

# Integration of the Heterogeneous All Optical Network and Intelligent End-to-End Automation in Hybrid Cloud Era

iPOP2025 Showcase

We showcase end-to-end network service and slice management empowered by hybrid cloud-based orchestration and machine learning, including latency-sensitive communications, distributed edge/data center networks, and open/disaggregated optical networks for B5G/6G era.

## Interop Showcase Committee

Co-Chairs: **Shinya Nakamura**, UBiquo, Japan  
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Advisors: **Noboru Yoshikane**, KDDI Research, Japan  
**Satoru Okamoto**, Keio University, Japan  
**Hyde Sugiyama**, Red Hat, USA



## Motivation

- (1) Open/disaggregated packet and optical network systems
- (2) All-optical/photonic networks
- (3) Remote control/orchestration
- (4) Machine learning-based networking
- (5) Lifecycle management in cloud and edge computing
- (6) In-network computing for network service application
- (7) Enhanced technology of network security
- (8) Monitoring/streaming telemetry
- (9) Technologies for robust networks
- (10) Technologies for network Digital Twin
- (11) Multi-domain integration & control
- (12) Autonomous Network (NEW)
- (13) Applications for the Beyond 5G (NEW)

## Locations & Network Configuration

### Validation of Heterogeneous Technology Integration & Interoperability:

- Combining diverse optical, network, application technologies (transmission systems, switching systems, fiber, control/management systems, use-case applications etc.) from each organization enables the evaluation of real-world interoperability and system stability, identifying potential issues early on.

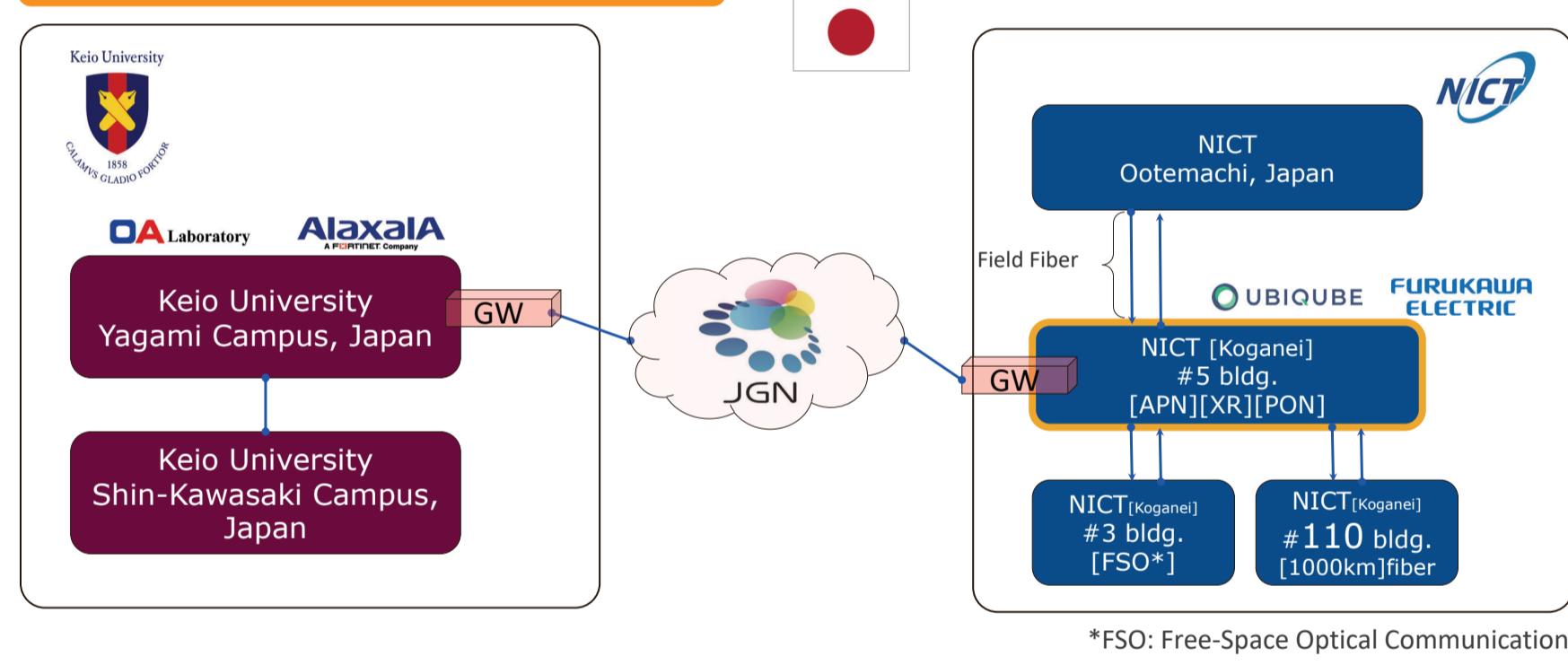
### Cultivation of Young Researchers & Engineers:

- Cross-organizational collaboration promotes knowledge exchange and expands the perspectives of young talent, fostering innovative ideas.

### Synergistic Effect through Joint Research:

- Sharing challenges and collaboratively seeking solutions streamlines R&D.

