ALAXALA Networks Corporation
Fujitsu Limited
Keysight Technologies (Former Ixia Communications)
Keio University
National Institute of Information and Communications Technology
NIPPON TELEGRAPH AND TELEPHONE CORPORATION
OA Laboratory
Red Hat K.K.
UBiqube

iPOP2019 Showcase:
"End-to-End Network Slicing with Transport Network Coordination and Edge Cloud Applications in 5G Era"

Introduction:

Industries will be undergoing significant and radical evolution, which will challenge their "digital transformation" to enable new services and revenue growth in the 5G networks that provide eMBB(enhanced Mobile BroadBand), URLLC(Ultra-Reliable and Low Latency Communications) and mMTC(Massive Machine Type Communications). Those 5G requirements and specifications are designed as "cloud native". Many technologies and solutions are inherited from cloud computing and virtualization to realize new service use cases such as MR(Mixed Reality), IoT (Internet of Things), Health care, V2X(Vehicle to everything) and so on.

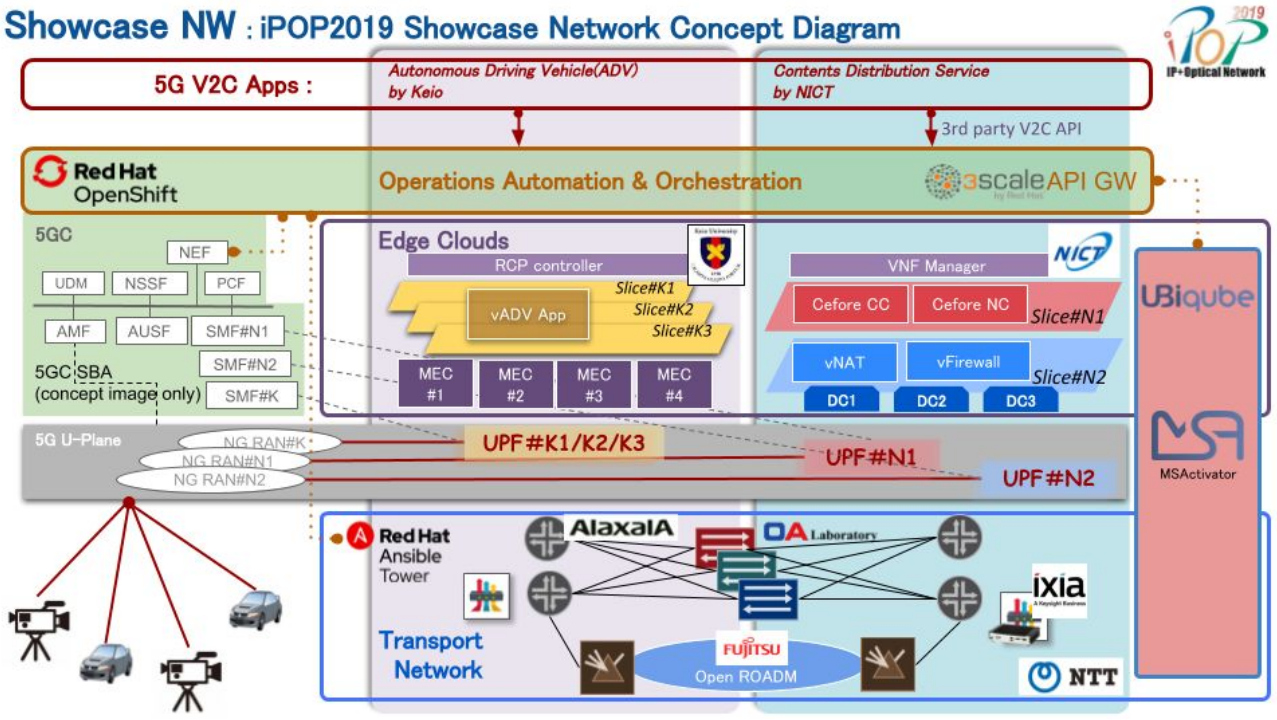
"Network Slicing" is an important and mandatory feature to provide diverse services over Transport Networks (TNs). Yet, only instructions of requirements to the relevant TN is stipulated. Operations and management requirements for TN to satisfy 5G service requirements remain unstipulated.

