PRAGMA-ENT: Exposing SDN Concepts to Domain Scientists in the Pacific Rim

Kohei Ichikawa (NAIST, Japan),
Matthew Collins (University of Florida, USA),

Pongsakorn U-chupala, Che Huang, Chawanat Nakasan (NAIST, Japan),
Te-Lung Liu, Jo-Yu Chang, Li-Chi Ku, Whey-Fone Tsai (NARLabs, Taiwan),
Jason Haga (AIST, Japan), Hiroaki Yamanaka, Eiji Kawai (NICT, Japan),
Yoshiyuki Kido, Susumu Date, Shinji Shimojo (Osaka University, Japan),
Philip Papadopoulos (UCSD, USA), Mauricio Tsugawa, Kyuho Jeong,
Renato Figueiredo and Jose Fortes (University of Florida, USA)

PRAGMA-ENT (Experimental Network Testbed)

- An international SDN/OpenFlow testbed for use by PRAGMA researchers and collaborators
  - provides complete freedom to access and configure network resources

ENT Members

- **Nara Institute of Science and Tech**
  - Kohei Ichikawa
  - Yasuhiro Watashiba
  - Pongsakorn U-chupala
  - Chawanat Nakasan
- **University of Florida**
  - Matthew Collins
  - Maurício Tsugawa
- **Osaka University**
  - Shinji Shimojo
  - Susumu Date
  - Yoshiyuki Kido
- **University of California, San Diego**
  - Phil Papadopoulos
- **Advanced Industrial Science and Tech**
  - Atsuko Takefusa
  - Yoshio Tanaka
  - Jason Haga
- **Indiana University**
  - Quan Zhou
  - Jim Williams
  - Jennifer Schopf
- **National Institute of Information and Communications Technology**
  - Jin Tanaka
  - Hiroaki Yamanaka
- **Jilin University**
  - Xiaohui Wei
- **Computer Network Information Center – Chinese Academy of Sciences**
  - Ren Young Mao
  - Kejun Dong
- **National Center for High-performance Computing**
  - Fang-Pang Lin
  - Te-Lung Liu
  - Li-Chi Ku
- **Kasetsart University**
  - Putchong Uthayopas

Contents

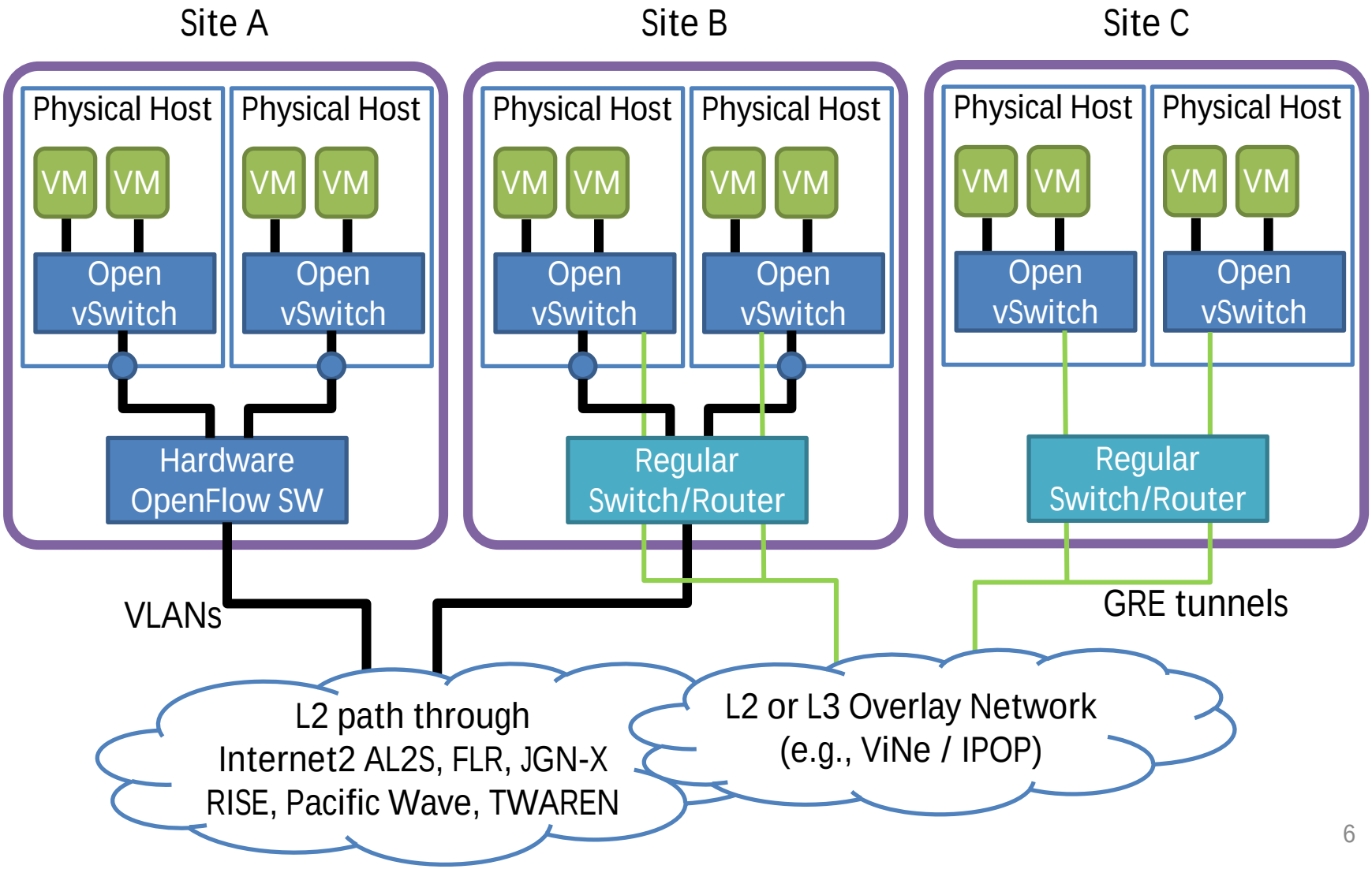
- ENT Architecture
  - Data Plane & Resources
  - Control Plane
- Applications on ENT

