SDN/OpenFlow Optical Network on JGN-X

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GEC20, Optical Software Defined Networking Session

NICT 情報通信研究機構
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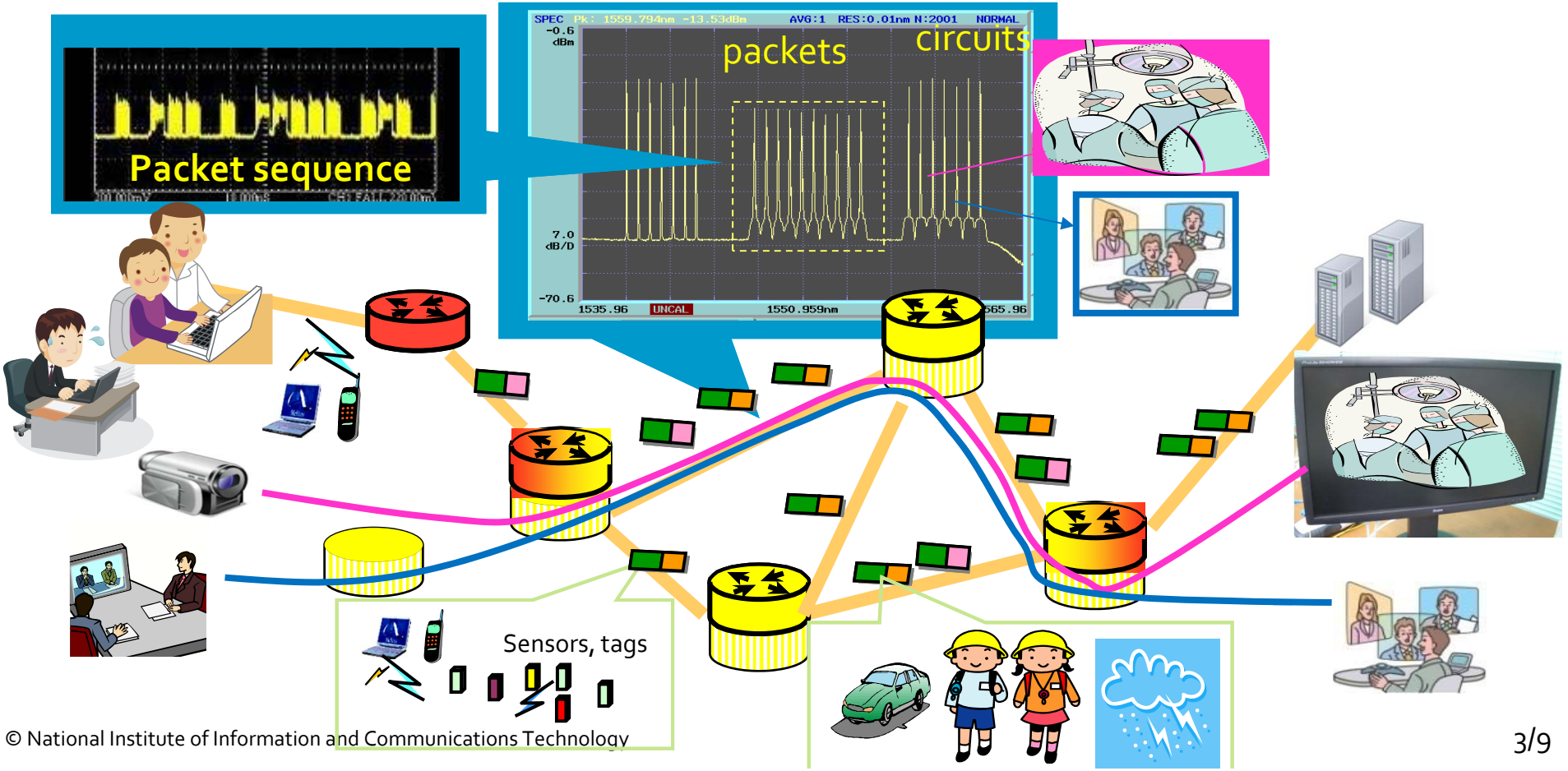
Optical SDN

- My mission at NICT
  - Making **optical packet & circuit integrated switching node** stable, operatable, and interwork with SDN
  - And others …
- How for the 1st mission?
  - Verification of optical nodes and networks
  - Test on field optical fibers
  - Use nation-wide SDN/Openflow test environment
  - Interop test with other optical systems

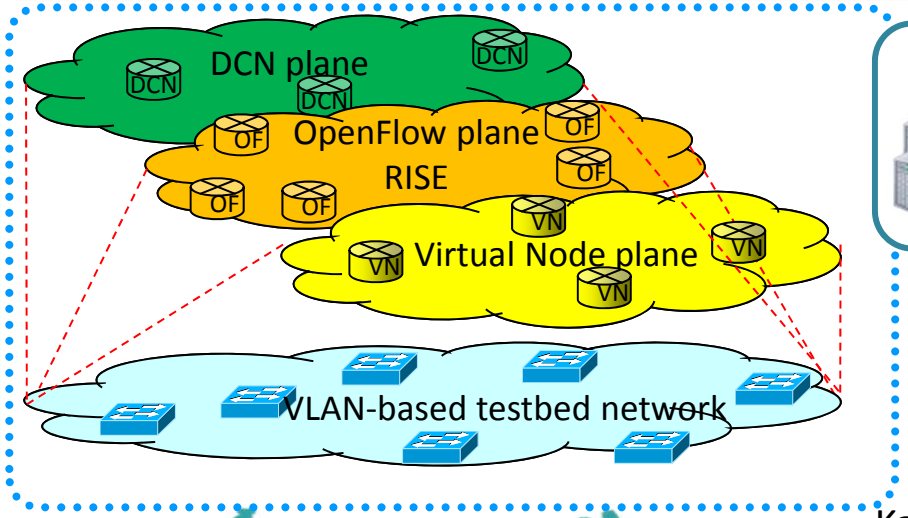
Optical Packet & Circuit Integrated Network

- User view: A "**high-speed, inexpensive**" service and "**low delay, low data-loss**" service on a **single** optical network
- Network provider view: Large **switch capacity (>100Gbps Optical Packet)**, **energy** saving, and flexible & efficient **resource use** under a **simple** control



JGN-X: Nation-Wide R&D Network Testbed
StarBED: Large-scale Emulation Testbed

Promoting **verifications and demonstrations of NWGN R&D activities** of Industries, Univs., & Foreign Research Institutes.



