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# iPOP2017 Showcase: Beyond 100-Gb/s Transmission and Disaster Recovery Technologies for Network Resilience

- **Introduction**

Network traffic has been increasing every year and recent research efforts have focused on the efficient use of network resources in future optical networks designed to support the increase in traffic. Recently, transmission technologies that go beyond a 100-Gb/s-basis are being intensively developed to meet the growth of the network traffic. In addition, standard organizations such as ITU-T and IEEE are planning to complete specifications of interfaces that go beyond a 100-Gb/s-basis in the near future. Considering the nature of this environment, interfaces of over a 100-Gb/s-basis are expected to be introduced into optical networks sooner or later.

When considering network design, the networks should be resilient to failures and other disasters because network operators are responsible for providing services that satisfy service level agreement. If interfaces of more than 100-Gb/s are introduced in the networks, the impact of a failure/disaster is expected to be larger than ever, because a larger number of services would be accommodated in an interface of more than 100-Gb/s, compared to the conventional situation with interfaces such as 10-Gb/s and 100-Gb/s.

Therefore, network resilience, i.e. the robustness of the network infrastructure, should ensure the continuity of communication network services despite any damage caused by failures and large disasters.

Below is a showcase of high-speed transmission systems, including the 400-Gb/s interface and failure/disaster-resilient network technologies, with a special focus on transport networks.

- **Showcase network configurations**

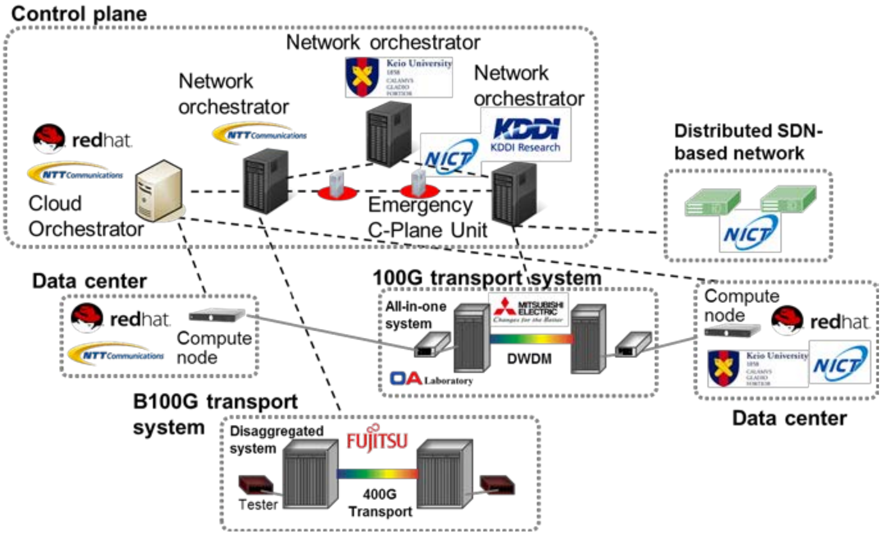
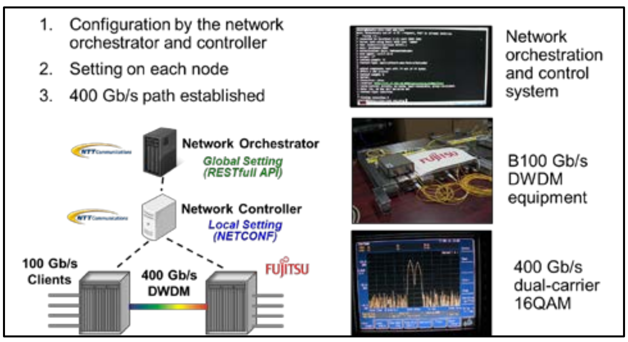



Figure 1 Showcase testbed configuration

Figure 1 shows the testbed configuration. The data plane of the testbed was implemented at the NICT premises in Tokyo, Japan. The testbed consisted of three different network domains: a wavelength division multiplexing (WDM) core network domain, a WDM metro network domain, and a software-defined networking (SDN)*1-based network domain. The core network domain comprised of two disaggregated WDM nodes and an SDN controller. Each node was equipped with 400-Gb/s optical transponders. The metro network comprised of two all-in-one type WDM nodes with an SDN controller. The metro network domain provided a 100-Gb/s transmission pipe and 10 x 10 GE client interfaces for the attached emulated datacenter, controlled by an OpenStack*2 controller. The SDN-based network consisted of 15 Lagopus*3 switches controlled by four Ryu*4 controllers.