ENT Architecture

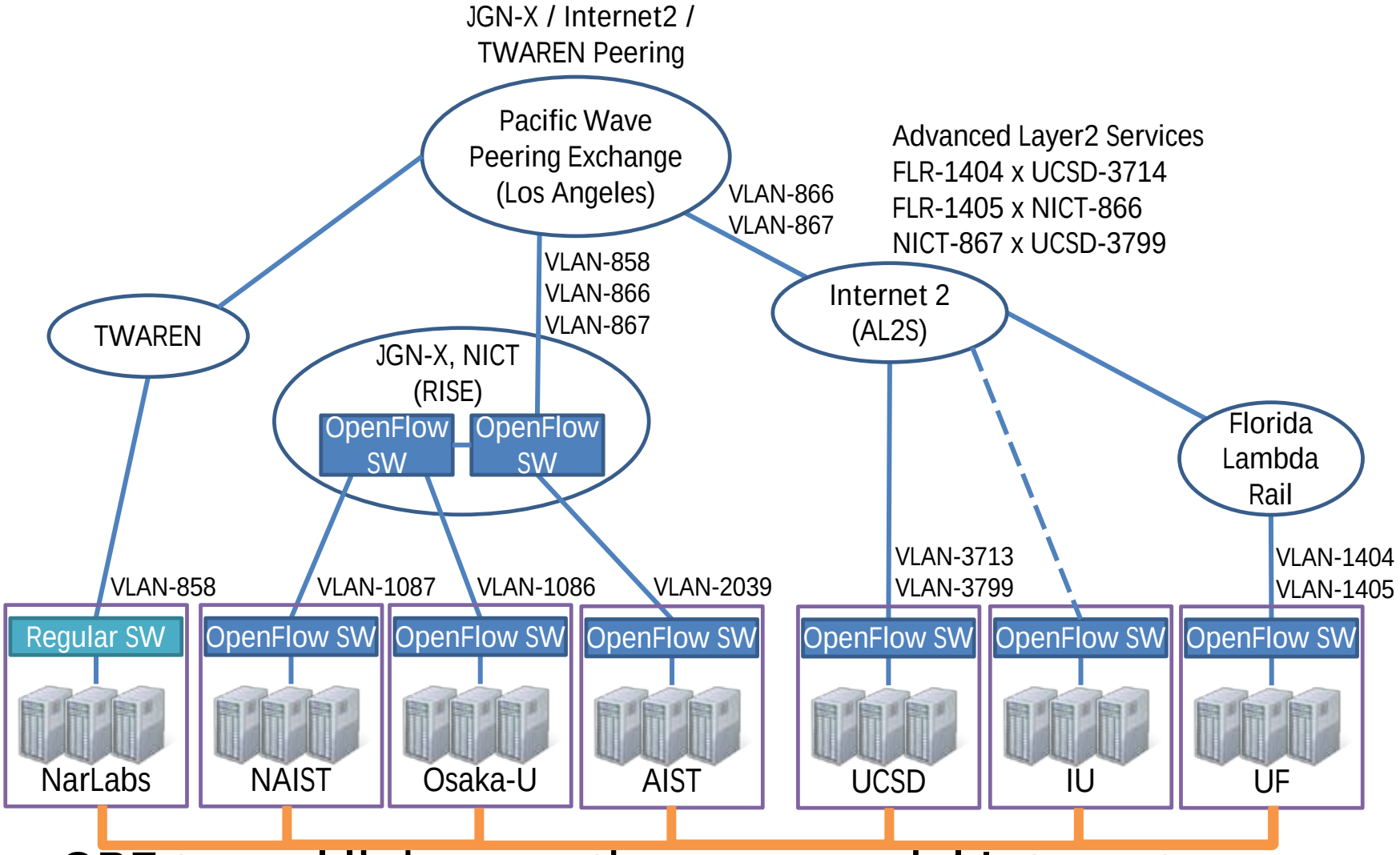
1. **Data Plane & Resources**

2. Control Plane

ENT Architecture: Data Plane & Resources

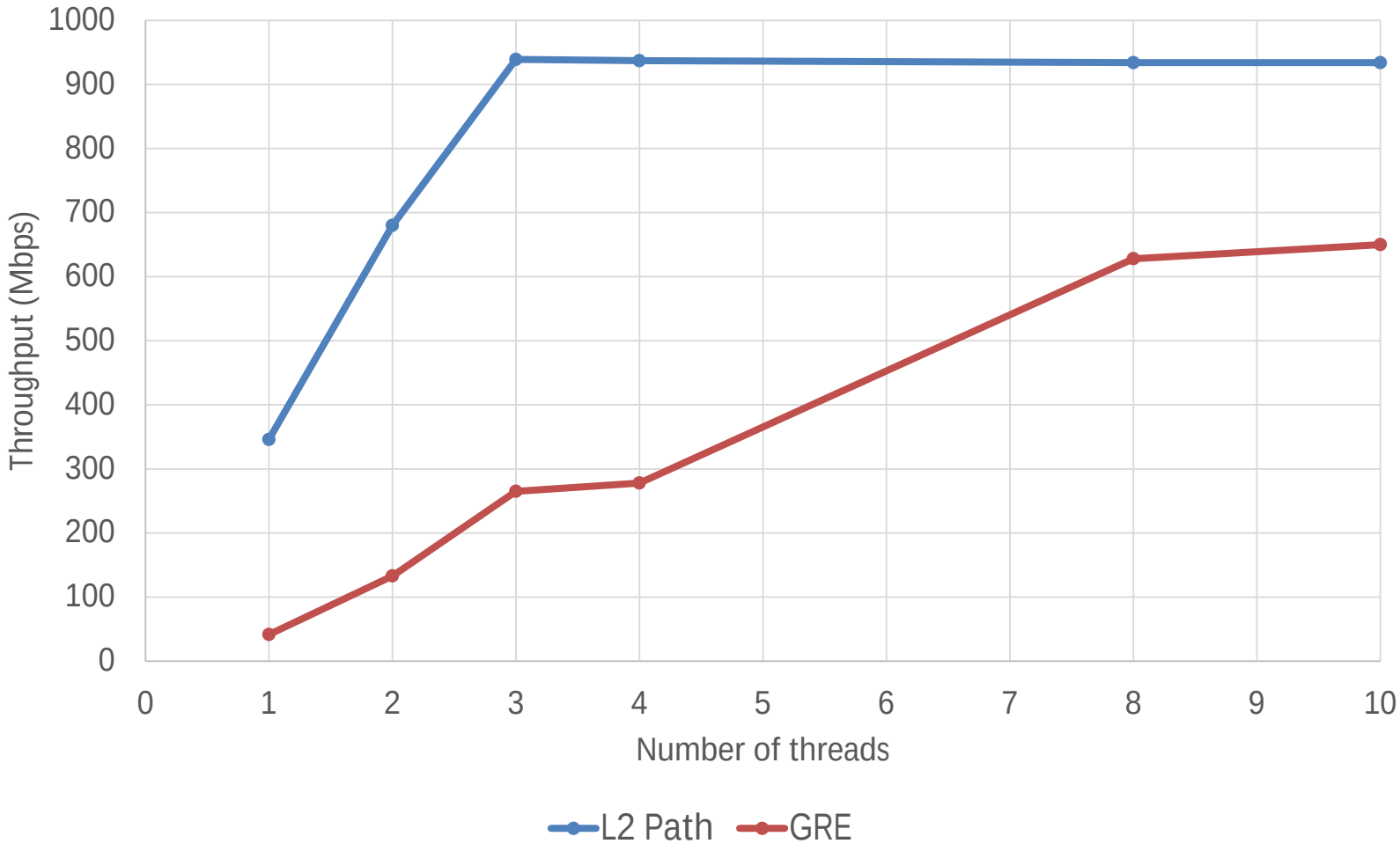


ENT Architecture:
L2 Data Plane Backbone



GRE tunnel links over the commercial Internet are established as alternative paths

Direct Layer-2 Path vs. GRE Tunneling



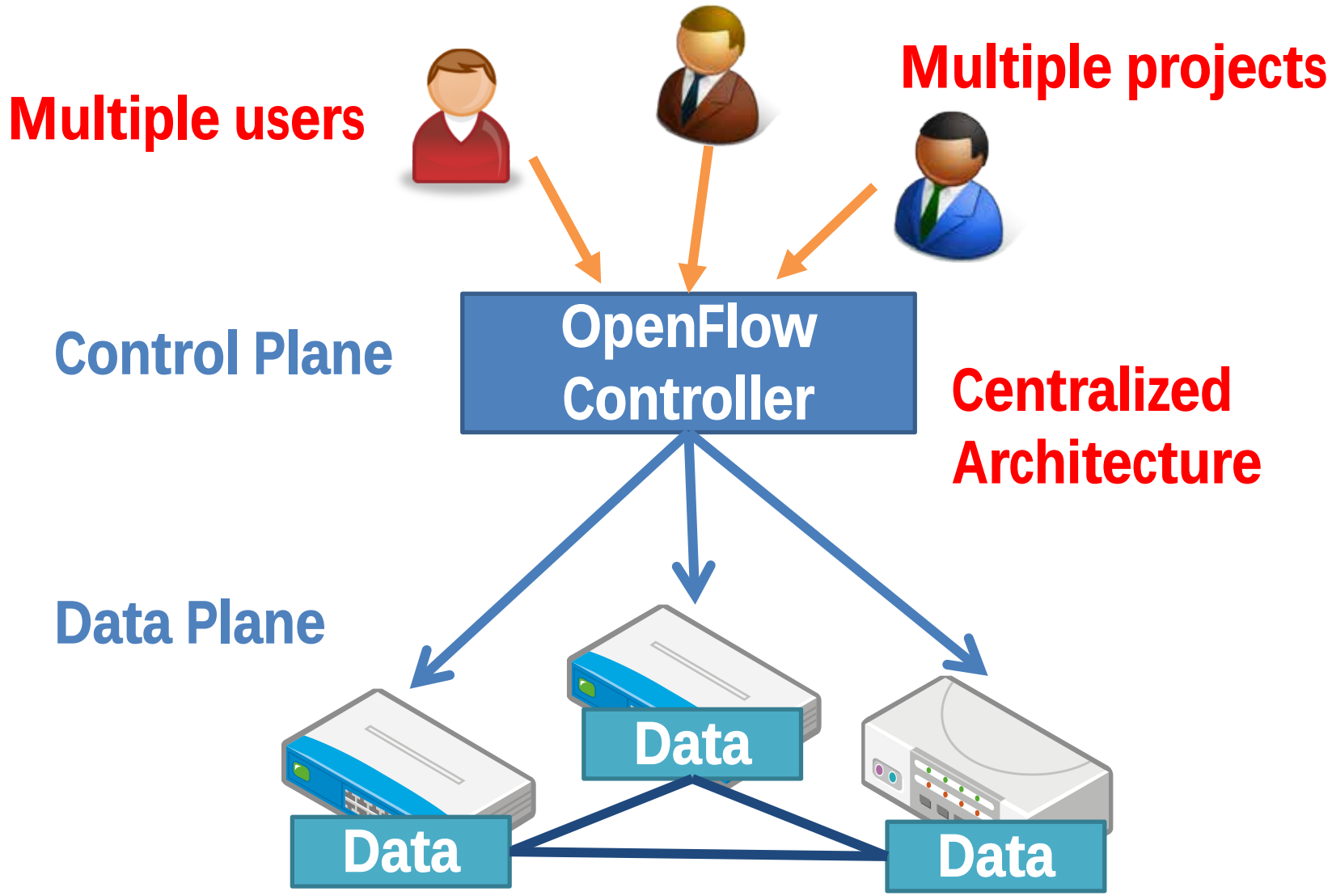
GRE tunneling links are still useful as alternative paths despite the heavy software processing overheads in a GRE tunnel.

