Technology Highlights of ShowNet 2024

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Interop Tokyo 2024 was held from June 12 to 14 in the *Makuhari Messe* exhibition hall. With 542 organizations exhibiting, and 124,482 visitors attending the exhibition, Interop Tokyo is one of the largest IT shows in Japan. *ShowNet,* the large demonstration network for Interop Tokyo, was also built at the venue. In 2024, the ShowNet was comprised of approximately 2,300 products and services in over 20 full-height racks, built and operated by 650 engineers of 31 *Network Operations Center* (NOC) team members, 38 volunteer members, and 581 engineers from vendors who contributed their products to ShowNet. These engineers gathered at Makuhari Messe on May 31 and built the network in two weeks. Figure 1 is a picture of the second day of the ShowNet construction in 2024.

Figure 1: A snapshot of constructing ShowNet in Makuhari Messe on June 1, 2024.

The fundamental role of ShowNet is to provide network connectivity to Interop exhibitors and visitors. Furthermore, ShowNet conducts various experiments and demonstrations of new protocols, technologies, and products while serving user traffic.

In 2024, ShowNet features the following technical topics in each field:

- *Facility:* A high-density MDF with SN connector[1]-based patch panels.
- *Optical Transport:* Multi-vendor optical transport network with emerging optics such as 400GBASE-ZR+ and XR Optics.
- *Backbone Network:* An SRv6 uSID-based backbone network and EVPN-VXLAN for access.
- *Data Center and Cloud:* Distributed container clusters and testing lossless networks for *RDMA over Converged Etherne*t (RoCE) traffic.
- *Wireless Network:* Multi-band Wi-Fi access with Wi-Fi6E and Wi-Fi7-capable APs, and multi-vendor *OpenRoaming* [2].
- *Monitoring:* Integrated monitoring systems with various sensors and user interfaces, and how to exploit AI for future monitoring.
- *Security:* Incorporating multiple aspects of protection and hardening such as SASE, ZTNA, EASM, and NGFW.
- *Tester:* Testing upper layers with protocol emulation for routing and penetration tests for security, and demonstrating automating test processes.
- *5G:* Multiple private 5G systems of RAN and cores with multiple vendors, and demonstrating live streaming over the 5G networks.
- *Media-over-IP:* Professional audio and media are now migrating from SDI to IP: demonstrating real-time broadcasting over IP networks.

In this article, we will describe four of these topics, namely: The *Backbone Network, Optical Transport, 5G,* and *Media-over-IP*.

The Backbone Network

The backbone network of ShowNet is the core of the all experiments and demonstrations. In 2024, the backbone network was composed of ten routers of nine products listed in Table 1. In addition, two containerized routers, XRd from Cisco Systems and cRPD from Juniper Networks, performed route reflectors for BGP. With those routers, we built the backbone network based on Segment Routing while conducted SRv6 uSID interop.

Table 1: *Routers composing the backbone network of ShowNet in 2024*

Vendor	Product
Cisco Systems	Cisco 8201-32FH, Cisco 8608, NCS-57B1
Furukawa Electric	FX2
Huawei Technologies	NE8000-M4
Juniper Networks	ACX7348, MX204, MX304, PTX10002-36QDD

Segment Routing (SR) [3] is a recent routing and forwarding paradigm that enables source routing. In SR, any topological entities are represented by segments, for example, nodes, links, and adjacency. SR nodes control where packets should flow and how packets are processed by embedded a series of segments into a packet. SR has two concrete data plane implementations: SR-MPLS leveraging *Multi-Protocol Label Switching* (MPLS) labels as *Segment Identifiers* (SIDs) and SRv6 leveraging IPv6 addresses as SIDs. An MPLS label stack encapsulating a packet indicates a SID list in SR-MPLS, and IPv6 addresses in a *Segment Routing Header* [4], which is a new IPv6 extension header, also indicates a SID list in the SRv6 data plane.