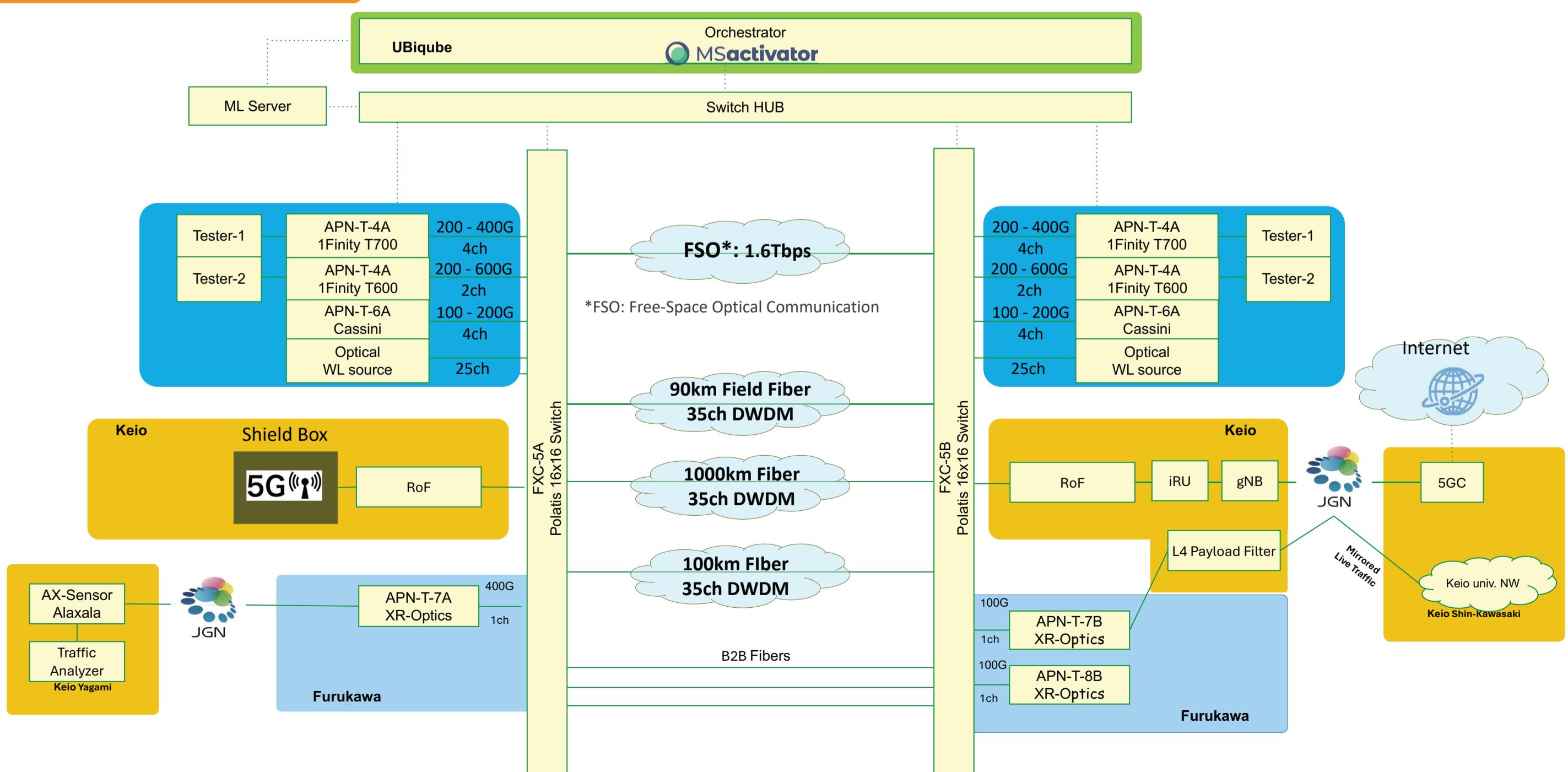
## Locations & Network Configuration



## Photo@Koganei



## Locations & Network Configuration



### Interop Showcase Committee

#### Showcase-1 (NICT): ML-assisted Networking and End-to-end Transmission over FSO, Field Fiber, Long Distance Fiber Networks

- 1A: Over 1 Tbps Transmission through 1,000 km long distance fiber link with burst-mode EDFA, 90 km field fiber link, and 50 m FSO link
- 1B: ML-assisted Networking/Orchestration for Human-in-the-loop control
- 1C: Disaster Recovery Strategy with Multi-Carrier Cooperation
- 1D: Optical Testbed Data Sharing

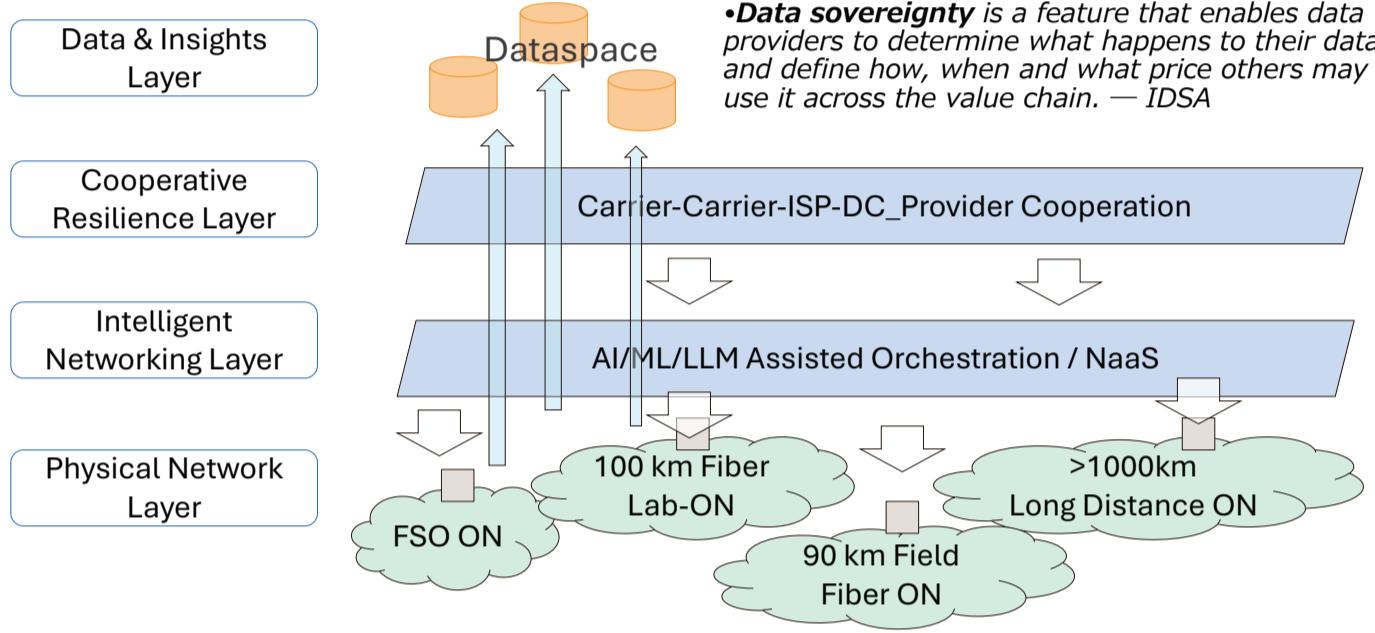
#### Showcase-2 (Keio University, Alaxala): Local 5G over APN and Secured Packet Analysis