ENT Architecture

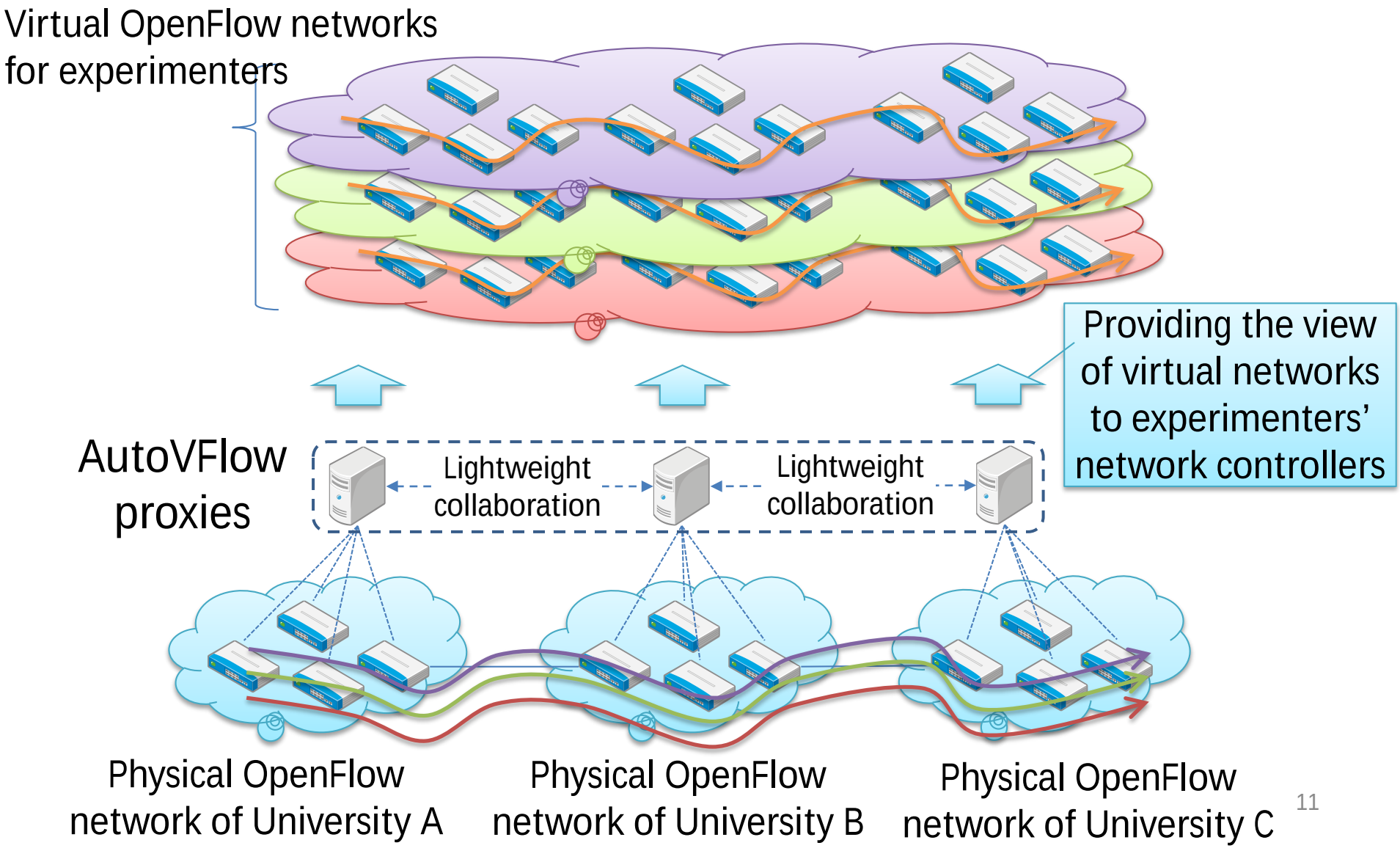
1. Data Plane & Resources

2. **Control Plane**

ENT Architecture: Control Plane



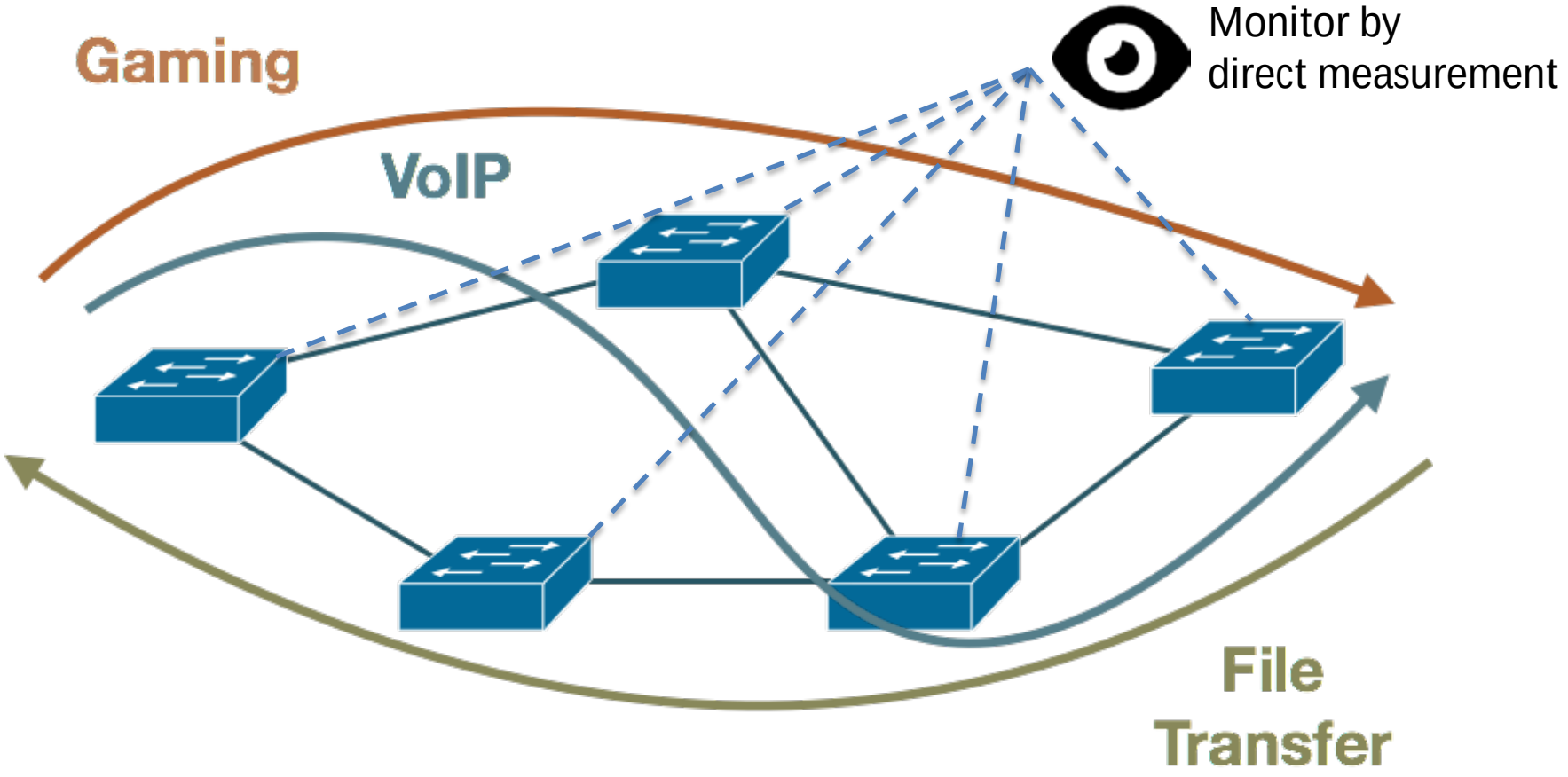
Distributed Sliced Control Plane: AutoVFlow