We believe methods and standards for coordinated management between TN and 5G "Network Slicing" is the most important domain for the future 5G TN and services architectures. "TN Slice" needs to be coordinated and managed according to each 5G application's performance requirement. How "TN Slice" should be mapped into the specific slice of NG RAN (Next Generation Radio Access Network) and 5GC (5G Core) is the biggest issue and needs to be addressed to realize optimized 5G TN.

At iPOP2019 showcase, we focused on 5G's "Network Slicing" requirements from Transport Network(TN) view points and tried to demonstrate possible scenarios of coordination between 5GC and operation and management of TN.

Showcase Test Bed Configuration:

Figure.1 shows the iPOP2019 Showcase testbed conceptual configuration.



Note: In this demonstration, 5GC and NGRAN is not included

Figure 1 Showcase Network Concept

Assuming 5GC and NG RAN are (virtually) available in this environment, showcase test beds (implemented with four-layer-configurations) are:

- **Transport Network**
- **Edge Clouds**
- **Operations Automation & Orchestration**
- **5G V2C(Virtual to Cloud) Applications**

On the top, we have implemented two types of 5G applications as examples:

- **Contents Distribution Service** (by NICT: National Institute of Information and Communications)
- **Autonomous Driving Vehicle Service** (by Keio University)

These 5G services are instantiated as Virtual Network Functions (VNF) in each Edge Cloud, and trigger API GW to create “5GC Network Slice” and coordinated TN resources, which we call “TN Slice”, according to each service’s requirement.

To orchestrate and coordinate “5GC Network Slice” and “TN Slice” with each 5G services, we have implemented the following softwares, whose operations are automated:

- **3scale API GW** software(Red Hat) running in OKD (Open Kubernetes Distribution)/Openshift (Red Hat) : Providing the API infrastructure to manage APIs for internal or external users brokerage/coordination services among multiple 3rd party applications and 5G infrastructure.
- **Ansible TOWER** (Red Hat) and **MSActivator** (UBiqube) : Providing Operations Automation, Zero Touch Provisioning and Orchestration for Edge Cloud and TN (TN Slices). Ansible tower and MSActivator configured Fujitsu Open ROADMs and Alaxala Routers respectively for network slicing in data networks.

Please note that each software is Open Source based and each community is actively generating up-to-date features enhancements.

- OpenMSA https://www.openmsa.co/
- Ansible Tower https://www.ansible.com/products/awx-project
- 3scale https://github.com/3scale

Open and multi vendor devices can be automatically configured by IaC (Infrastructure as Code) with Open Source based software to maintain and/or scale operations for a massive number of devices, accelerating time to market.

TN infrastructure is configured by following technologies:

- **Reconfigurable Communication Processor**
  (by Keio University and ALAXALA Networks Corporation)
- **L2, L1 and L0(Optical) multi-layer switches** (by OA Laboratory)
- **100G OpenROADM** (by Fujitsu Limited)
- **Fast and precise localization of failures in optical network** (by NTT)

Open and Disaggregated Transport technologies are proceeding to avoid vendor lock-in and reduce costly proprietary software development efforts. Open ROADM MSA (Multi-Source Agreement) is one of the solutions for this requirement.

In the TN, we also implemented **“Active Monitoring”** with Network Test and Visibility solutions for application level communication quality management by Keysight Technologies.

Showcase Demonstrations:

Figure 2 shows physical connections and interfaces/protocols of the Showcase Network.