Large-scale emulation testbed

StarBED³

Optical Testbed

Koganei- Otemachi

Otemachi～Otemachi

Bandwidth International

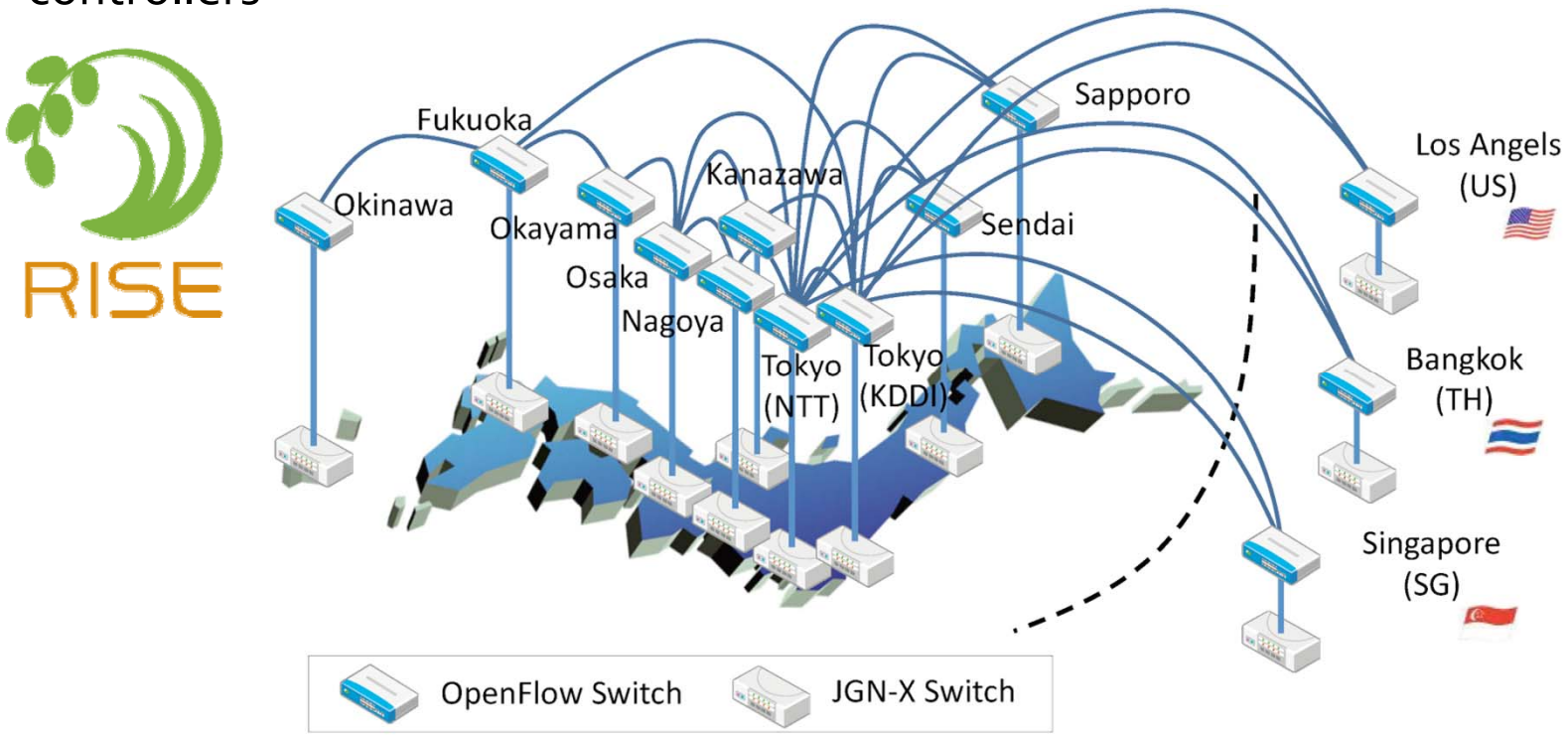
Japan- USA : 10Gbps
Japan - Korea : 10Gbps
Japan – Hong Kong : 10Gbps
Hong Kong - Singapore 2.4Gbps
Singapore - Thailand : 622Mbps

USA **Thailand** **Singapore**

Hong Kong **South Korea**

RISE

- RISE = ***R***esearch ***I***nfrastructure for large-***S***cale network ***E***xperiments
  - Reorganized our OpenFlow network environment on JGN2plus as a testbed
  - Ver. 1.0: started to accept public users (October 2011)
  - Ver. 2.0: **multi-user model** (April 2012)
- We now provide OpenFlow-based user-slices in which users can use their own controllers