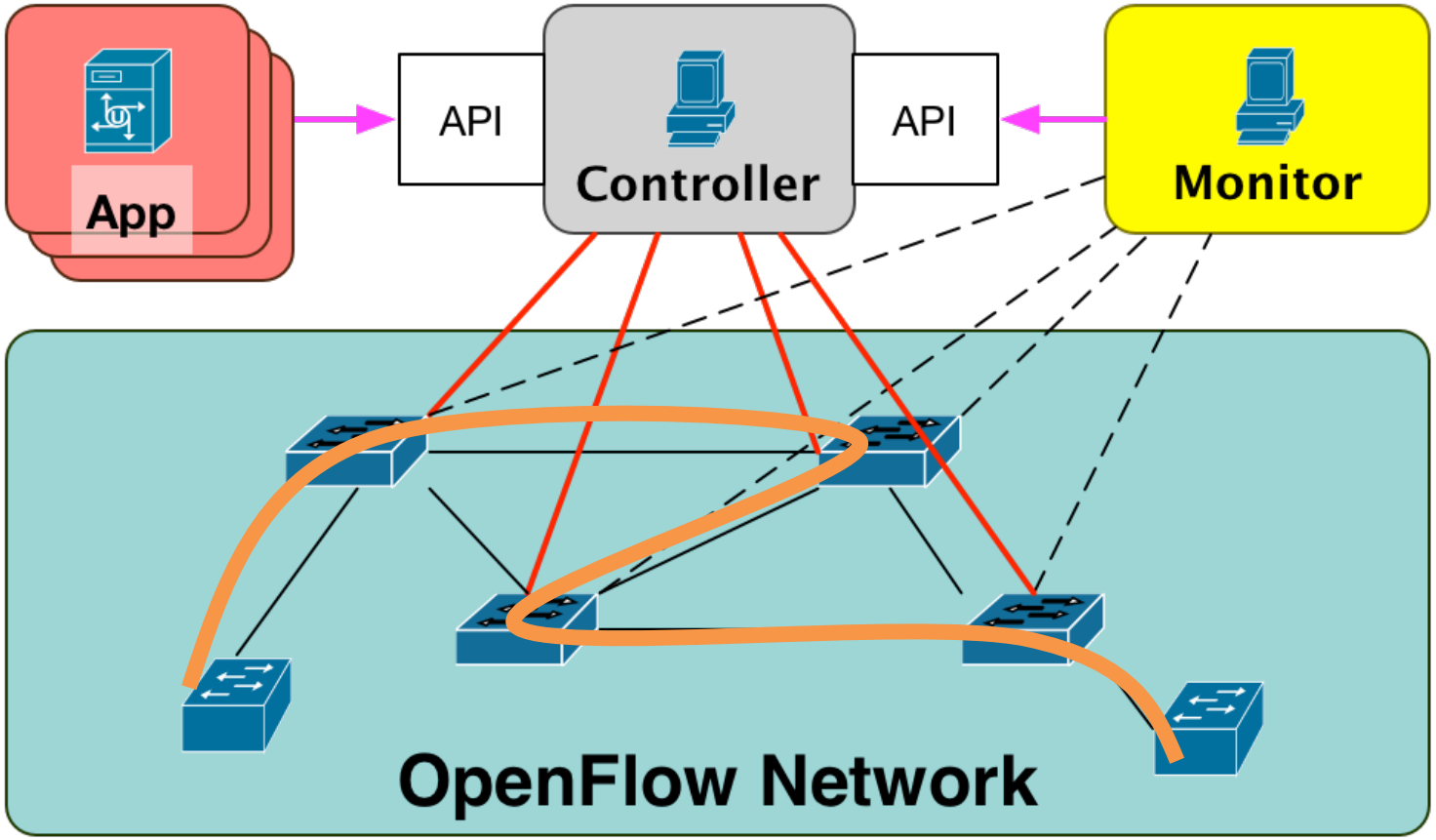
Applications on ENT

- Bandwidth and Latency aware routing
- Multipath routing
  - Multipath GridFTP
  - Multipath TCP
- eScience Visualization Application
  - Satellite Image Sharing between Taiwan and Japan
  - Flow Control for Streamings on Tiled Display Wall

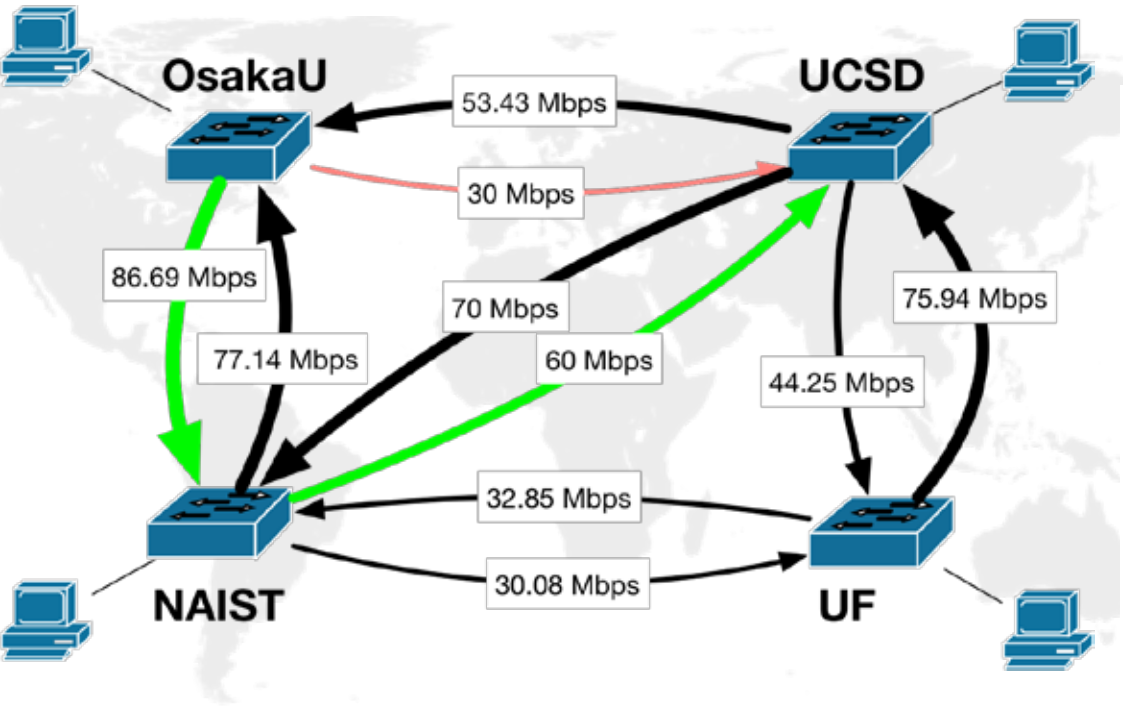
Concept of Bandwidth and Latency aware routing