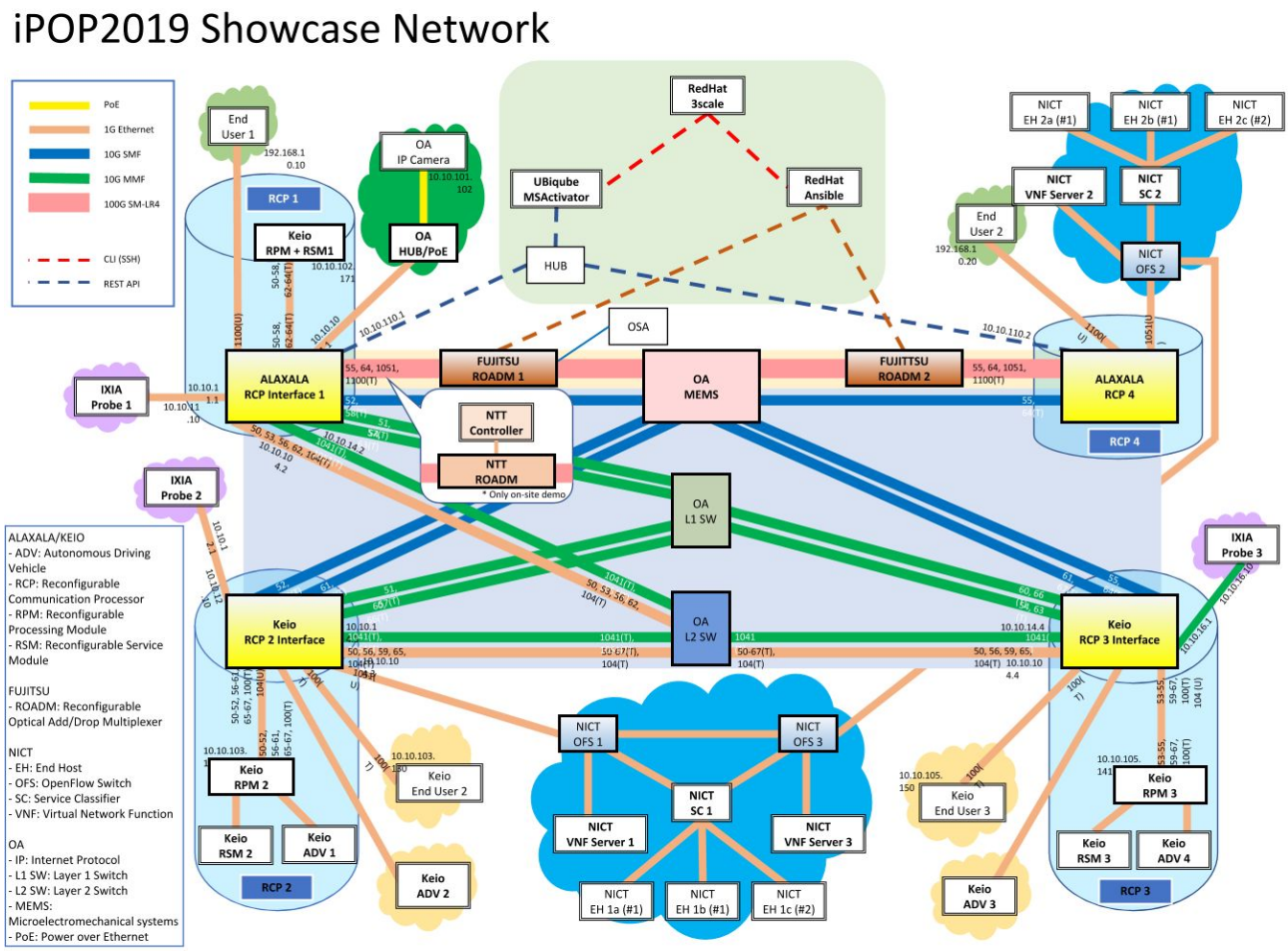


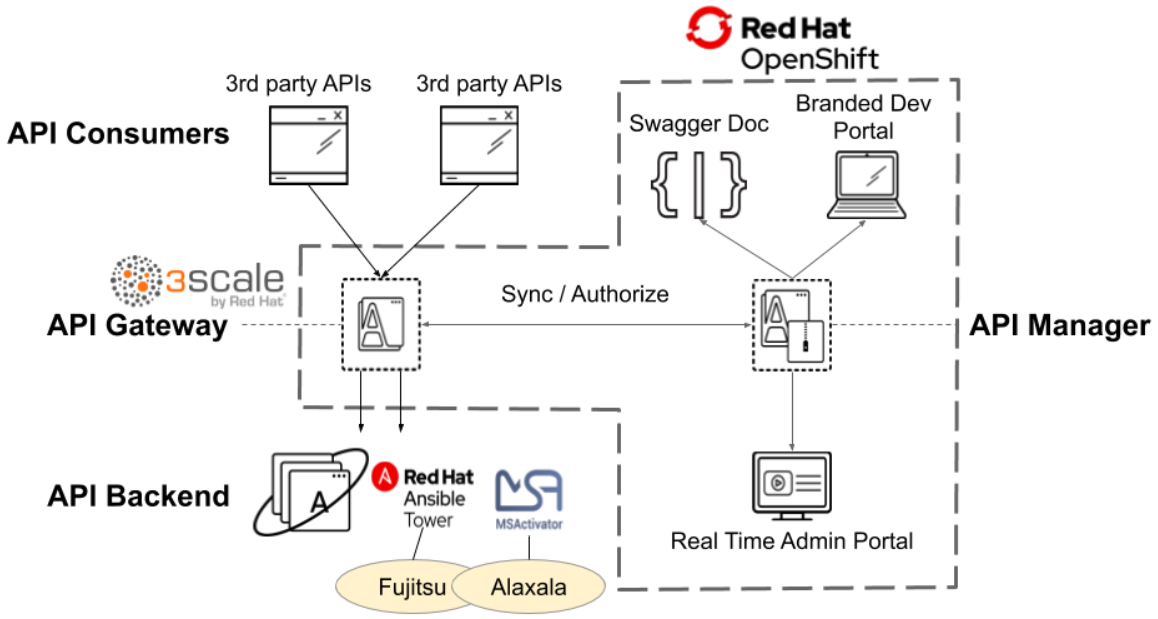
Figure 2 Showcase Physical Network

This section explains following demonstration scenarios and technologies.

1. Operations Automation and Orchestration (UBiqube and Red Hat)
2. Autonomic Resource Management for Service Function Chaining Platform (NICT)