- 2A: Local 5G Mobile Fronthaul, Analogue RoF Networking over RoF
- 2B: Traffic Analyze with L4 Payload Filtering

#### Showcase-3 (Furukawa Electric, NICT): XR optics PtMP transmission over FSO

- 3A: Signal quality of XR optics after 100Gbps x 2 Point-To-Multipoint(PtMP) transmission over FXC and FSO.

### Locations & Network Configuration

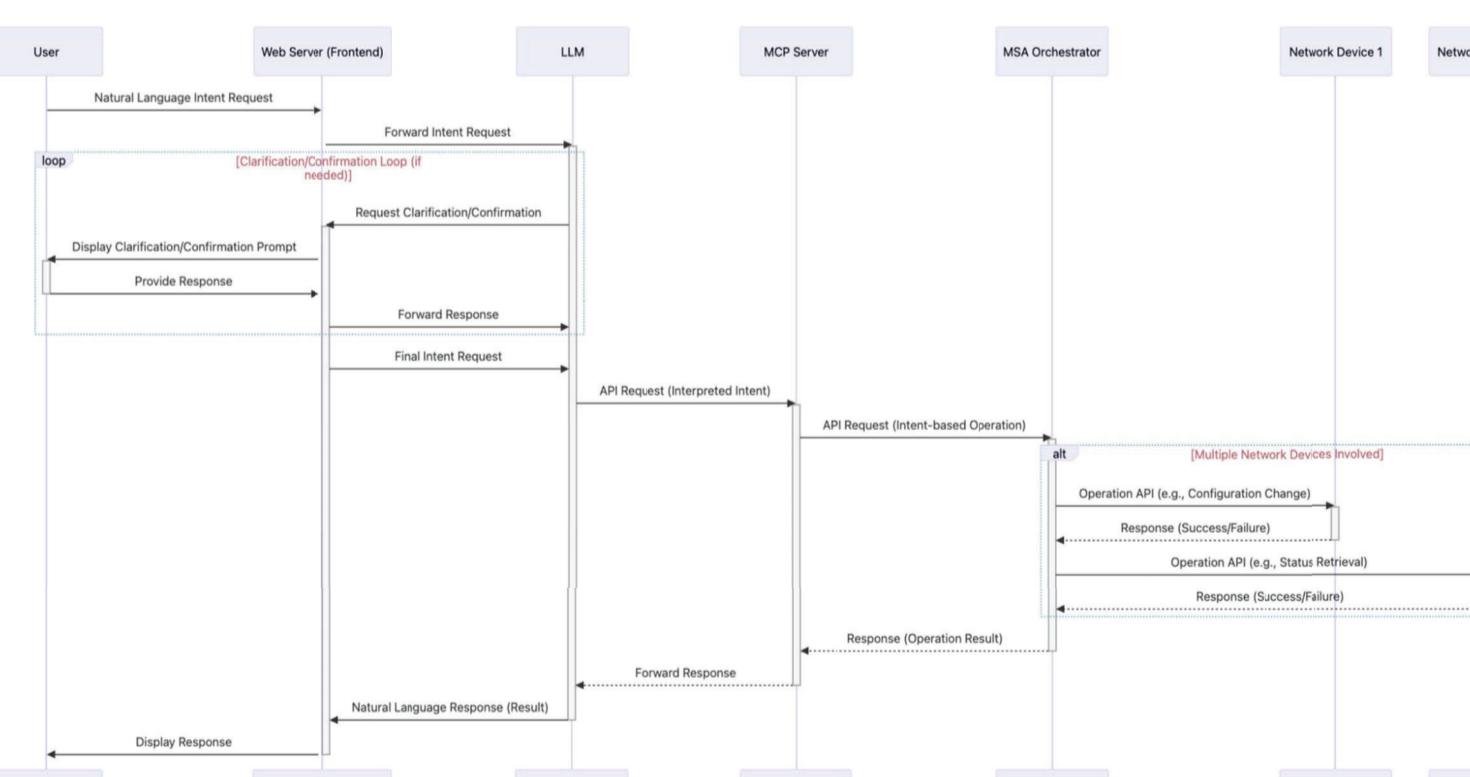
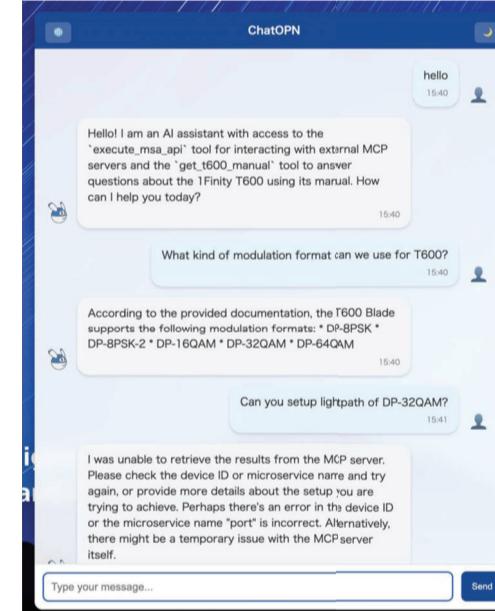


### ML/LLM-based Optical Network Management System

- LLM-Powered Automation:** Leveraging Large Language Models (LLMs) for dynamic network configuration, anomaly detection & proactive optimization.
- Seamless Orchestrator Integration:** Working with existing infrastructure – direct API connectivity to our MCP server-based network orchestrator for streamlined operation.
- RAG-Enhanced Knowledge Access:** Real-time access to operational manuals & troubleshooting guides via Retrieval Augmented Generation (RAG). Eliminates reliance on slow manual searches.