A major use case of SR is *Layer-3 VPN* (L3VPN). Figure 2 illustrates a simple example of SRv6-based L3VPN. Two SRv6 routers perform Provider Edge nodes for two customer sites, and exchange VPN prefixes via *Multi-Protocol Border Gateway Protocol* (MP-BGP). Note that the next-hops for those VPN prefixes are SRv6 SIDs: the ingress SRv6 router encapsulates packets from the customer site A to site B with IPv6 headers whose destination address is the SID (**`6:2::b`**) of the egress SRv6 router.

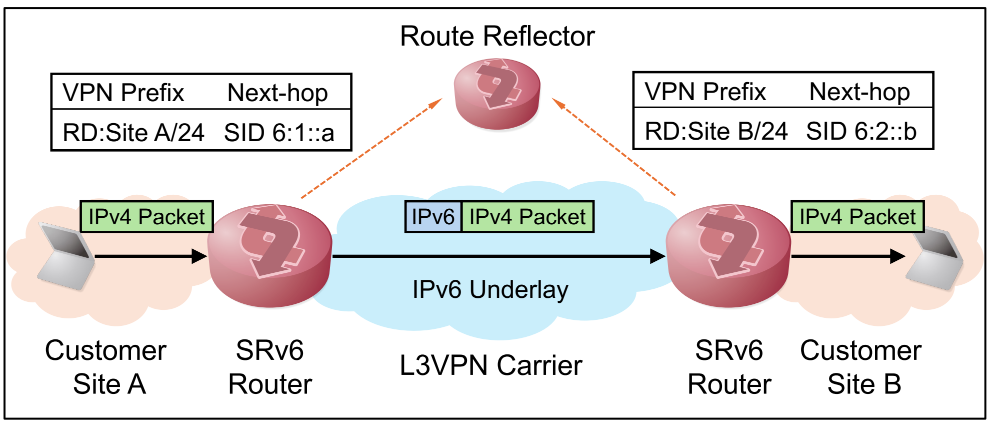

Figure 2: A simple example of SRv6-based L3VPN

For ShowNet at Interop Tokyo, we have been continuously working on Segment Routing since 2018. In 2018, we conducted a simple and small interoperability test of the SR-MPLS and SRv6 data planes, and in 2019, we demonstrated service chaining over SRv6 with multiple vendors' products. Since 2021, we have deployed SR on the ShowNet backbone networks. The backbone network of ShowNet 2021 was composed of SR-MPLS, and we further conducted a measurement experiment on Internet latency using SR-MPLS-based *Egress Peer Engineering*, which enables steering specific egress traffic to given eBGP peers. The results of the experiment were published in a paper [5] and in an APNIC blog post [6]. In 2022 and 2023, the ShowNet backbone was fully SRv6-enabled, and IPv4 addresses were eliminated—interfaces of backbone links had no IP addresses configured thanks to IPv6 link-local addresses. Our chronicle with SR was summarized in a presentation in APRICOT 2024 [7].

In 2024, a main topic in the backbone network is SRv6 micro SIDs (uSID). uSID, also known as the NEXT-C-SID flavor in [8], is a mechanism for compressing SID lists in SRv6. A SID in the original SRv6 is a 128-bit IPv6 address, thus encapsulating packets with multiple SIDs for, for example, traffic engineering, involves non-negligible overhead on MTU sizes. uSID encodes multiple SIDs into a 128-bit IPv6 address format to avoid the overhead. Figure 3 illustrates a uSID structure with F3216 format [9], which implementations must support at present.

The first 32-bit is a uSID block that all routers in an SRv6 domain shares. The following 16-bit blocks are uSIDs. When the first uSID (`fcbb:ccbb:0001:...`) is processed by an SRv6 node, the node shifts the 80 bits from the second to the last uSID 16 bits to the left and overwrites the first uSID. In other words, the new destination address of the packet is `fcbb:ccbb:0002:0003:0004:0005::`, and the packet is forwarded to the next SRv6 node having the uSID 0002. This brand-new packet forwarding mechanism is currently being implemented in router products of multiple vendors, and we confirmed that uSID interoperability between the devices listed in Table 1 was successfully achieved in ShowNet 2024.