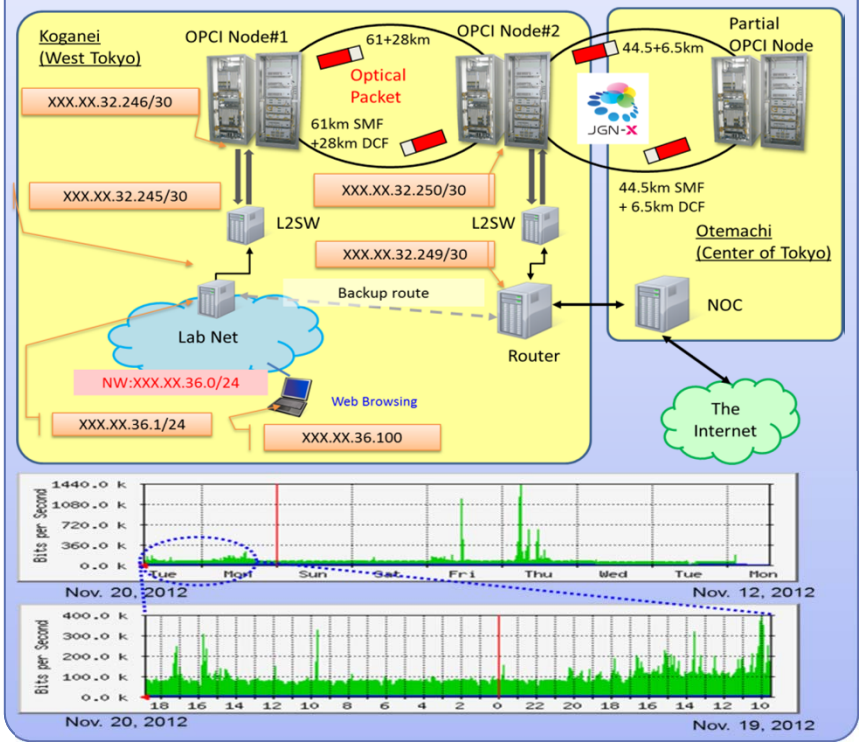


Source: Eiji Kawai (NICT)

Stable, Operational, and SDN-capable Optical Packet & Circuit Integrated Network

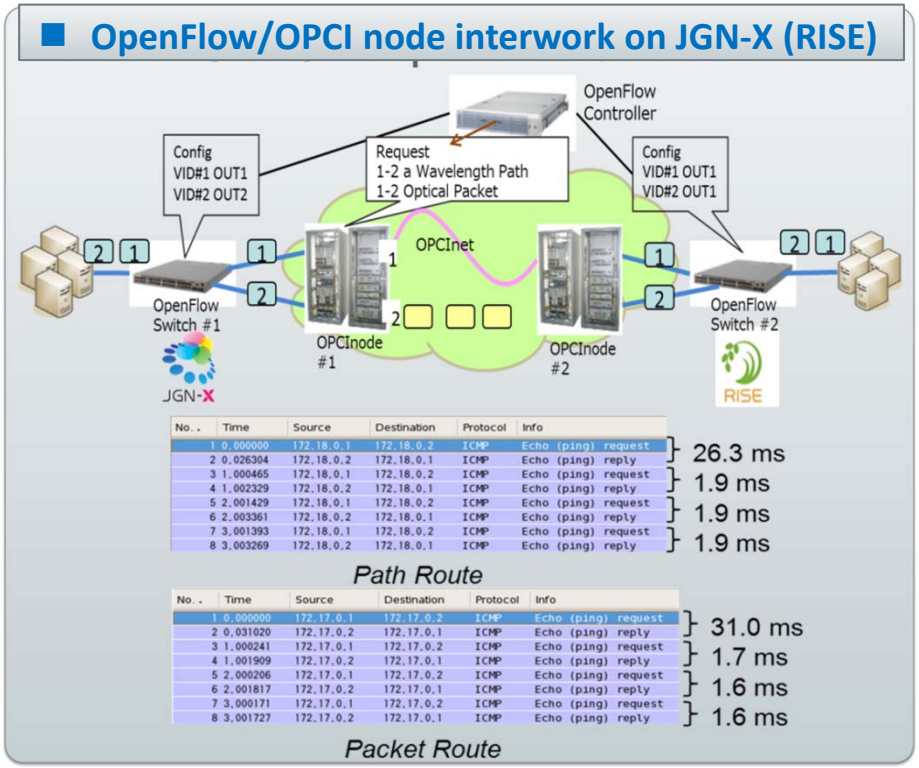
- Performance of packet error rate is compliant with ITU-T Y.1541
- 5-hop, 244 km 100Gbps optical packet switching ■ 8 buffer embedded
- Longest prefix matching of optical packet header, management system connected
- Testbed experiment

■ **Our lab net is accessible to the Internet via OPCInodes**



H. Harai, ONDM 2013.

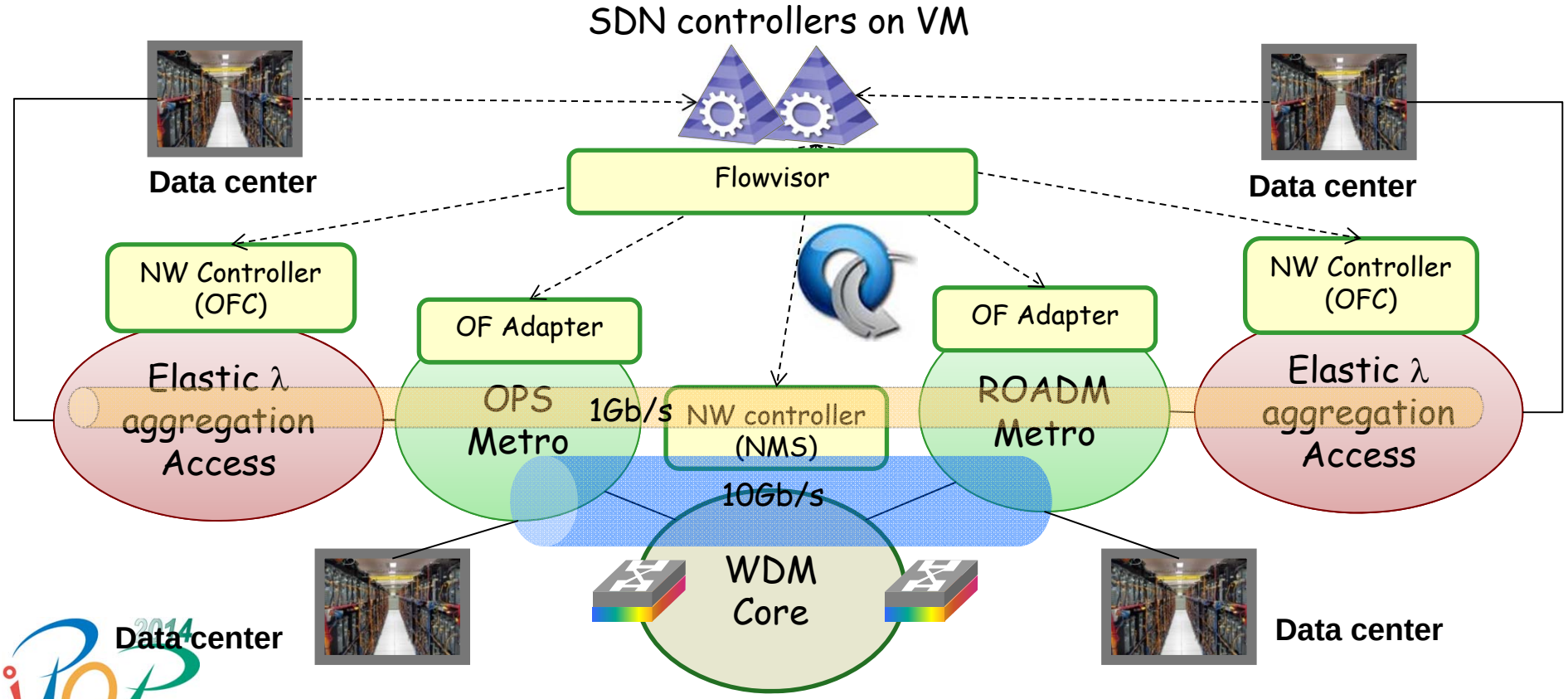
■ **OpenFlow/OPCI node interwork on JGN-X (RISE)**