3. Multi-access Edge Computing Service for Autonomous Driving Vehicle Control (Keio Univ., ALAXALA Networks, OA Lab)
4. Open Transport System using OpenROADM and IaC (Infrastructure as Code) (Fujitsu)
5. Active Monitoring/Network Test and Visibility Solutions (Keysight Technologies)

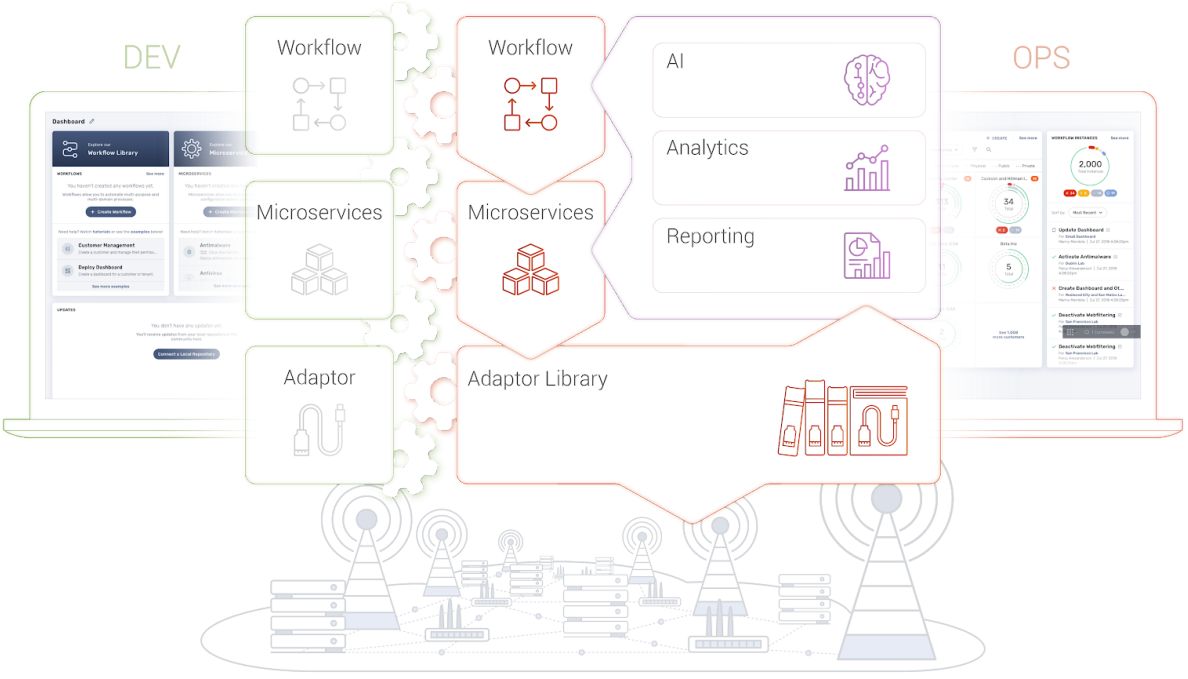
1. Operations Automation and Orchestration (UBiqube and Red Hat)