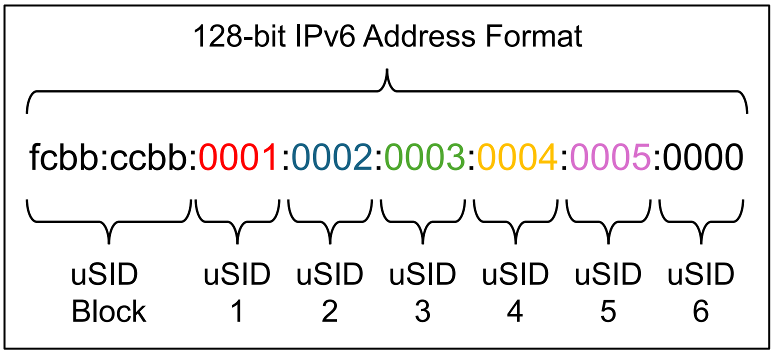

Figure 3: A uSID structure with the F3216 format.

The second topic is a demonstration for campus and enterprise networks. Customers of ShowNet are exhibitor booths; it means that the last one hops to the booths are several hundreds of UTP cables spread over the exhibition halls. Accommodating those access circuits becomes a technical demonstration of campus and enterprise networks. This year, we built those access networks as L2 and L3VPN with *Ethernet VPN* (EVPN) and *Virtual eXtensible Local Area Network* (VXLAN) by campus switches from multiple vendors.

VXLAN [10] is an Ethernet over IP tunneling protocol, and EVPN is a BGP-based control plane that can construct overlay fabrics using VXLAN as its data plane [11]. EVPN-VXLAN was originally designed and introduced for data center use; therefore, switches and routers that primarily were intended for use in data centers supported these protocols in the early days. Over the years, recent switches for campus and enterprise networks, which are different product lines from those for data centers, have begun to support EVPN-VXLAN for campus use. Adopting Ethernet overlays for campus networks will eliminates (often fragile) spanning tree protocols and provide scalability and resiliency by underlying dynamic routing protocols.

The access network in ShowNet 2024 was composed of three routers and eight switches of seven models listed in Table 2. All devices exchanged EVPN routes via route reflectors, constructed a VXLAN fabric, and forwarded user traffic over the fabric. User VLANs could be extended between the switches over the IP underlay. In addition, EVPN can construct L3VPNs using EVPN Type-5 routes [12]. We also confirmed that the EVPN Type-5 route interoperability works well with these devices.

Table 2: Routers and Switches composing the access network with EVPN-VXLAN

Vendor	Product
Cisco Systems	Catalyst 9300, Nexus 93108TC-FX
Huawei Technologies	CloudEngine S5732, NE8000 M4
Juniper Networks	EX4400, MX304, SRX4600

While SRv6 uSID and EVPN-VXLAN for access were major topics, the demonstrations were not limited to just these two. Other demonstrations and technical challenges were also conducted at the ShowNet backbone network, for example, an experiment of SRv6 over a satellite for disaster recovery, testing *Path Computation Element Protocol* (PCEP), and total 2Tbps external circuits including a capacity of 1.8Tbps provided by Open APN.

Optical Transport

The optical transport network in ShowNet multiplexes waves on fibers to optimize fiber utilization while showcasing products in this area. Furthermore, the optical transport network in 2024 engaged in challenges, including interoperability tests, as with other layers above Layer-2. The topics in 2024 were as follows:

- Utilizing multi-band connections of C-band and L-band.
- Interoperability between 400GBASE-ZR+ transceivers based on OpenZR+.
- 1:N point-to-multipoint connections by Open XR Optics.