T. Miyazawa et al., SDN Workshop at IEEE Globecom 2013.

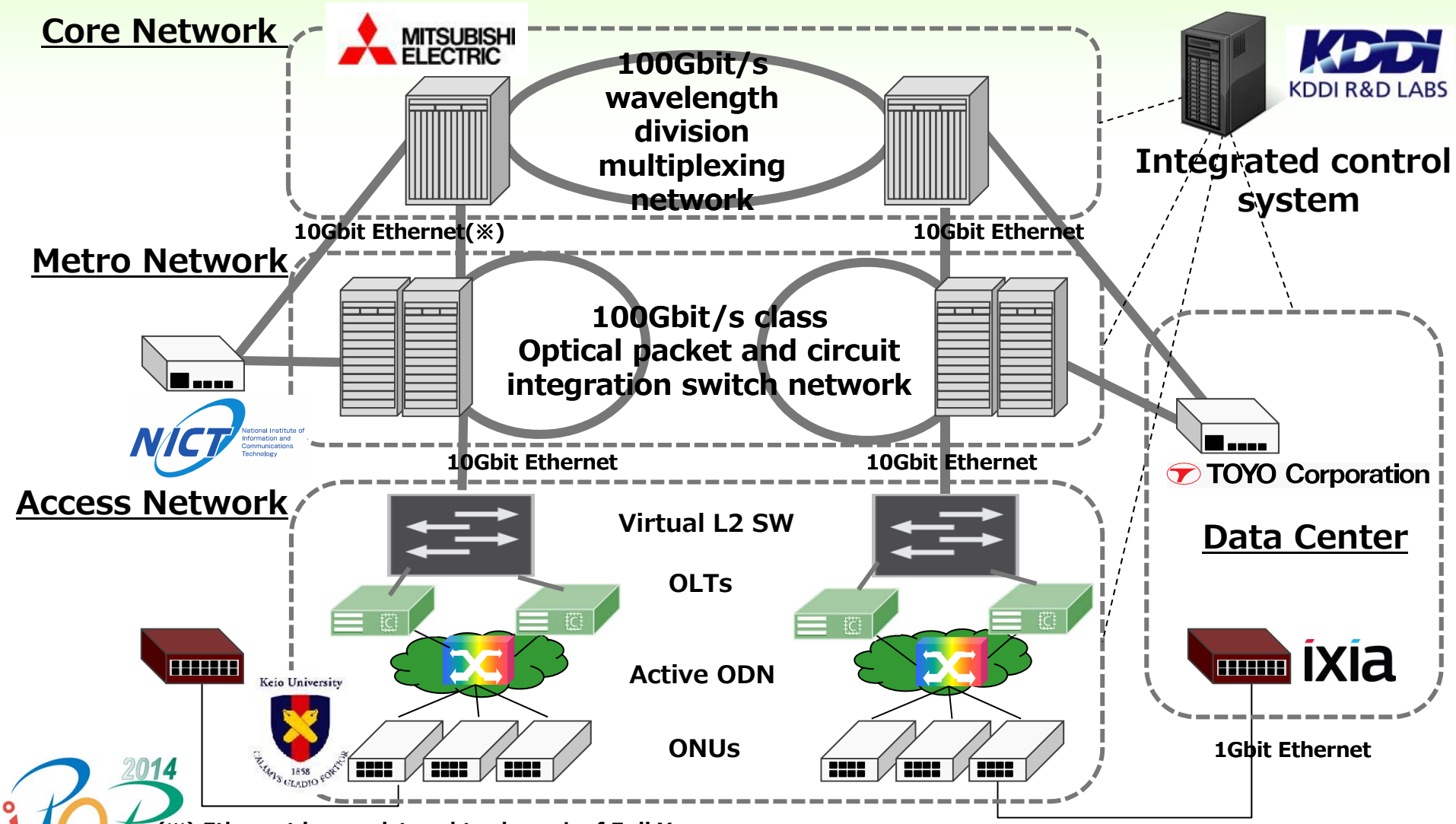
Software Defined Transport Networking

- Need to dynamically setup high-volume pipe via multiple core/metro/access optical networks for data centers
- Ability to create optical paths with flexible bandwidth based on data center request over multiple optical networks.



Source: T. Tsuritani (KDDI R&D)

Software Defined Transport Networking
iPOP2014 Showcase Network



(※) Ethernet is a registered trademark of Fuji Xerox.