#### LLM-assisted Optical Network Management System

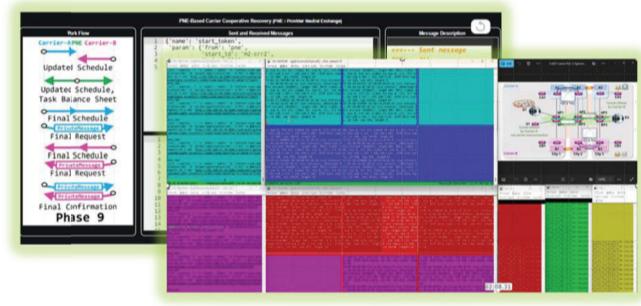
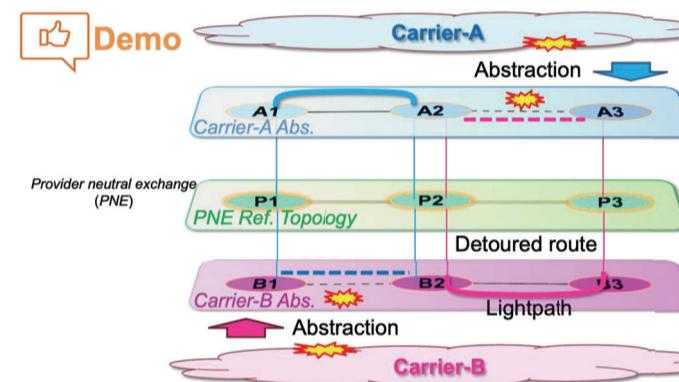
- Manage optical networks
- Manual etc. based Q&A chat



### Blockchain-based Carrier Cooperative Recovery

We present our latest development and experimental validation of carrier cooperative recovery for enhancing the resilience of optical packet transport networks. Experimental results prove that, in cases of resource shortages caused by, for example, traffic congestion, failures, man-made or natural disasters, swift and low-cost recovery can be achieved by exploiting the interconnection capabilities among carriers. This reveals a novel use case of interconnection technology.

#### How to cooperate in recovery?

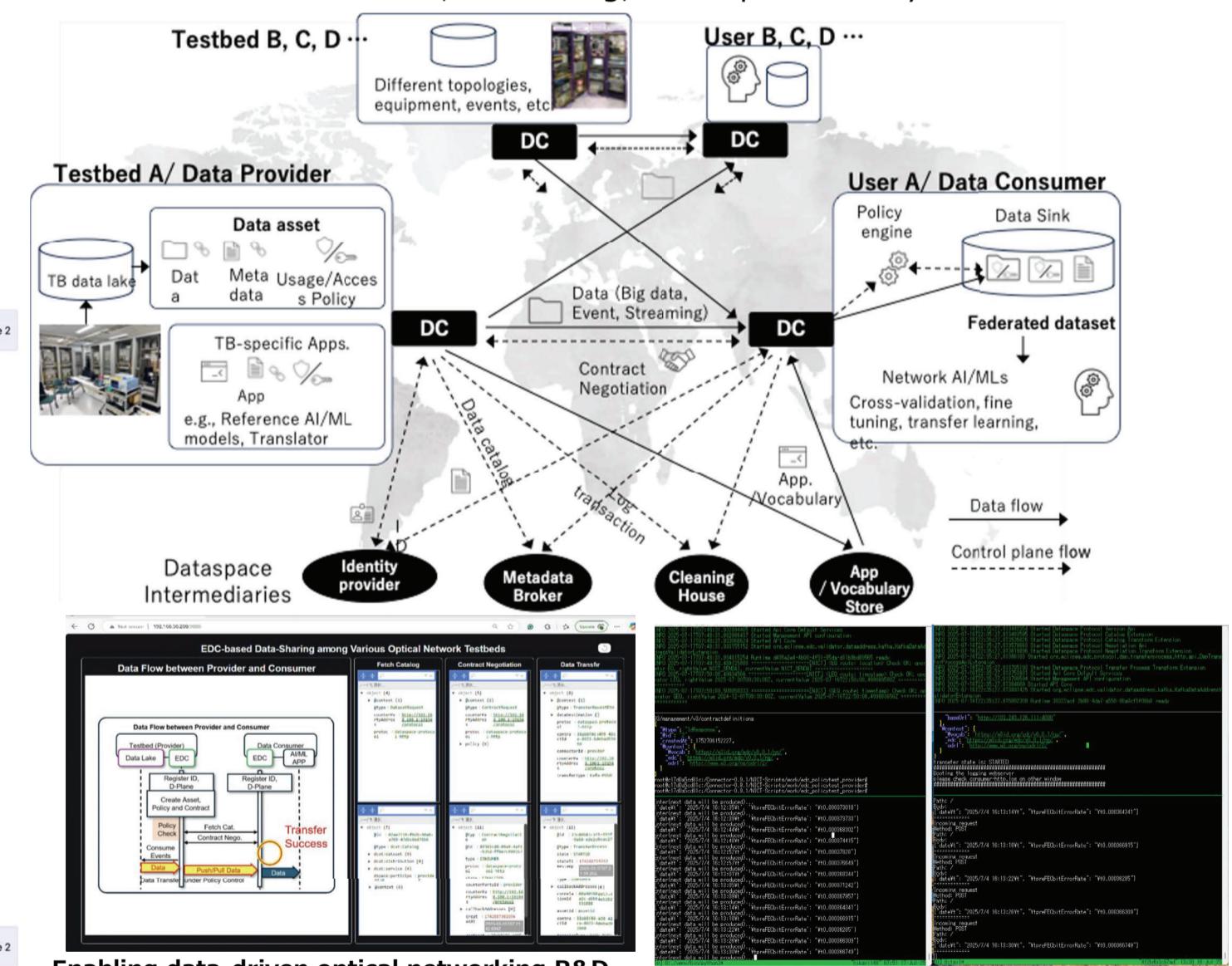


Find the best location/time for cooperation with abstracted view.