We demonstrated Open API and zero touch provisioning. With authorized REST API from 3scale API Gateway, Ansible tower and MSActivator configured TN Slices. In this automation, coordination between 5GC “Network Slice” and “TN Slice” can be realized.



[Red Hat] In 5G digital world, APIs are key to agile integration and delivering Biz value. 3scale API Management makes it easy to manage 3rd party APIs, share, secure, distribute, control, and monetize 3rd party APIs on mobile infrastructure built for performance, customer control, and future growth.

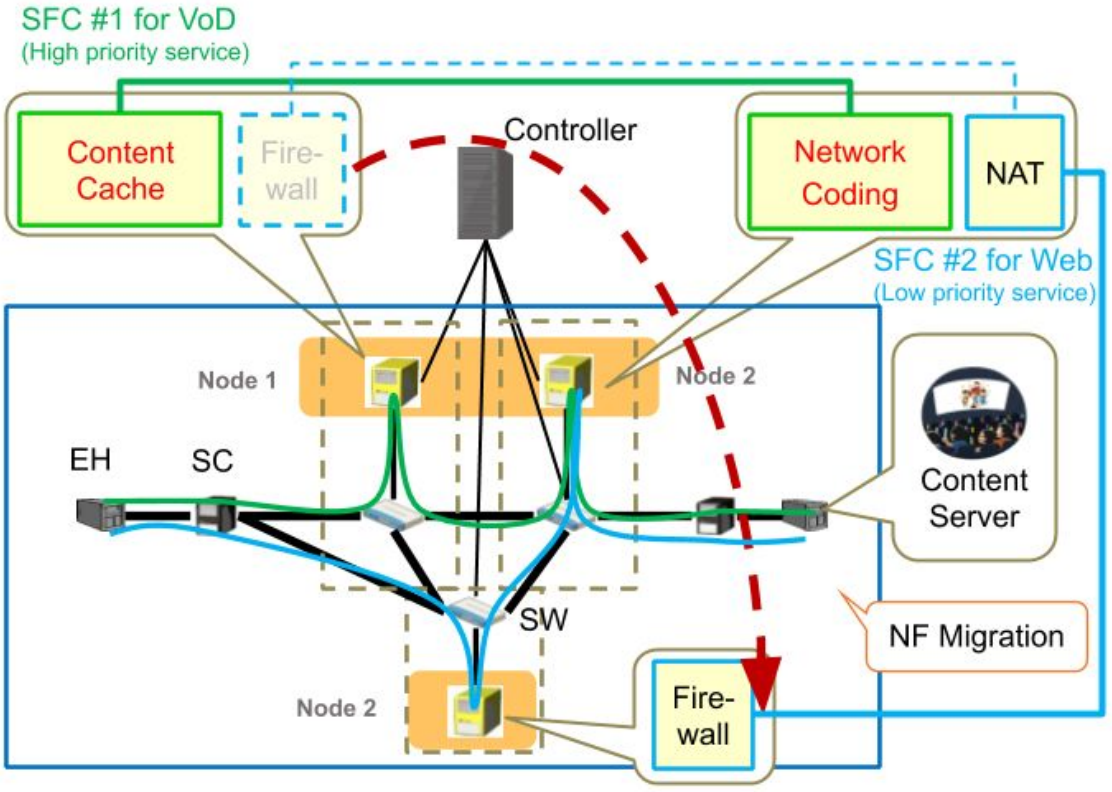
[UBiqube] In 5G, with the rise of IOT and AR/VR, SP(Service Provider) are keen to push



processing at the edge and deploy applications on demand. Networks must be dynamically orchestrated overtime. MSActivator orchestrates all the domains (SDN, VNF, PNF) for end to end

automation. MSActivator can not only activate services but also perform day2 change management.