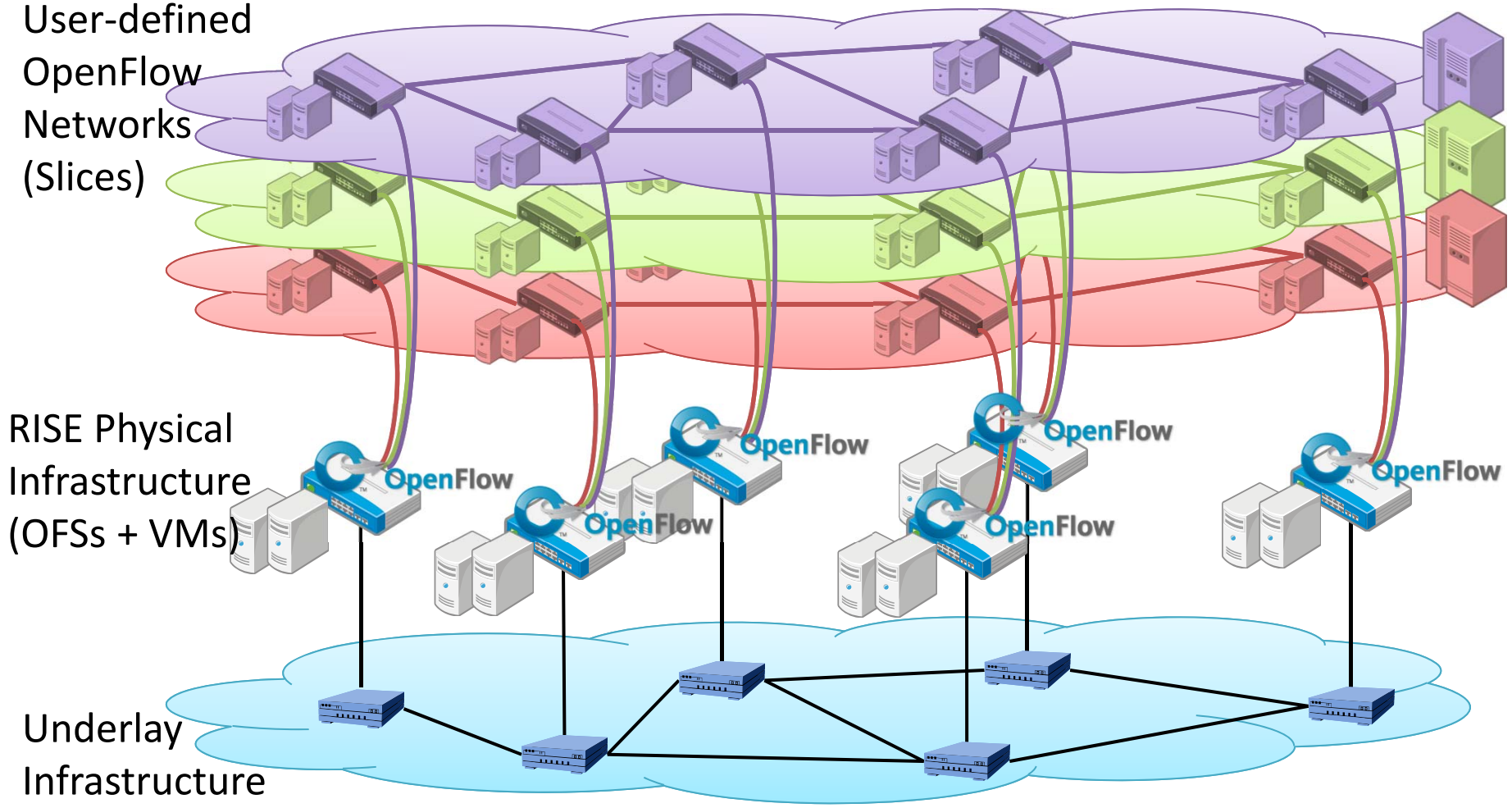
What I am Thinking is …

- Our optical packet switch looks up part of ("whole of" in future) IP address so IP and optical work together simply.
  - Circuit-switched part is solid (although upgrade to 100Gbps or 400Gbps is another issue)
  - Packet-switched part may be modified according to SDN operators' requests.
- Cloud and DC requests SDN, SDN configures optical core, metro, and access properly.
- Not covered in my talk but
  - ID-based communication lies in the access (mobile hosts and fixed/mobile server) for mobility, heterogeneity and security.
  - Automatic installation as well as path computation is also useful to (Optical) SDN.

Thank You!