The optical transport network in ShowNet 2024 consisted of multiple *Wavelength Division Multiplexing* (WDM) networks. One of the WDM networks used a *Reconfigurable Optical Add-Drop Multiplexer* (ROADM) with C-band and L-band wavelengths, connecting transponders and muxponders with capacities ranging from 400Gbps to 800Gbps. This WDM network also provided connections of 100GBASE-LR4 and 400GBASE-FR4 to the backbone routers. In addition, we conducted an interoperability test of 400GBASE-ZR+ transceivers here. 400GBASE-ZR+ [13] employs coherent optics that enable configuring and transmitting multiple wavelengths so that they can remove transponders. Different manufacturers provide coherent optics equipped with *Digital Signal Processing* (DSP), and we confirmed that they operated correctly in various combinations. Using this infrastructure, we also tried to transfer wavelengths directly from a carrier through the optical transport network built at ShowNet in collaboration with the carrier.

Another WDM network conducted a test of coherent 100GBASE-ZR in the QSFP28 form factor, which was developed after 400GBASE-ZR+ emerged, with ROADMs using C-band wavelengths, in addition to the interop of 400GBASE-ZR+ transceivers. Further, we deployed XR Optics [14], which enables point-to-multipoint optical connections. Deploying Open XR Optics with a ROADM was the first challenge, and it was successfully completed by strong cooperation with each vendor of the transceiver, transponder, ROADM, and *Erbium-Doped Fiber Amplifier* (EDFA) at ShowNet.

5G

Private 5G networks are wholly owned and operated 5G networks that enable individual companies to possess spectrum for their purposes. In Japan, private 5G networks are recognized as Local 5G. This type of private 5G and local 5G is defined as *Standalone Non Public Network* (SNPN) in 3GPP standards. We have been conducting private 5G experiments in a part of ShowNet with 5G-related vendors and integrators since 2022. This year, we deployed three different private 5G networks with multiple vendors and conducted two demonstrations: live streaming in NOC guided tours in the exhibition using the 5G networks to improve participants' experience and provided Internet connectivity to several exhibition booths. In addition, we designed a stable and redundant *Precision Time Protocol* (PTP) [15] network for the 5G networks. In this demonstration, we constructed three private 5G networks that utilize licensed n79 spectrums in Japan. The demonstration highlighted the advantages of private 5G networks over mobile carriers' 5G services, including low latency and guaranteed access in licensed areas.

NOC guided tours in the exhibition adopted real-time video streaming with the private 5G systems for this year. The tours, called the *ShowNet Walking Tours,* are where a NOC team member gives a talk about design concepts and underlying technologies for every rack. However, the areas around the racks were crowded and noisy during the exhibition, so it was difficult for tour participants to see the equipment that NOC members were describing. Furthermore, technologies and devices introduced during the tour are extensive; therefore, conveying these clearly to the tour participants through only verbal explanations is also challenging.

To address the uncomfortable situation in the tours, we streamed the voice and live movie of the tour guide describing the racks to attendees' 5G-capable tablets and smartphones. Encoded movies and audio were transported to a decode server located in a ShowNet rack via a 5G system. Then, the decoded movie was mixed with supplemental slides and was presented on the attendees' tablets at the right time. An on-premises streaming server delivered the edited movie and audio to attendees' 5G tablets and smartphones via two different 5G networks. Figure 4 and 5 show that a camera is recording a tour guide describing a ShowNet rack, and the video is mixed with slides. Tour attendees watch the mixed stream, as shown in Figure 6.

Figure 4: Live broadcasting with private 5G-enabled smartphone cameras.

Figure 5: Mixing the received video image with a slide related to what the NOC member is describing.