Experimental validation of carrier cooperative recovery

### OTDS: Optical Network Data Sharing

Shift toward data-driven innovation: Optical networking research increasingly relies on data for simulation, AI training, and reproducibility



Enabling data-driven optical networking R&D

### Photo: Kogane (NICT) & Yagami/Shin-Kawasaki Campus (Keio Univ.)



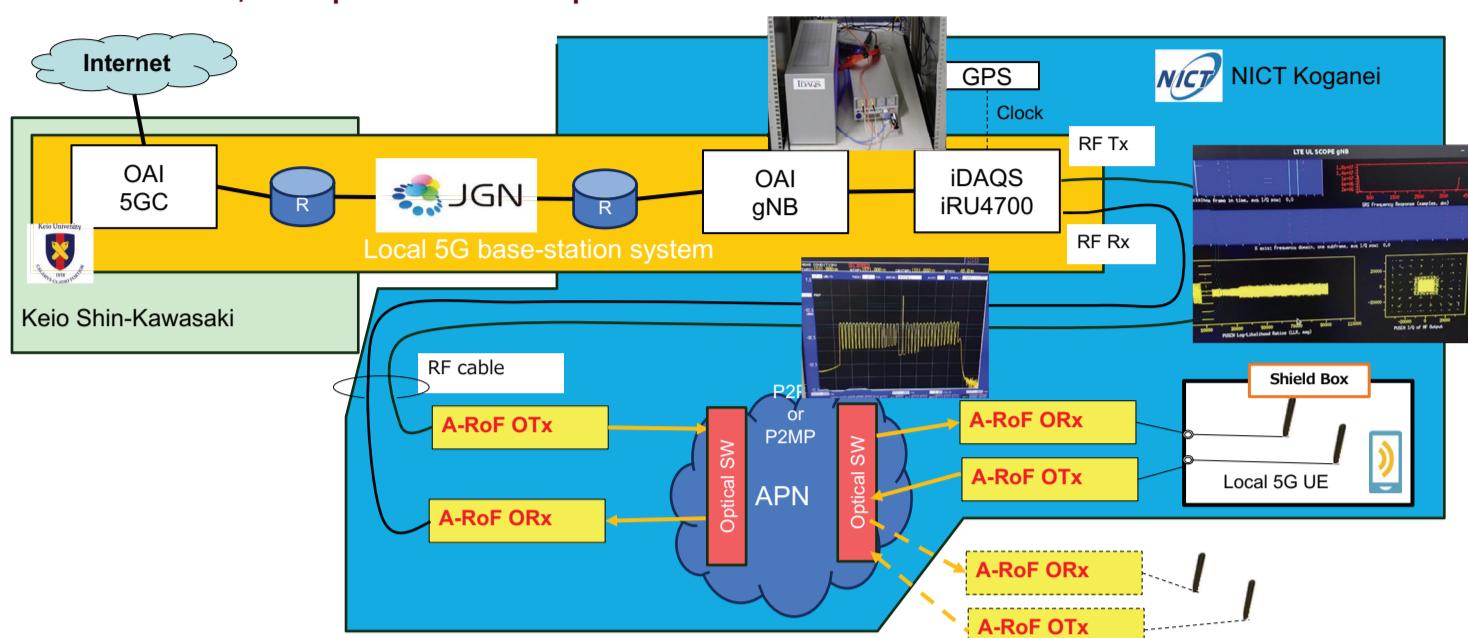
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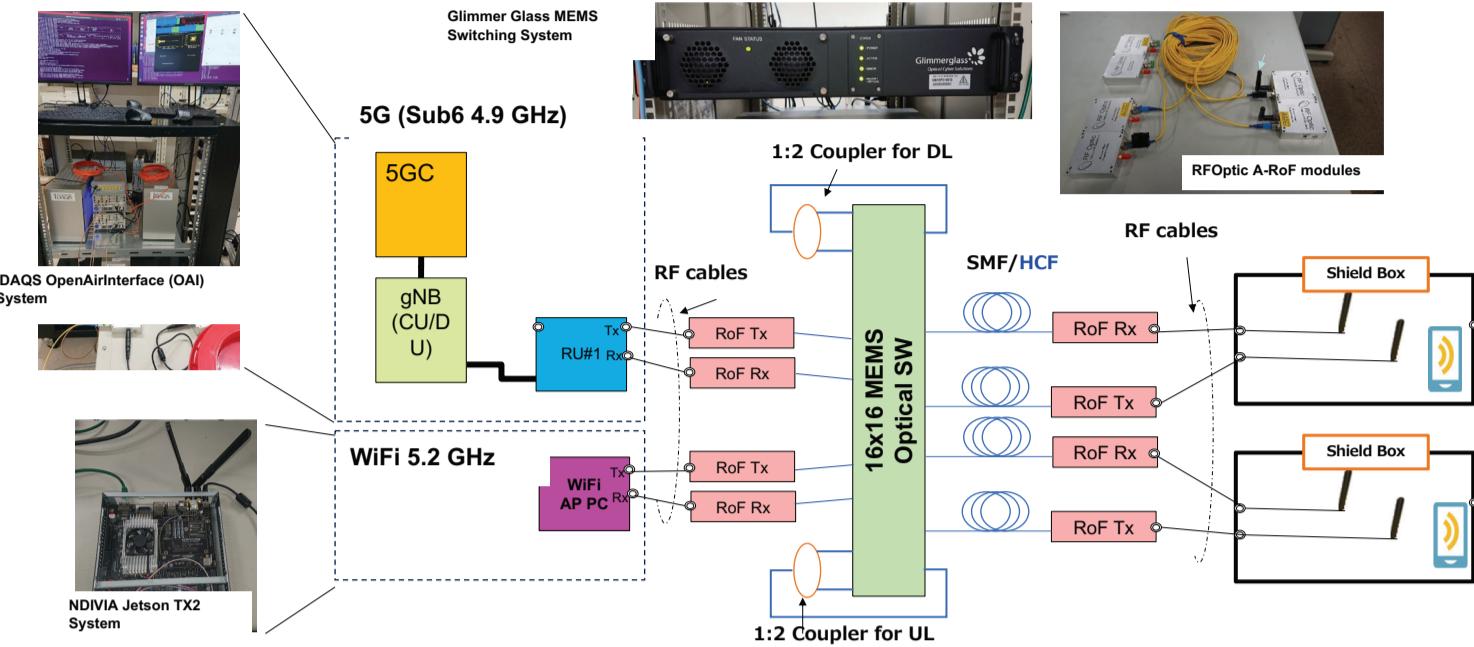
## 2. Local 5G over APN and Secured Packet Analysis