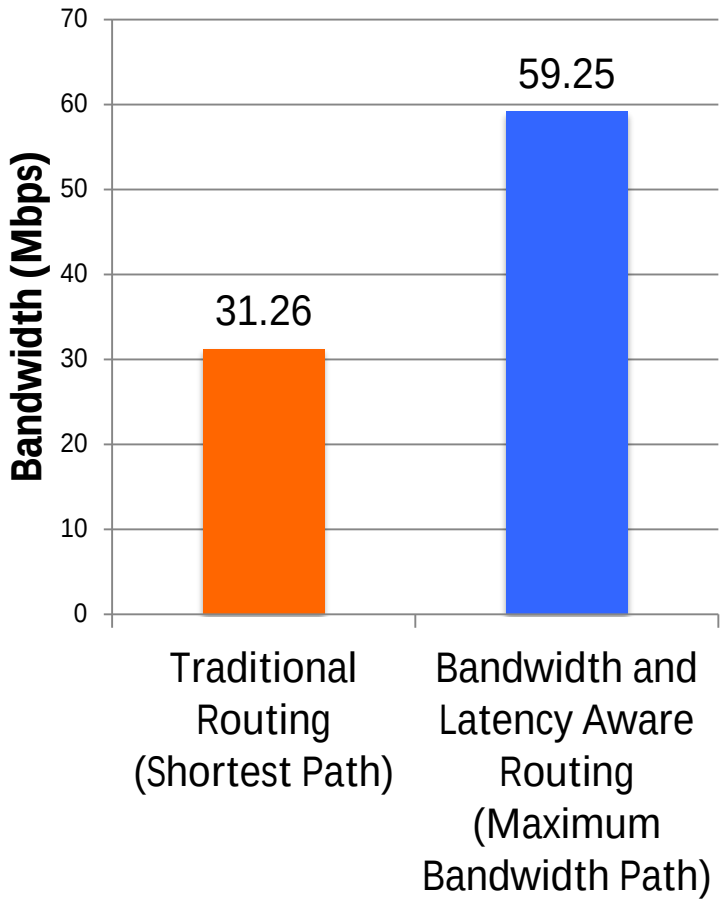


Architecture of Bandwidth and Latency aware routing



Results of Bandwidth and Latency aware routing

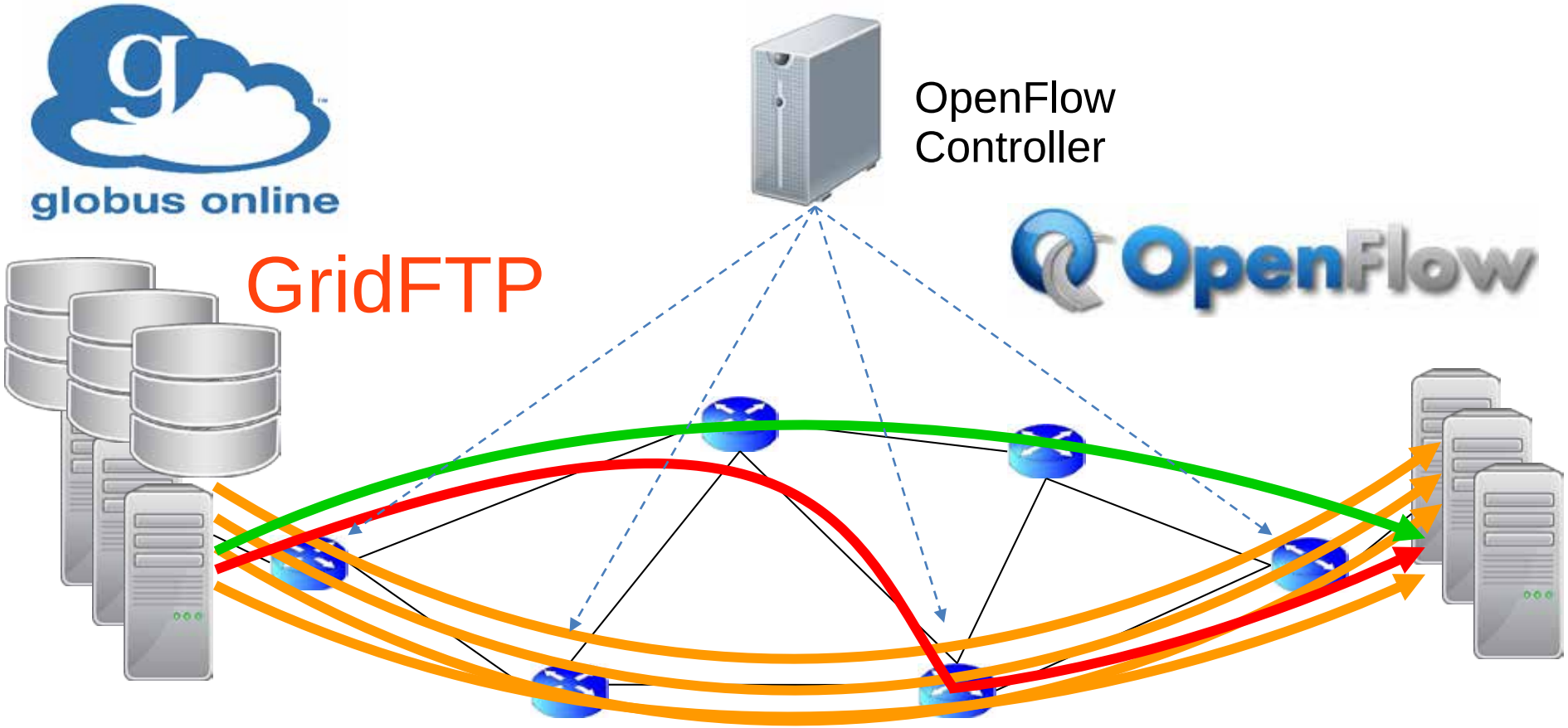




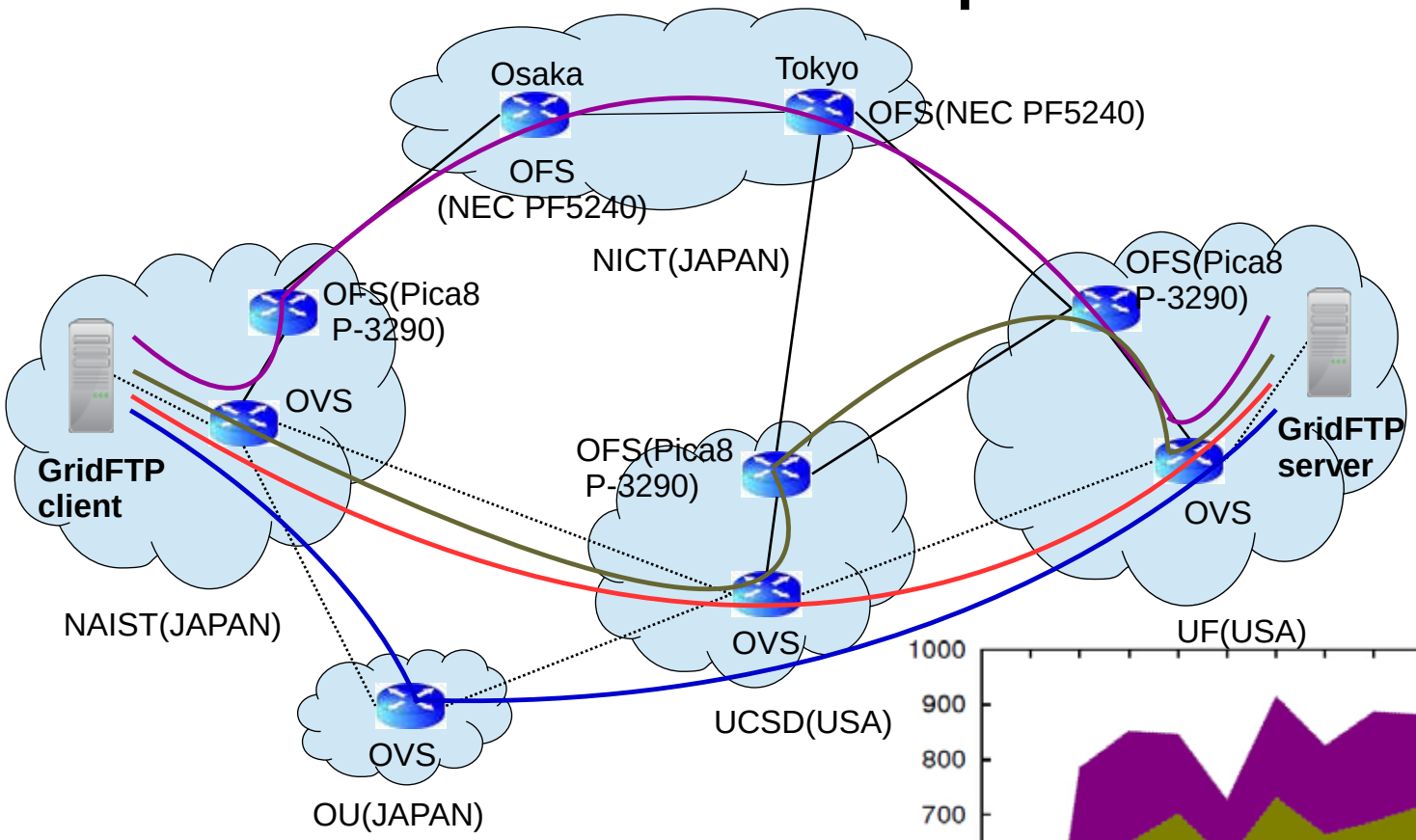
Multipath Routing

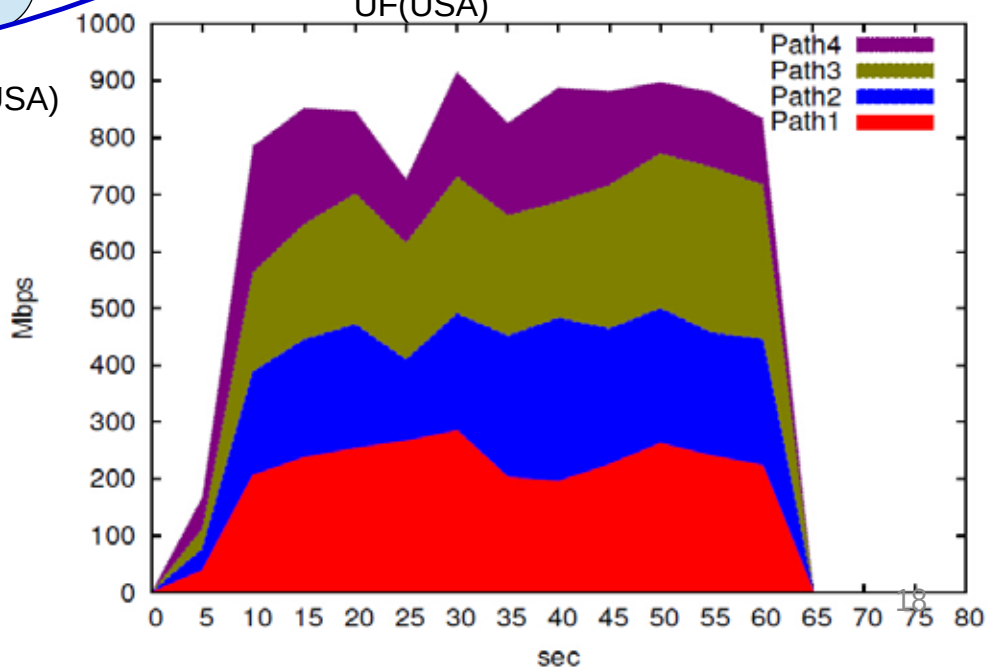
- Use multiple paths simultaneously
  - Application level
    - More flexible control (# of flows) for each application