BACKUP

Architecture of RISE 2.0

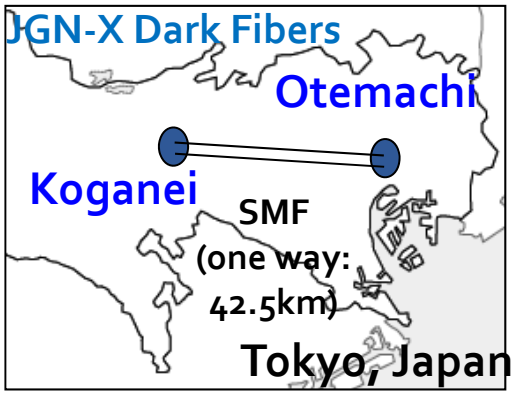


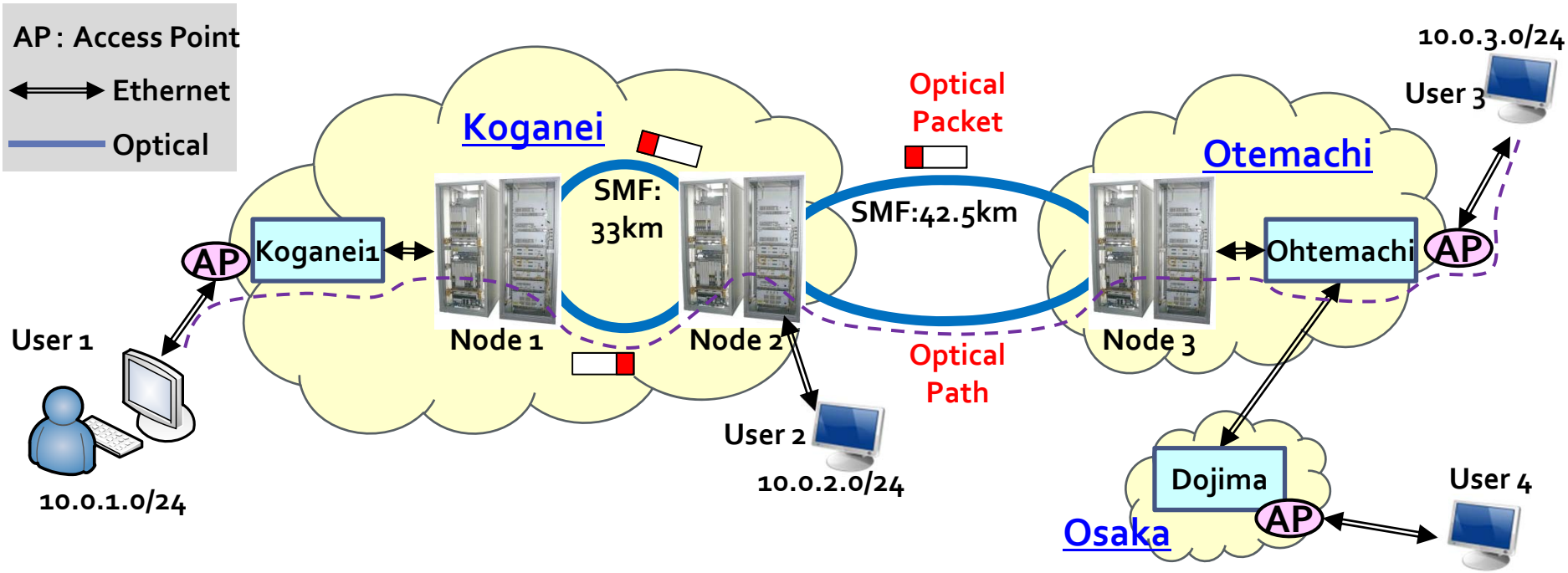
Yoshihiko Kanaumi et al., "Deployment and Operation of Wide-area Hybrid OpenFlow Network," in proc. of IEEE/IFIP MANFI 2012.

Source: Eiji Kawai

Open Ring Network Testbed in JGN-X

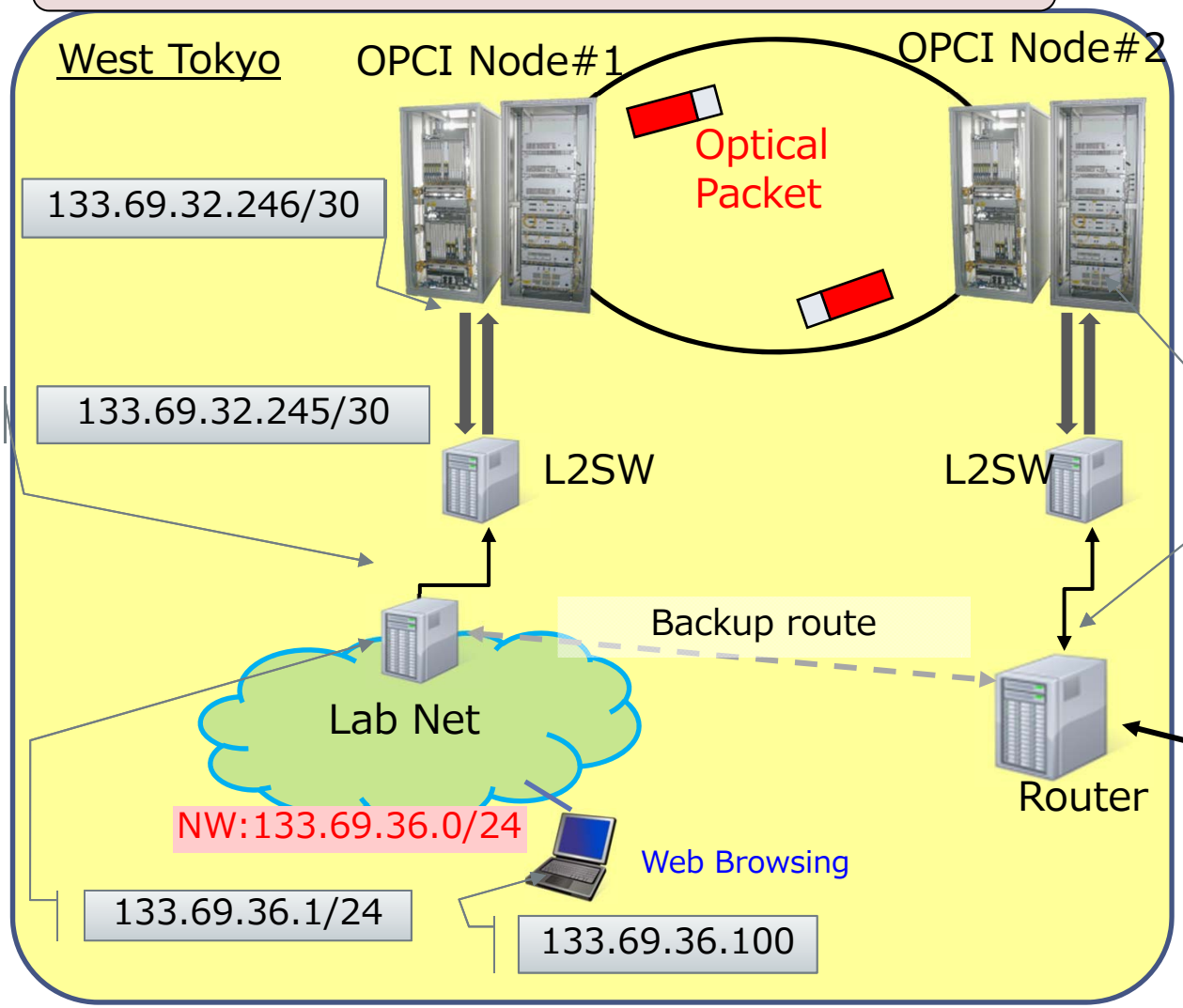
- Two nodes are placed in Koganei, and one node is placed in Otemachi
- 42.5 km field fibers between Koganei and Otemachi
- Guest users can use the OPCI testbed when they connect to access points on JGN-X L2 services