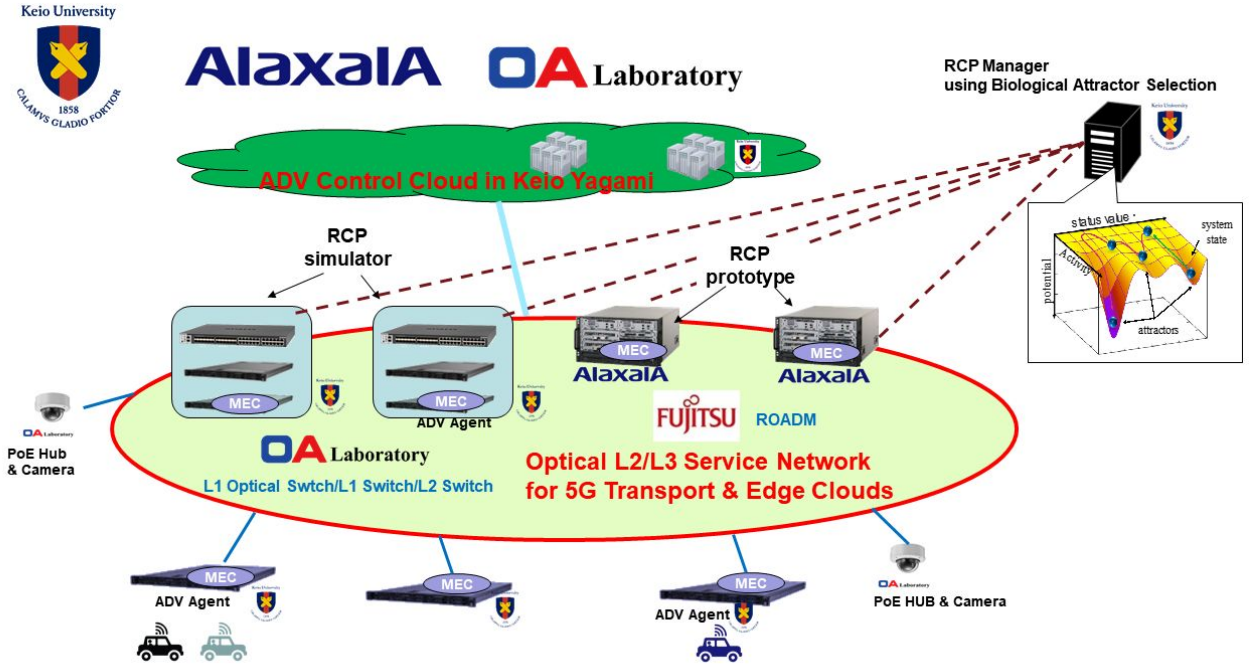
2. Autonomic Resource Management for Service Function Chaining Platform (NICT)



NICT has developed a service function chaining (SFC) platform specified in IETF RFCs 7665 and 8300, and designed an autonomic resource management system for the SFC platform. In this showcase, we demonstrate the network function (NF) migration mechanism to guarantee QoS of VoD services while optimally utilizing resources.

3. Multi-access Edge Computing Service for Autonomous Driving Vehicle Control (Keio Univ., ALAXALA Networks, OA Lab)

Multi-access Edge Computing (MEC) provides various networking services. Computing server resources are located near users, i.e., in edge servers. In this demonstration, a MEC cloud constructed by computing servers and Reconfigurable Communication Processors (RCPs), which provide both an IP/Optical transport function and a computing function, is presented. ALAXALA Networks provides the RCP prototypes which support over 100 Gbps interfaces and edge server functions.