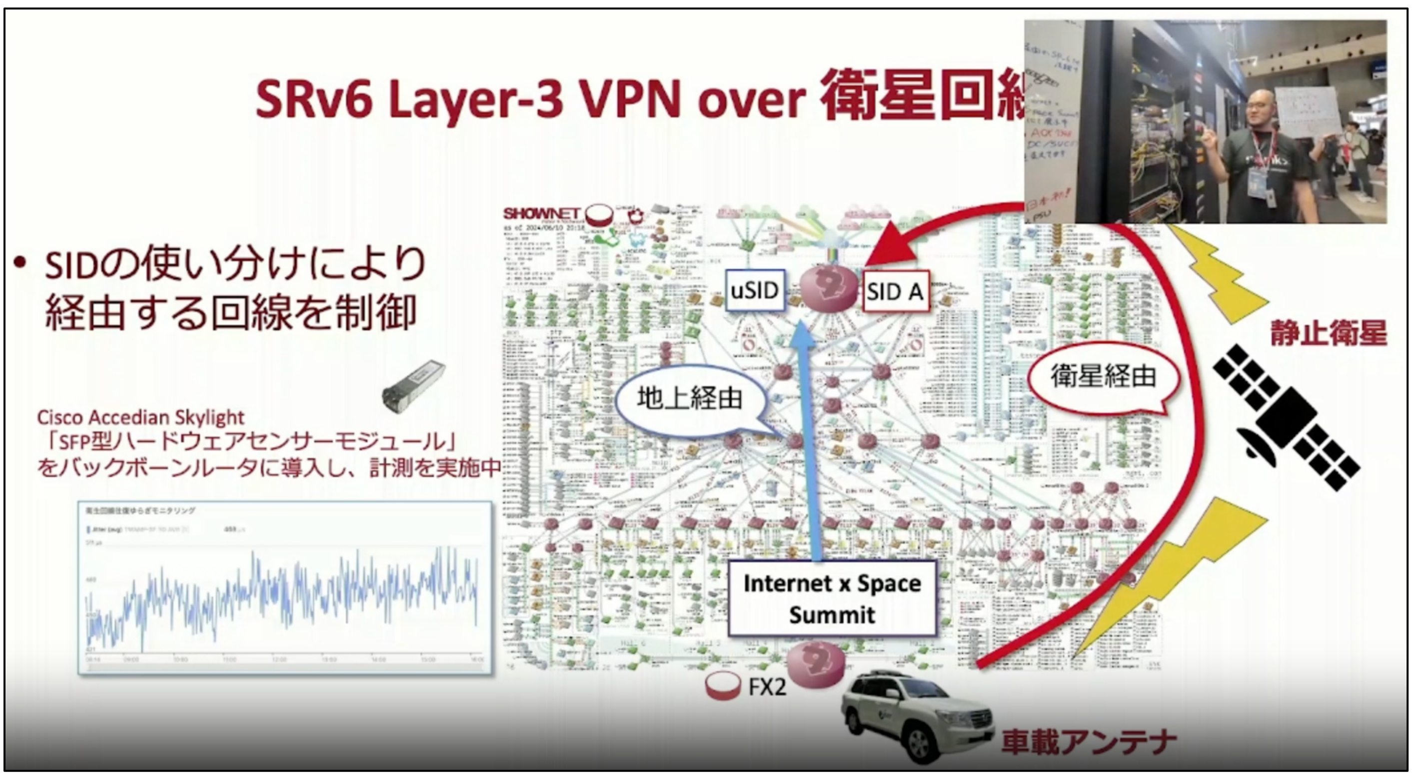

Figure 6: Video images delivered to tour attendees' tablets and smartphones.

This demonstration using the 5G systems provided very stable live streaming on the exhibition halls, in contrast to using Wi-Fi. Wi-Fi access was also available, but the Wi-Fi public bands of 2.4GHz and 5GHz were already experiencing congestion due to massive visitors' mobile Wi-Fi devices. Therefore, latency and available network bandwidth were unstable, and it was not easy to provide guaranteed streaming. Wi-Fi 6E, which uses 6GHz channels, still has not been congested because of the small number of capable devices. However, it is anticipated that this situation will change next year.