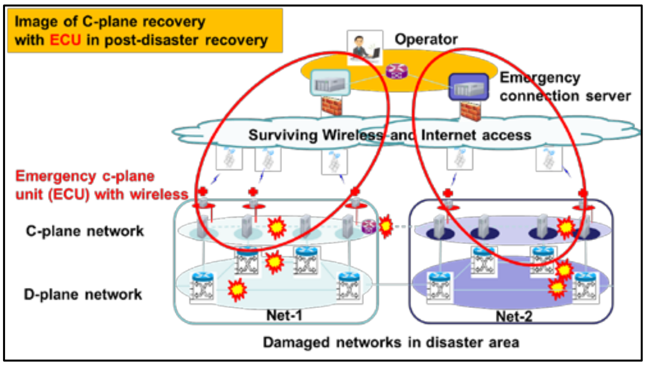
In the control plane, network orchestrators were connected to the core SDN controller, the metro SDN controller, the SDN-based network's controller and the cloud orchestrator. Each WDM network domain in the demo was controlled by the network control orchestrators. The emulated datacenters were controlled by the cloud orchestrator. The cloud orchestration system issues requests for creation of the virtual machines (VM) at the emulated datacenters and establishing paths across the optical network domains. More specifically, VM creation was performed by the data center/cloud control system (OpenStack), while the path provisioning between the emulated datacenters was performed by each network domain orchestrator and controller, respectively.

### (1) 400-Gb/s Transmission System



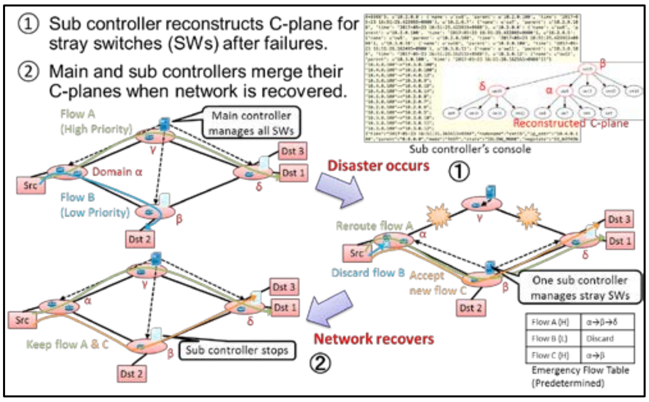

This system was comprised of two commercially available disaggregated WDM nodes (1FINITY), a network controller, and a network orchestrator. Each WDM node was equipped with a 400-Gb/s line interface and 4 x 100 GE client interfaces. The network orchestrator issues a request for provisioning paths across the optical network domain and the path provisioning was performed by the network controller.

## (2) Automatic Reconstruction of C-Plane for Failure and Disaster Recovery



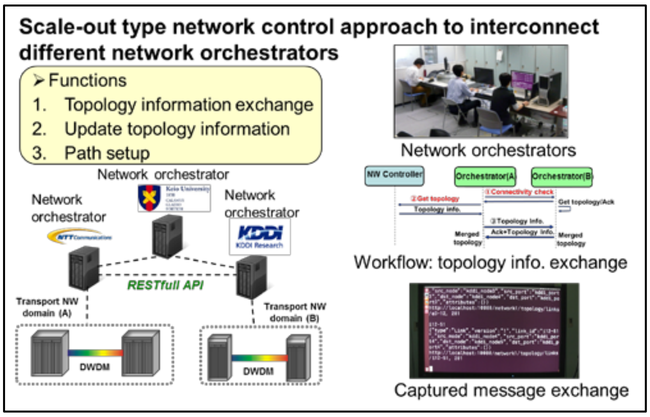

In order to strengthen the resiliency of the networks, especially the control-plane, against any damage caused by failures and large disasters, NICT and KDDI Research Inc. have collaborated and developed an emergency control-plane unit (ECU) that enables the automatic recovery of the damaged control-plane network. ECU takes advantage of the surviving wireless and the Internet access capability, and restores the control plane network securely. In this multi-organization collaboration, ECU demonstrates automatic C-plane reconstruction.

## (3) Distributed C-plane Construction for Higher Availability




Logically-centralized SDN (C-Plane) architecture is vulnerable to large-scale failures. The C-plane is required to be applicable for emergency use in such circumstances. In this system, controllers and switches reconstruct their C-plane if a disaster occurs. Furthermore, the C-plane will be smoothly reconstructed just after network recovery. This system is implemented into a 15 Lagopus switches network controlled by 4 Ryu controllers. This system can add(delete) flows when the network is separated or reconnected automatically.

## (4) Peer Transport Network Orchestration




Deploying a single and integrated controller for a large-scale network may present scalability issues. This model shows a scale-out type network control approach to the interconnection of different network orchestrators (peer model) through multiple administrative domains. The feasibility of the system was verified by implementing the proof of concept system. In the event of a disaster, this concept can be applied for the emergent recovery of transport networks by inter-carrier network orchestration.


Acknowledgments

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*1. SDN (Software Defined Networking):
SDN (Software Defined Networking) technology is network technology that enables network configuration to be dynamically set and changed using software.

*2. OpenStack:
OpenStack is an open source body and software that is widely used to manage and control server and cloud environments.

*3. Lagopus switch:
Lagopus switch is a high-performance software OpenFlow 1.3 switch. http://www.lagopus.org/

*4. Ryu:
Ryu is a component-based software defined networking framework. https://osrg.github.io/ryu/

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<Trademarks>



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