### Analog Radio over Fiber Networking

- Local 5G system over JGN and APN
- "Switched/Multipoint RoF" over all photonics network

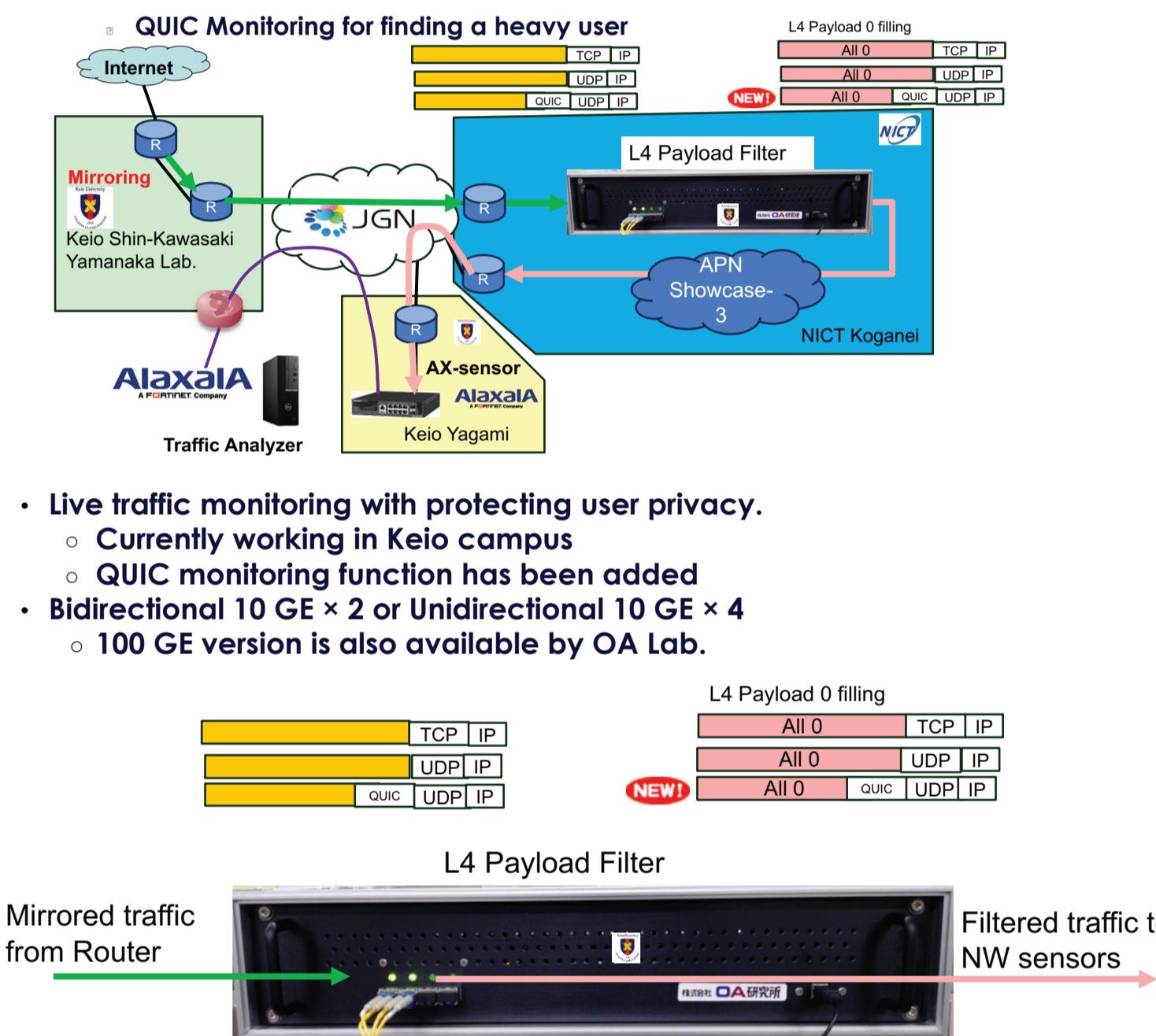


- Analog RoF networking testbed with field installed Hollow-core Fiber is constructed in Keio Shin-Kawasaki Campus