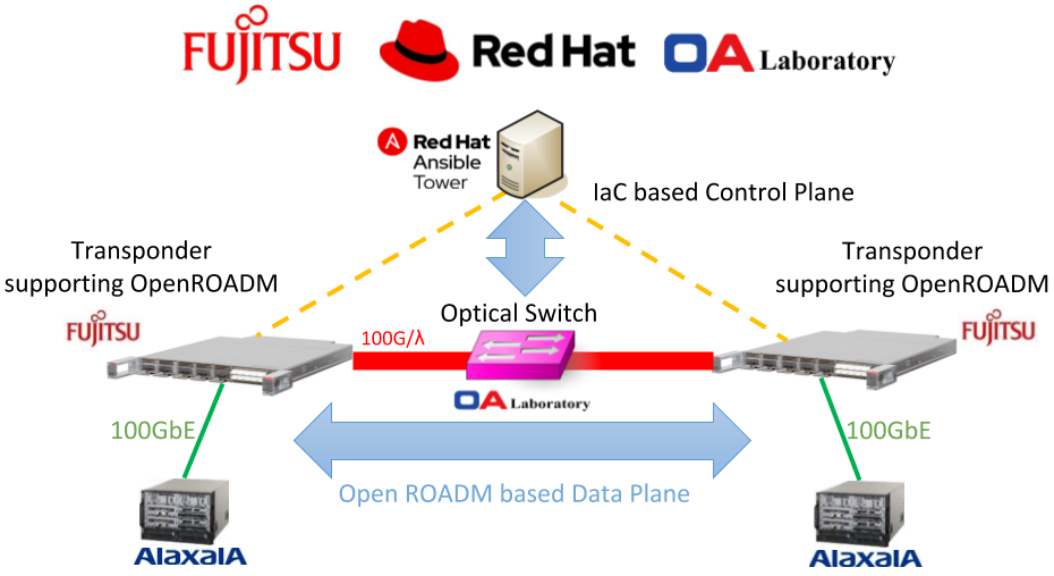
RCP: Reconfigurable Communication Processor, MEC: Multi-access Edge Computing, ADV: Autonomous Driving Vehicle

Keio University provides the RCP simulators and the RCP Manager. The unique feature of this manager is using a biological attractor selection method for determining the location of functions. OA Laboratory provides the MEMS-based optical layer 1 switch, 10 Gbps layer-1 switch and small embedded type layer-2 switch for constructing an optical layer2/3 service network which is used for providing 5G transport and edge clouds network in this showcase. Fujitsu's open disaggregated ROADM is also used in the network.

A network-controlled Autonomous Driving Vehicle (ADV) with high mobility is one of the important applications of MEC. Cloud, edge, and local coordination are required. In this demonstration, Keio University provides an ADV-control system prototype, and OA Laboratory provides Power over Ethernet (PoE) Hub system with camera as a sensor for ADV.