    - Needs application specific implementation
  - Network level
    - No modification is needed for applications
    - Implemented in OS/system library level; less flexibility

SDN Multipath GridFTP

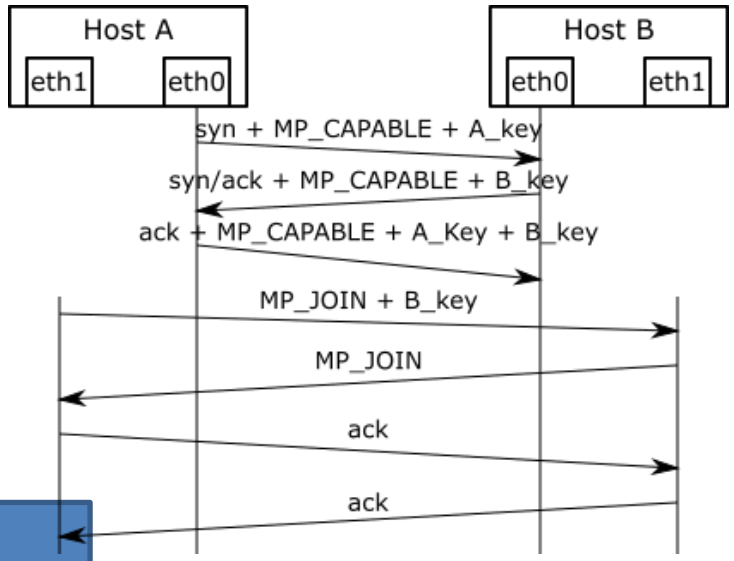


Results of SDN Multipath GridFTP



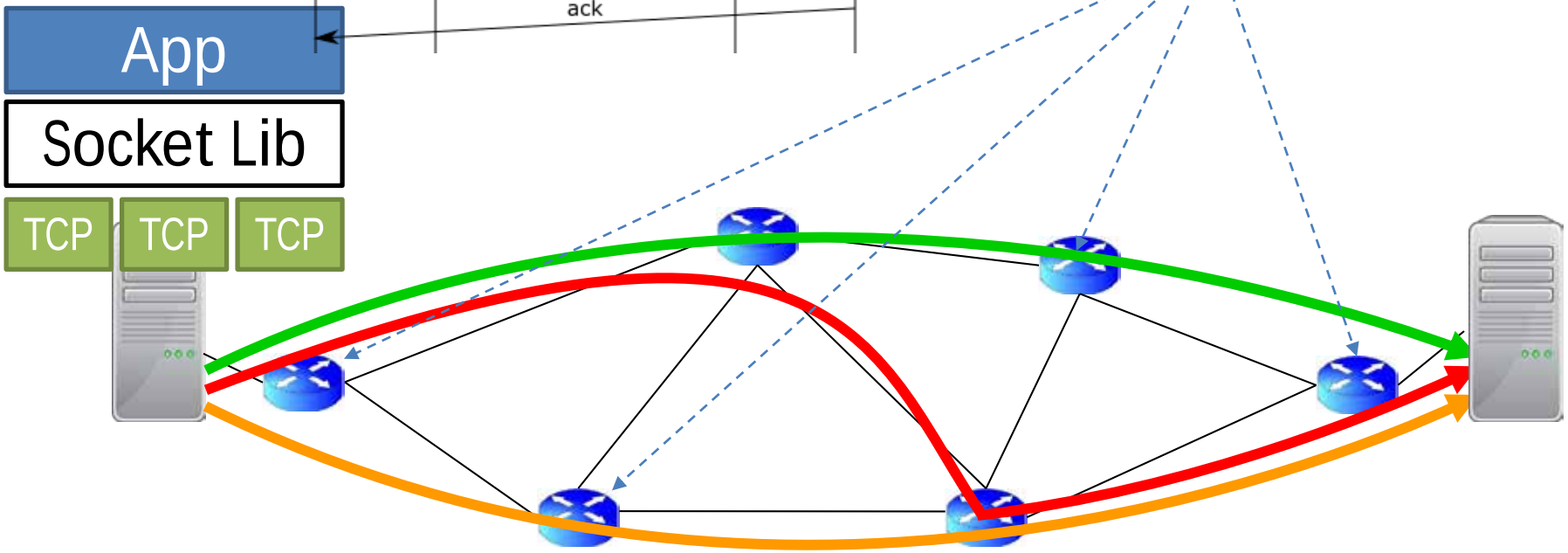


SDN Multipath TCP (MPTCP)