## 2. Local 5G over APN and Secured Packet Analysis

### Traffic Analyze with L4 Payload Filtering



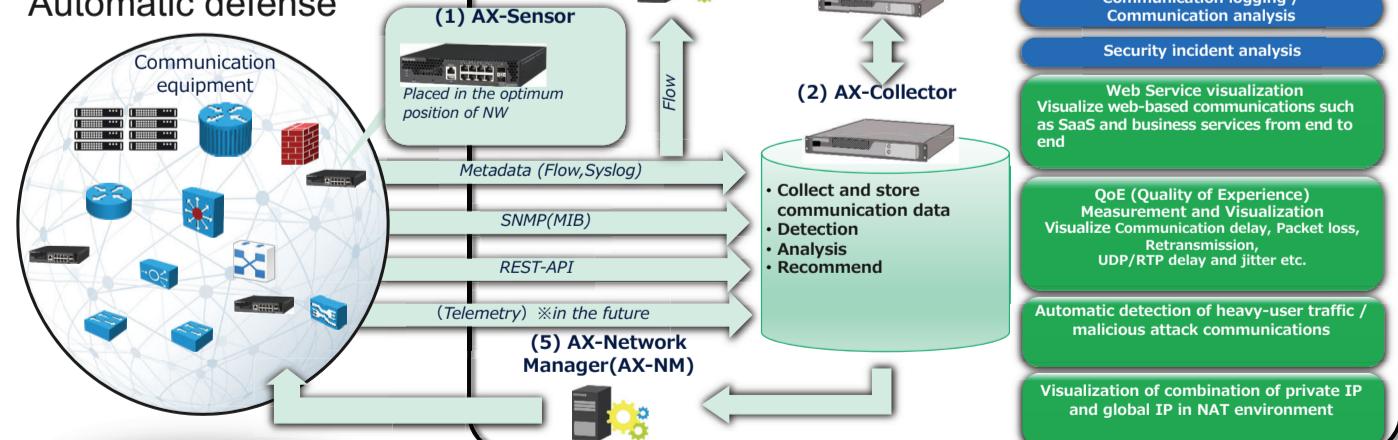
- Live traffic monitoring with protecting user privacy.
  - Currently working in Keio campus
  - QUIC monitoring function has been added
- Bidirectional 10 GE × 2 or Unidirectional 10 GE × 4
  - 100 GE version is also available by OA Lab.

### ALAXALA's Network Visualization and Control Solution

AX-Network-Visualization(AX-NV) efficiently collects data and device information on the network and uses machine learning to achieve accurate visualization and anomaly detection.

AX-Network-Manager(AX-NM) provides cyber attack automatic defense solution with UTM, FW, IDS/IPS system and AX-NV, and minimize damage by "automatic cause elimination".

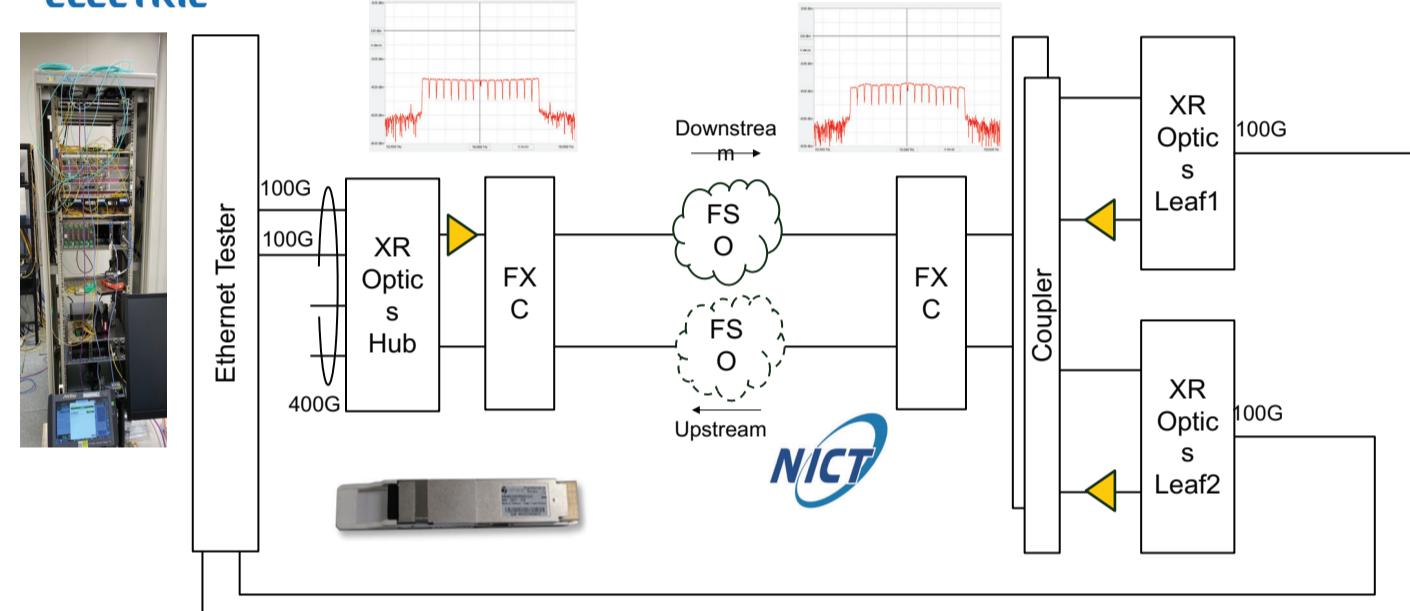
Technical keywords:  
Traffic Visualization  
Machine Learning  
Anomaly detection  
Automatic defense