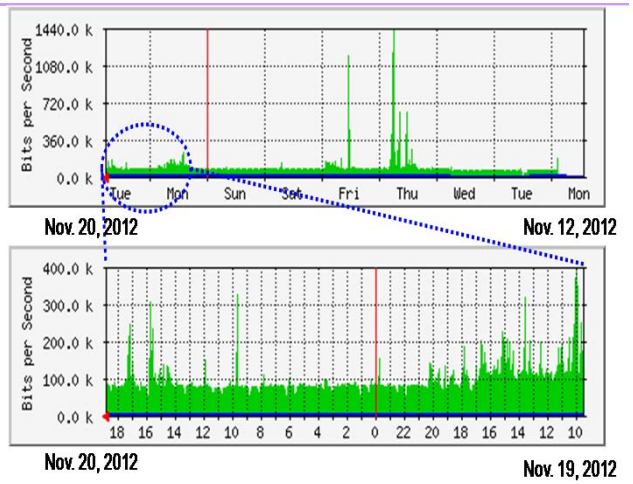




Internet Access via the OPCI Nodes

- Will be a NWGN testbed





133.69.32.250/30

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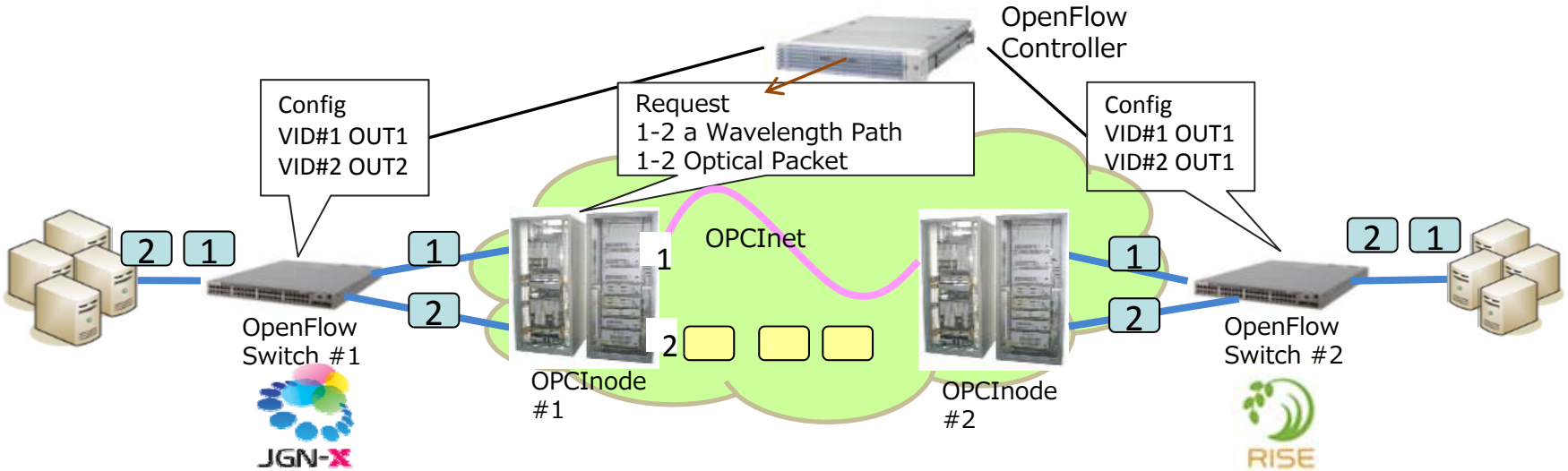
Center of Tokyo

NOC

The Internet

Optical SDN: Centralized OpenFlow × Distributed OPCInode Interwork

- Edge Net or Data-Center Net requests route with required quality information
- OPCI Net sets up proper path routes or packet routing table



No.	Time	Source	Destination	Protocol	Info	
1	0.000000	172.18.0.1	172.18.0.2	ICMP	Echo (ping) request	26.3 ms
2	0.026304	172.18.0.2	172.18.0.1	ICMP	Echo (ping) reply	
3	1.000465	172.18.0.1	172.18.0.2	ICMP	Echo (ping) request	1.9 ms
4	1.002329	172.18.0.2	172.18.0.1	ICMP	Echo (ping) reply	
5	2.001429	172.18.0.1	172.18.0.2	ICMP	Echo (ping) request	1.9 ms
6	2.003361	172.18.0.2	172.18.0.1	ICMP	Echo (ping) reply	
7	3.001393	172.18.0.1	172.18.0.2	ICMP	Echo (ping) request	1.9 ms
8	3.003269	172.18.0.2	172.18.0.1	ICMP	Echo (ping) reply	