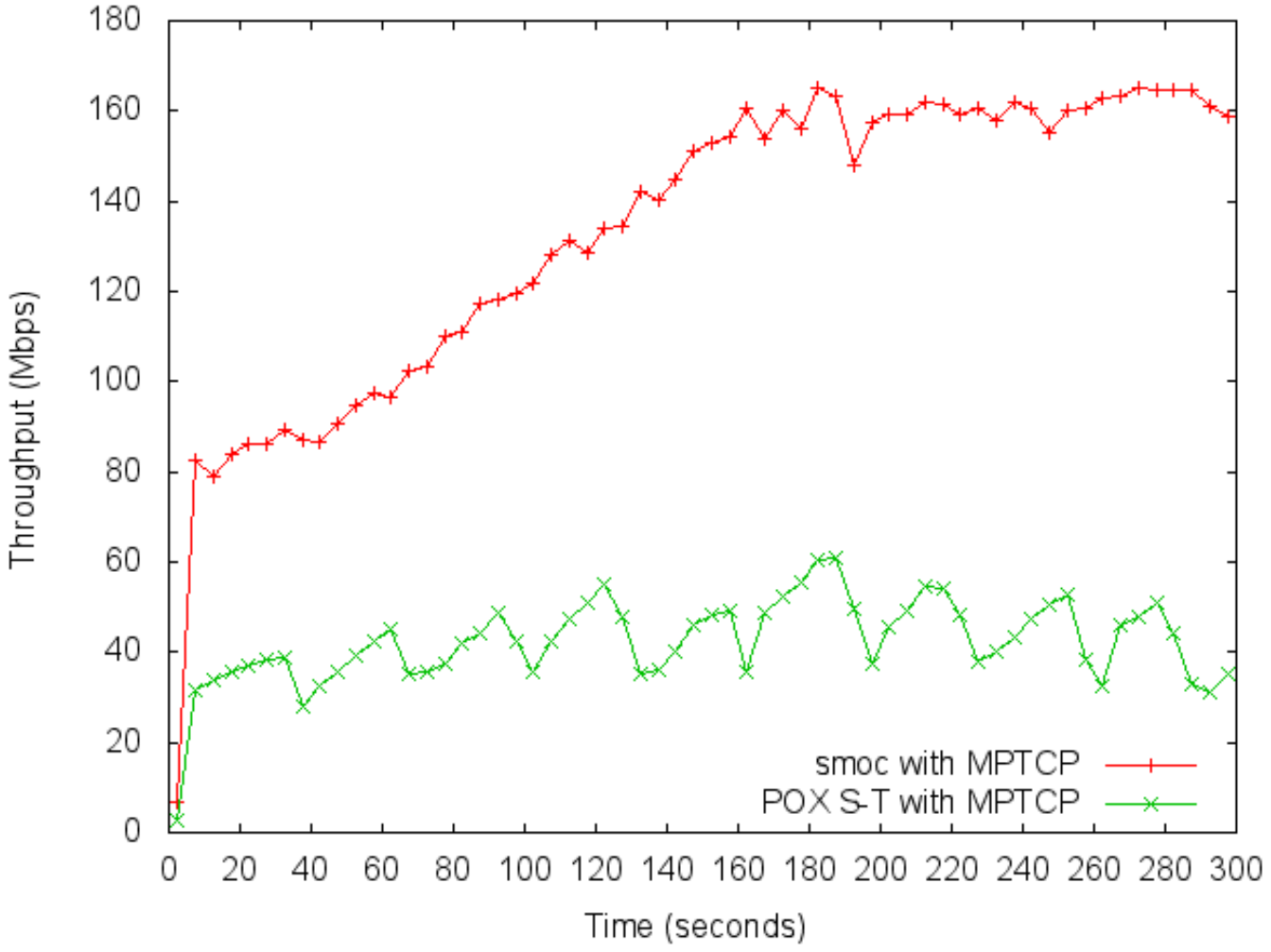


Analyzes MPTCP handshake, detect flow group and distributes the sub-flows over different multiple paths