## 3. XR optics PtMP transmission over FSO

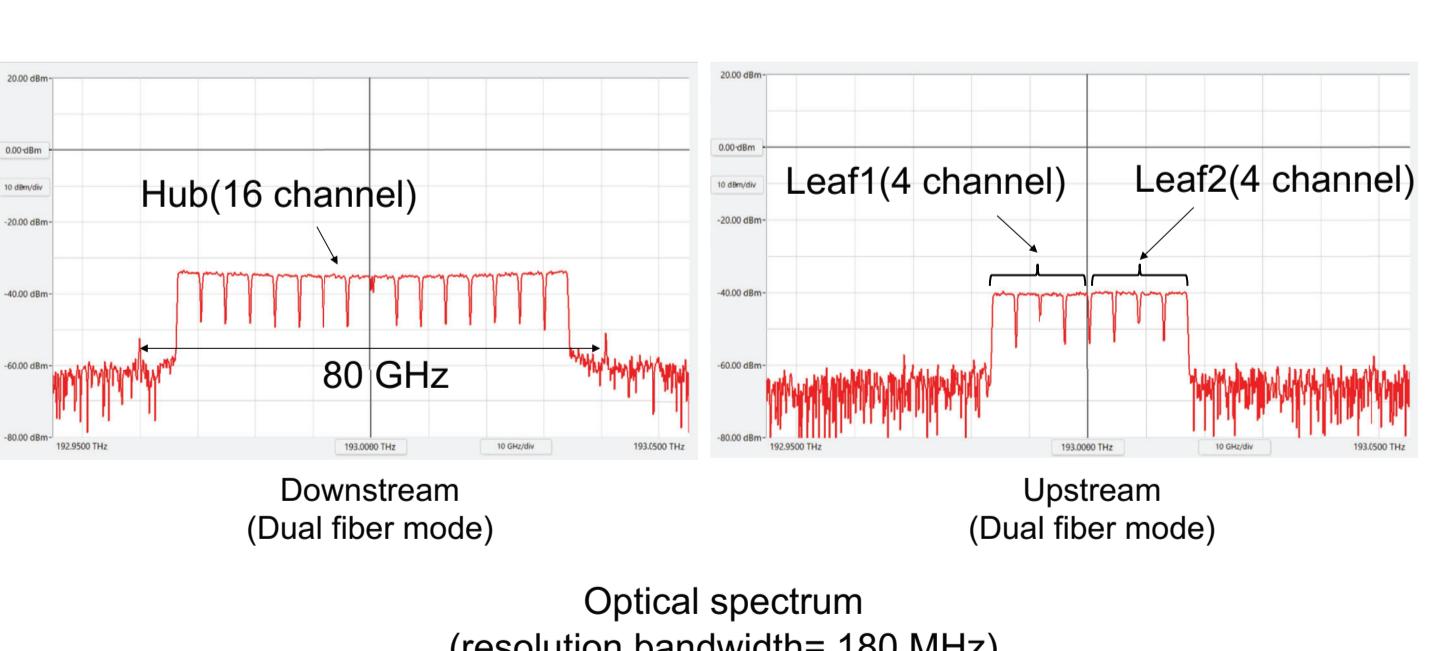
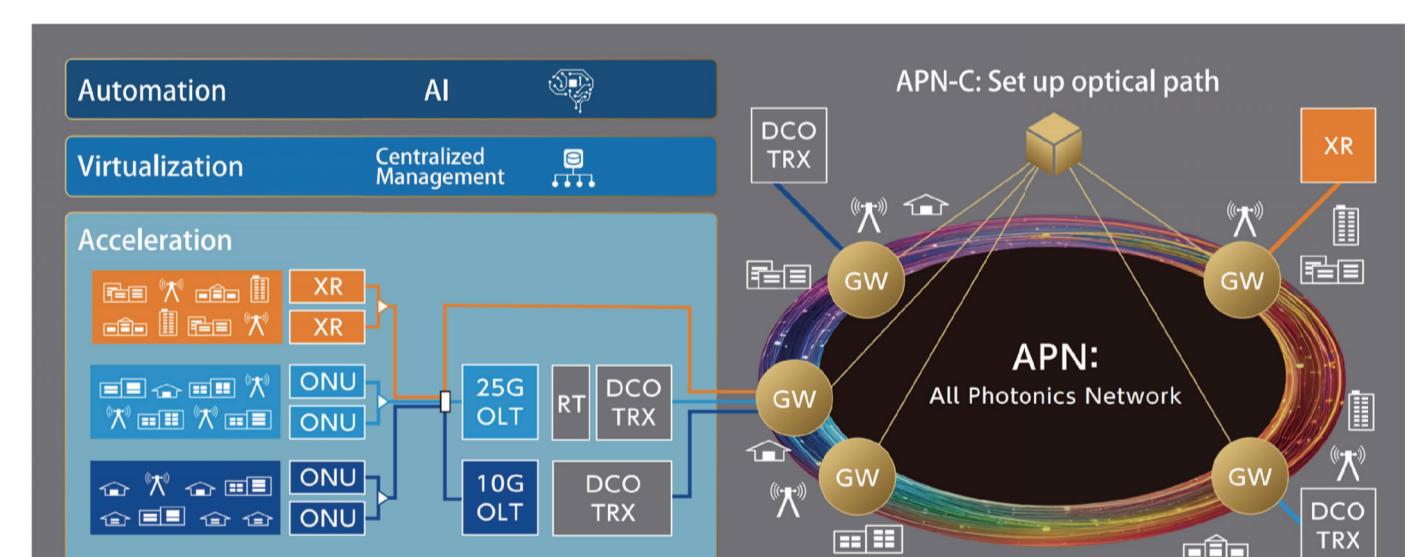
Signal quality of XR optics after 100Gbps x 2 Point-To-Multipoint(PtMP) transmission over FXC and FSO.  
Measure pre-BER, latency and optical spectrum and compare with back-to-back.

FURUKAWA ELECTRIC



### XR Optics

- High-speed solutions with coherent technology
- Flexible distribution of up to 400 Gbps (25 Gbps x 16 subcarriers) to users in 25 Gbps units
- Low latency communication due to the ability to occupy user-distributed subcarriers
- Consideration to overlay with PON at Open XR Optics Forum



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