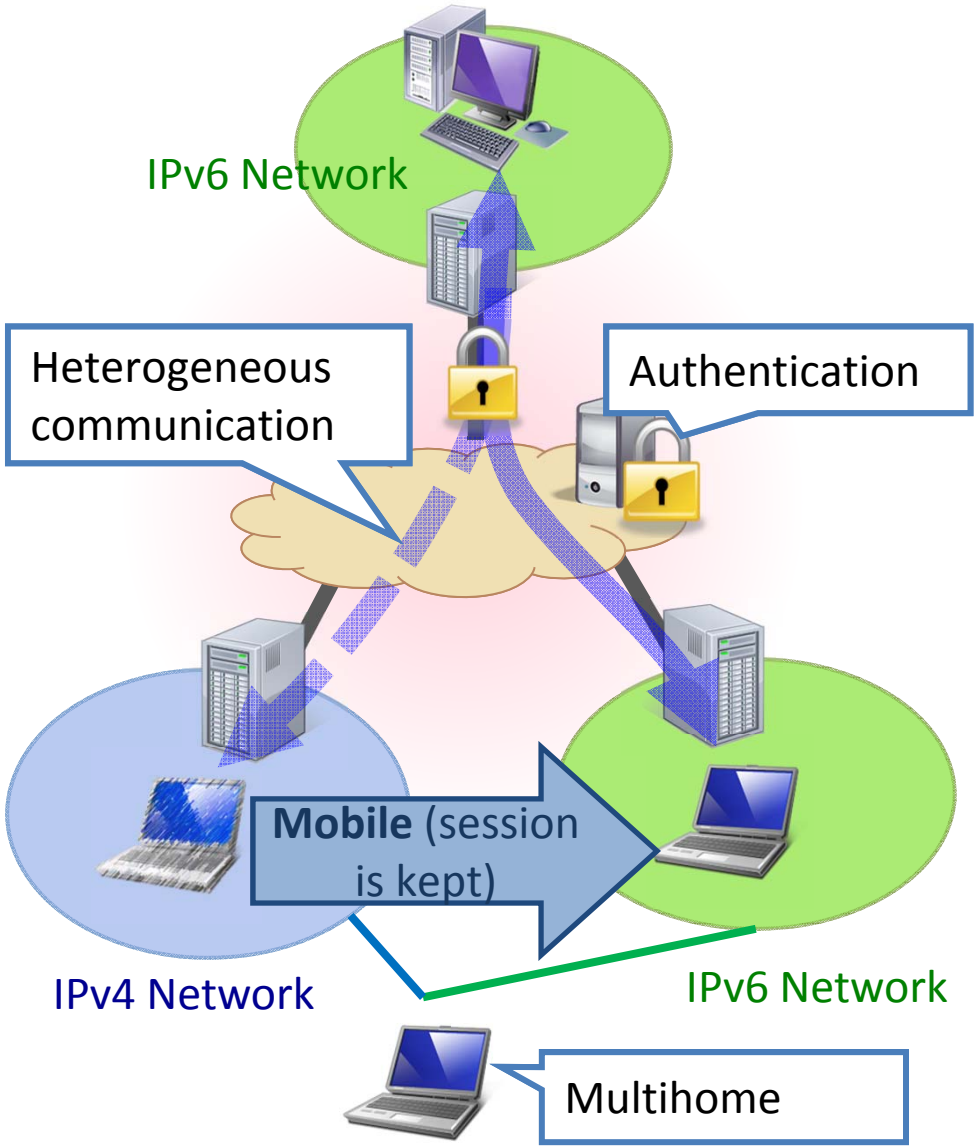
Path Route

No.	Time	Source	Destination	Protocol	Info	
1	0.000000	172.17.0.1	172.17.0.2	ICMP	Echo (ping) request	31.0 ms
2	0.031020	172.17.0.2	172.17.0.1	ICMP	Echo (ping) reply	
3	1.000241	172.17.0.1	172.17.0.2	ICMP	Echo (ping) request	1.7 ms
4	1.001909	172.17.0.2	172.17.0.1	ICMP	Echo (ping) reply	
5	2.000206	172.17.0.1	172.17.0.2	ICMP	Echo (ping) request	1.6 ms
6	2.001817	172.17.0.2	172.17.0.1	ICMP	Echo (ping) reply	
7	3.000171	172.17.0.1	172.17.0.2	ICMP	Echo (ping) request	1.6 ms
8	3.001727	172.17.0.2	172.17.0.1	ICMP	Echo (ping) reply	

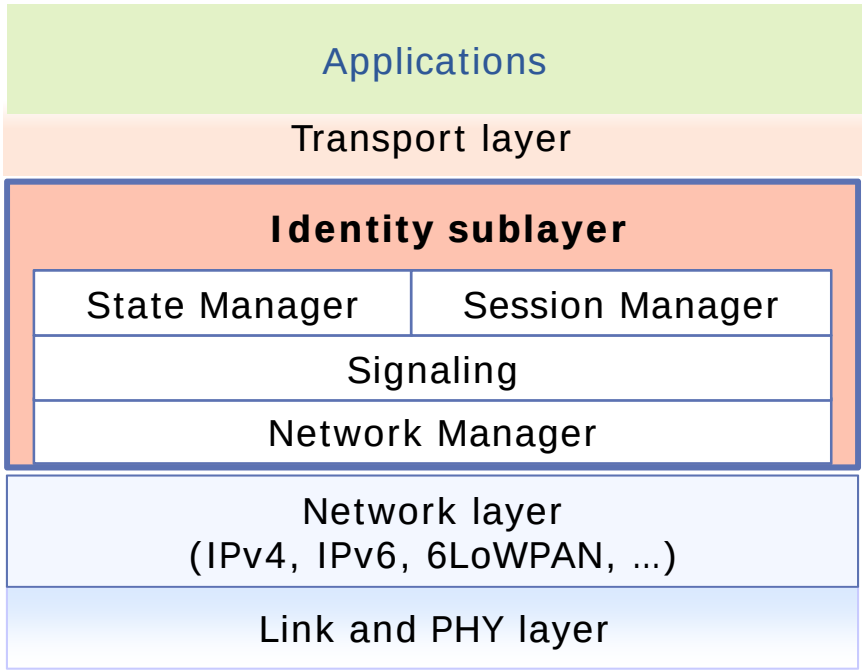
Packet Route

T. Miyazawa et al., SDN Workshop at IEEE Globecom 2013.

HIMALIS for heterogeneity inclusion and mobility adaptation thru locator/ID separation



- Application and transport layers are independent of network layer
  - Mobility, multihoming, heterogeneity support
- Access and data security



cf) V. P. Kafle, et al., IEEE Com. Mag., Feb 2010.