Media-over-IP

Professional audio and media are now migrating from *Serial Digital Interface* (SDI) cables, which have low transfer rates and high costs, to Ethernet/IP-based systems for higher transfer rates and lower costs due to the availability of commodity equipment. ShowNet has featured these media-over-IP solutions as one of the main topics since 2022. This year, we collaborated with broadcasters pursuing the transition to IP in broadcasting to explore the possibilities of media-over-IP networks and services for broadcasting industries; we attempted to connect and exchange media between the ShowNet booth and three geographically distributed broadcasting stations over IP networks.

In the ShowNet booth, we built the *Media Operation Center* (MOC), a broadcast control room for media production and remote operation with IP-based systems. Using this MOC, we demonstrated real-time recording, editing, and broadcasting of a stage where many sessions were held during the exhibition. Additionally, this facility also supported live mixing and streaming on the tours with the 5G demonstration described above.

Media-over-IP technologies are standardized by the *Society of Motion Picture and Television Engineers* (SMPTE) [16], and its standards are prefixed with SMPTE. For example, the SMPTE ST 2110 series [17] defines protocols and parameters for professional video, audio and data over IP transport.

Figure 7: The Media Operation Center at the ShowNet booth.

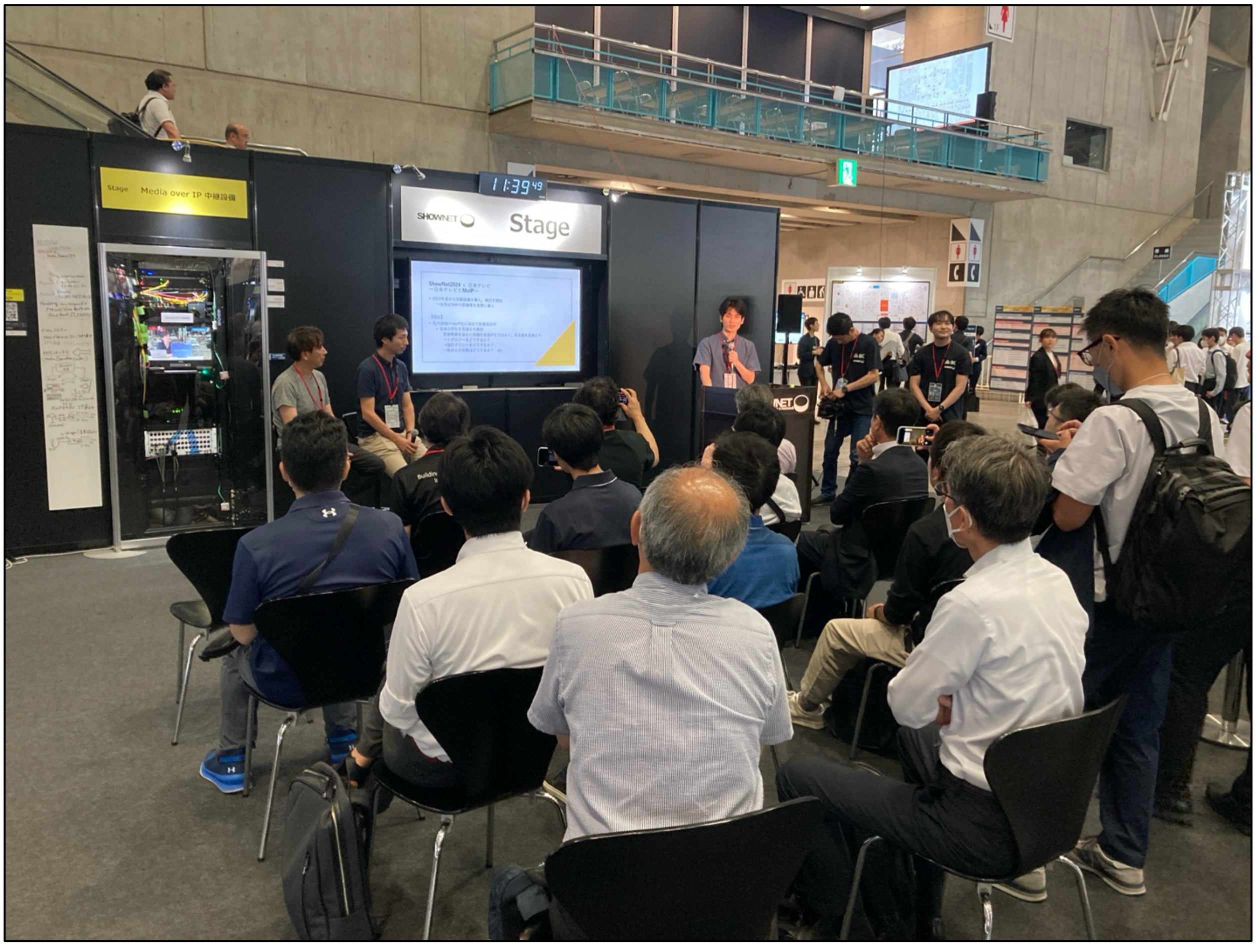

Figure 8: A stage broadcasted by the media-over-IP systems deployed on ShowNet.

From the network viewpoint, those media traffic are RTP streams over IP multicast, and media endpoints speaking the protocols require PTP to synchronize clocks. Thus, in ShowNet 2024, we built a Layer-3 multicast network with OSPFv2 and PIM-SM for the control room by using Cisco Nexus series and Huawei Cloud Engine switches. These switches are capable of PTP for broadcast profiles (SMPTE ST 2059-2). Furthermore, we configured Layer-2 VPN and Layer-3 VPN connections using VPN devices for media transmission and control between two broadcasting stations in Tokyo (30km away from the venue) and a station in Sapporo (830km away from the venue) over the Internet. These connections established a remote production environment between the broadcasting stations and the MOC booth at ShowNet.

