latency and packet loss.

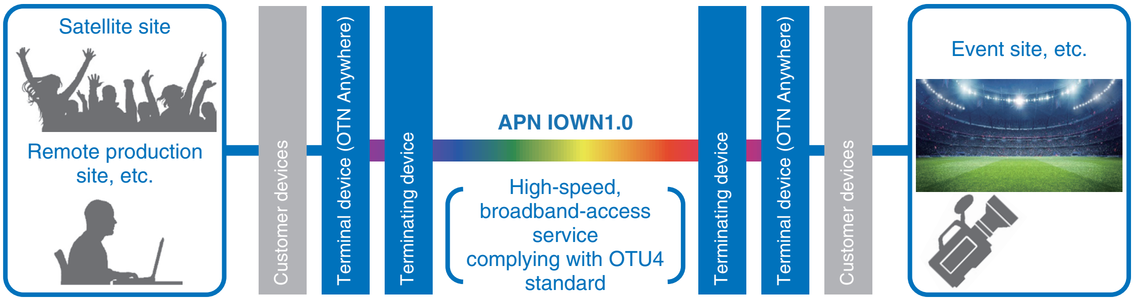


Fig. 4. Overview of APN IOWN1.0 service.

5. Conclusion

We launched APN IOWN1.0 as the first service offering of IOWN. We expect that this early provision of the APN will accelerate the creation of new services in collaboration with external partners as well as the creation of new use cases and value for customers. We will continue to enhance the unique features of the APN, such as low power consumption enabled by photonics-electronics convergence technology and high-quality, high-capacity transmission that uses high-capacity optical-transmission-system technology on the basis of new optical fibers such as multi-core fibers.

References

[1] Press releases issued by NTT EAST and NTT WEST on Mar. 2, 2023 (in Japanese),
https://www.ntt-east.co.jp/release/detail/20230302_01.html
https://www.ntt-west.co.jp/news/2303/230302a.html

[2] Website of NTT R&D, IOWN, https://www.rd.ntt/e/iown/0002.html

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Joining NTT EAST in 2005, he worked as a network planner for regional networks. He was involved in Next Generation Network (NGN) operations from 2007. He was then engaged in the launch of an NGN security task and enhancement in-house systems security until 2021. In his current position, he has been promoting the implementation of services actualizing the IOWN concept.

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Joining NTT WEST in 2007, she worked as a network engineer, mainly formulating the strategy for network enhancement and performing network operations and maintenance. In her current position, which she has held since 2022, she has been promoting the commercial implementation of IOWN aimed at creating new businesses that take advantage of IOWN technologies.