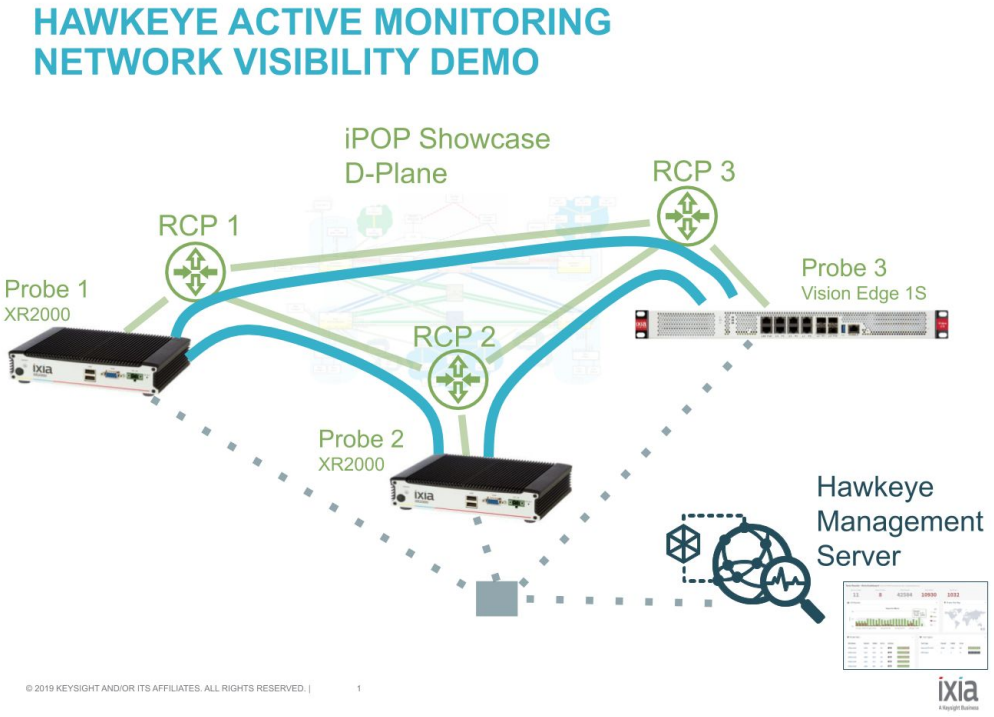
4. Open Transport System using OpenROADM and IaC (Infrastructure as Code) (Fujitsu)

We demonstrated a mixed transport system using an IaC based control plane and an Open ROADM based data plane. For control plane, we use Ansible Tower provided by RedHat. For the data-plane, we used a pair of Transponders supporting Open ROADM provided by Fujitsu and an Optical Switch provided by OA laboratory.



5. Active Monitoring/Network Test and Visibility Solutions (Keysight Technologies)

On this demo, we execute network monitoring for measurement of various metrics, including QoE, using probes located in 3 places in D-Plane network at Showcase.



Acknowledgments

These demonstrations have been partially conducted as part of the project entitled "Research and development for innovative AI network integrated infrastructure technologies" supported by the Ministry of Internal Affairs and Communications, Japan, and supported by the Research Promotion Council of Kei-han-na Info-Communication Open Laboratory, the Reconfigurable Packet Lambda Project funded by National Institute of Information and Communications Technology (NICT) of Japan, JSPS KAKENHI Grant Number JP17H03269, and the High-speed Optical Layer 1 Switch system for Time slot switching-based optical data center networks (HOLST) Project funded by the New Energy and Industrial Technology Development Organization (NEDO) of Japan.

<< iPOP2019 Information >> <https://www.pilab.jp/ipop2019/>

Date: May 30-31, 2019

Venue: NEC Tamagawa Renaissance City, Kawasaki, Japan

<< Trademarks >>

Abbreviations:

5G SBA	5G Service-based Architecture
5GC	5G Core
AF	Application Functions
AMF	Access and Mobility Management Function
AUSF	AUthentication Server Function
DN	Data Network
NEF	Network Exposure Function
NRF	Network Repository Function
NSSF	Network Slice Selection Function
PCF	Policy Control Function
RAN	Radio Access Network
SMF	Session Management Function
UDM	Unified Data Management
UPF	User Plane Function
UE	User Equipment
eMBB	enhanced Mobile BroadBand
URLCC	Ultra-Reliable and Low Latency Communications
mMTC	massive Machine Type Communications
TN	Transport Network
MEC	Multi-access Edge Computing
VNF	Virtual Network Functions
PNF	Physical Network Functions
SDN	Software Defined Networking
SFC	Service Function Chaining
IaC	Infrastructure as Code
MR	Mixed Reality
IoT	Internet of Things
V2X	Vehicle to everything
ROADM	Reconfigurable Optical Add-Drop Multiplexer
MSA	Multi-Source Agreement

Edited by iPOP2019 Interop Committee (Issue 2 on May 31st, 2019):

Interop Co-Chairs:	Kohei Shiomoto, Tokyo City University, Japan
	Yusuke Hirota, NICT, Japan
Vice Chair:	Hyde Sugiyama, Red Hat K.K., Japan
	Shinya Nakamura, S-Consulting, Japan
Advisor:	Noboru Yoshikane, KDDI Research, Japan