We demonstrated media production with the remote broadcasting stations over IP networks during the three-day exhibition. Traffic transferred through the networks were bidirectional uncompressed video streams (SMPTE ST 2110-20, 1080i with 59.94Hz, up to 1.3Gbps per stream) and compressed video streams by JPEG-XS (SMPTE ST 2110-22, 1080i with 59.94Hz, up to 200Mbps per stream). Additionally, sensors embedded in *Small Form-factor Pluggable* (SFP) modules from Accedian were placed at a ShowNet rack and the broadcasting stations to enable active monitoring by *Two-Way Active Measurement Protocol* (TWAMP) measurements. This setup allowed us to observe real-time network performance impacts on media traffic.

During the event, we collaborated with broadcasting industry members to conduct live broadcasting and video production of sessions at the exhibition. Eventually, all media transport and equipment operations between the broadcasting stations and the Media Operation Center at the ShowNet booth were conducted entirely over IP.

Conclusion

In this article, we have introduced technology highlights from ShowNet in 2024. ShowNet covers broader aspects of networking technologies and conducts demonstrations from Layer-1 to Layer-7. Unfortunately, if we were to explain all the topics in detail, we would not know how many pages it would take. So, this article picked up four topics: the backbone network, optical transport, 5G, and media-over-IP, and briefly described these technical overviews.

ShowNet is a show in the Interop exhibition; it is an ephemeral network built and operated for just three days, different from ordinary networks. However, we do not let the show network end as just a show. Through conducting various experiments and demonstrations, as described in this article, we aim to encourage network communities in Japan, foster relationships between engineers, and contribute the knowledge and insights gained at ShowNet to society.

Acknowledgments

The design, construction, and demonstration of the ShowNet network were made possible through the collaboration of NOC team members, contributing vendors and their teams, and ShowNet Team members. We would like to thank all the people involved in the ShowNet in Interop Tokyo 2024.

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