OpenFlow Controller



Results of SDN Multipath TCP

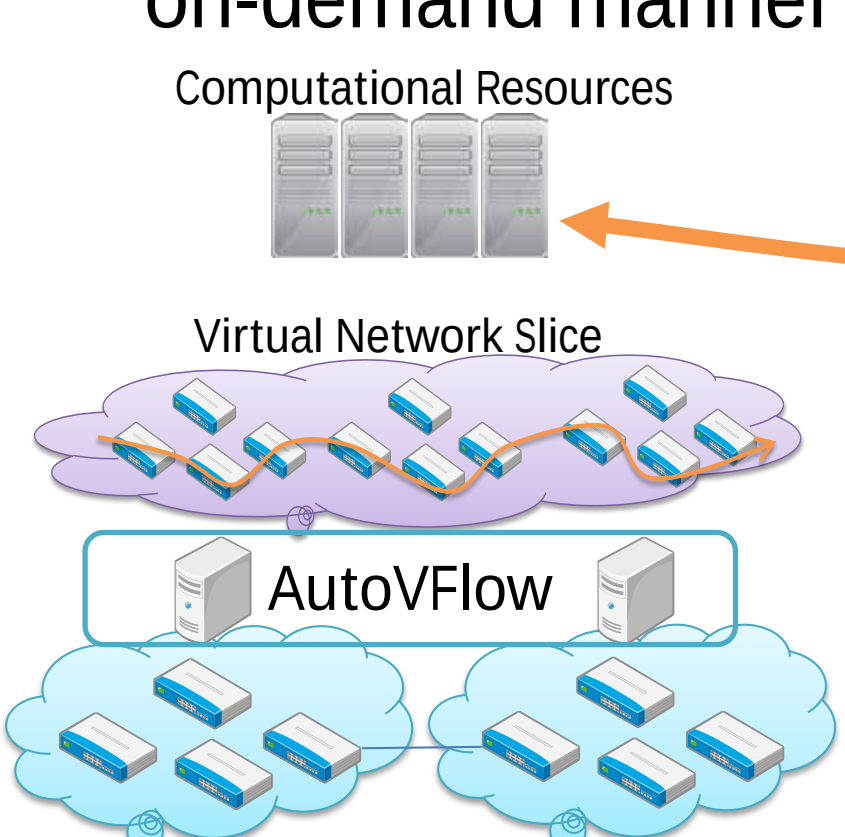


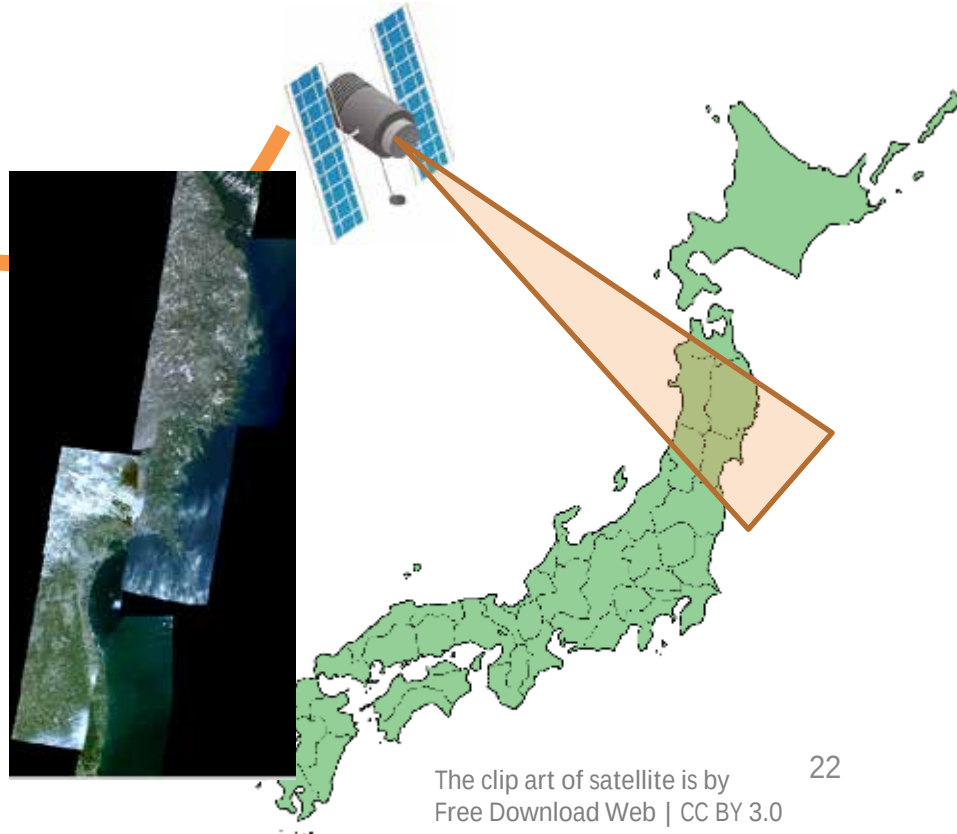
eScience Visualization

- Visualization in eScience applications relies on the network of a distributed environment.
  - **Where scientists view** the computational results is geographically different compared to **where the data was processed**

Satellite Image Sharing between Taiwan and Japan

- To rapid response to natural disasters, high-speed dedicated network needs to be established in a on-demand manner

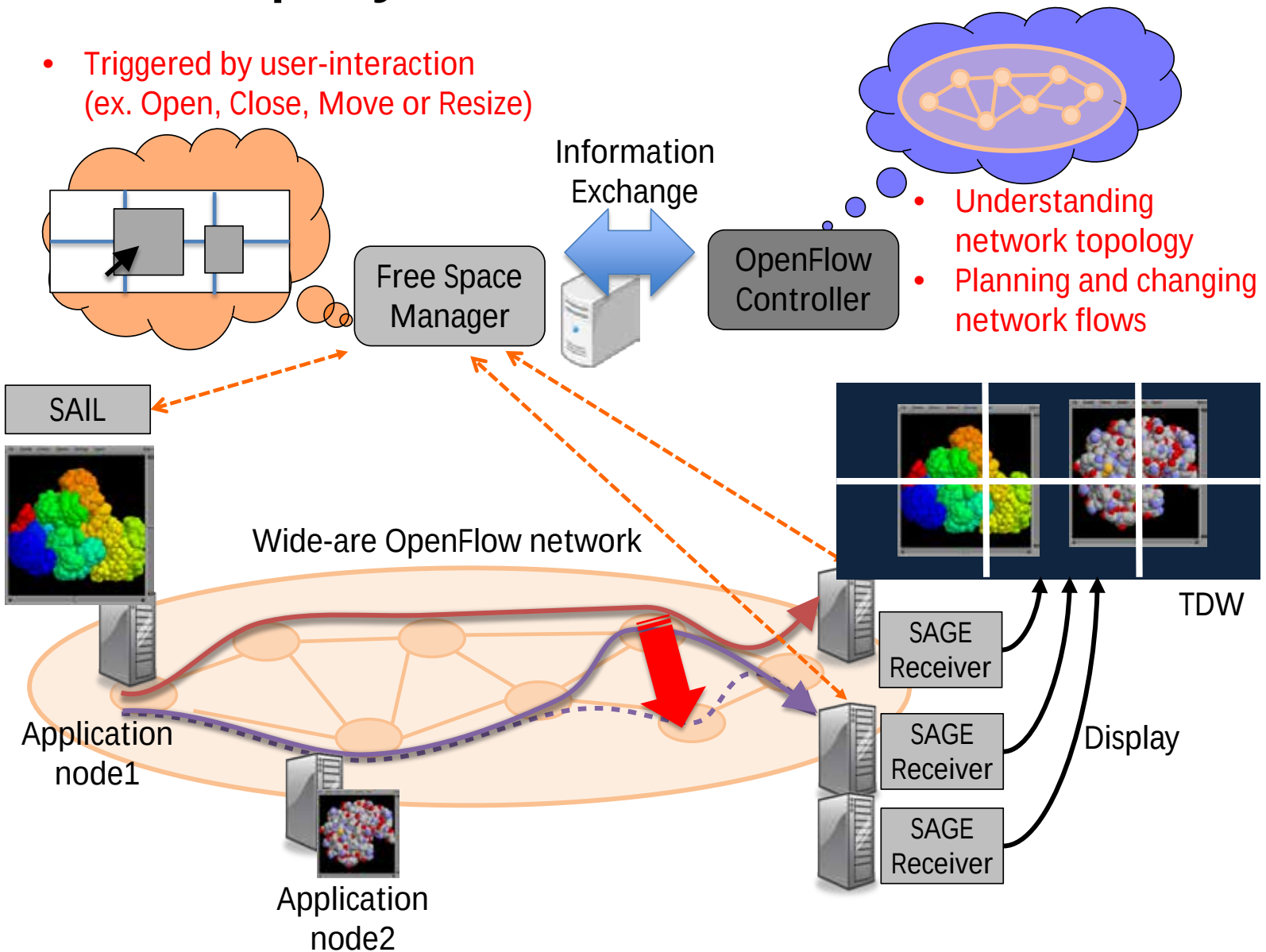




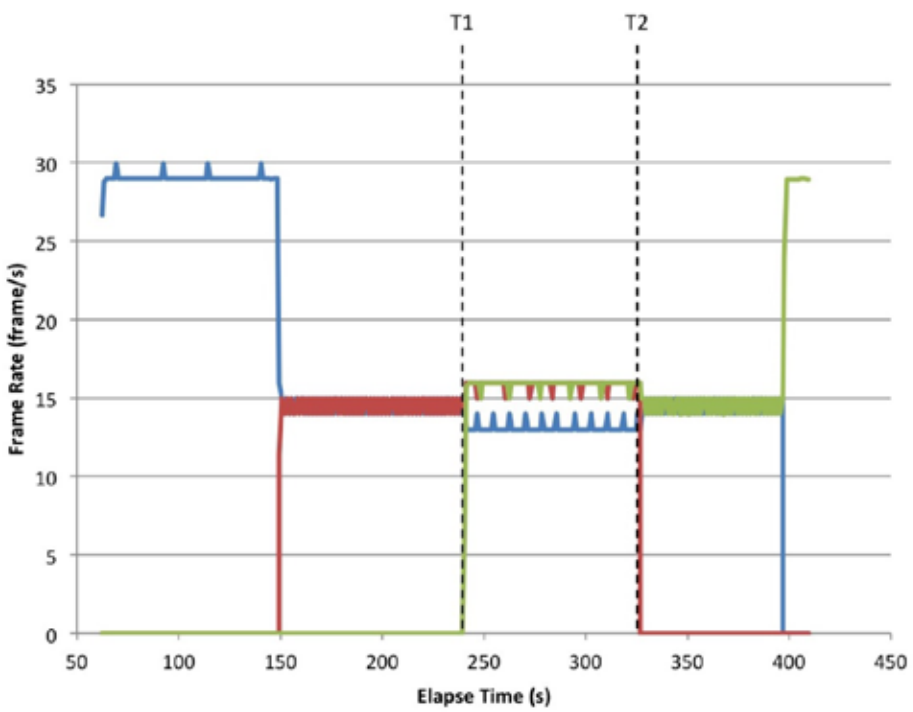
Results of Satellite Image Sharing

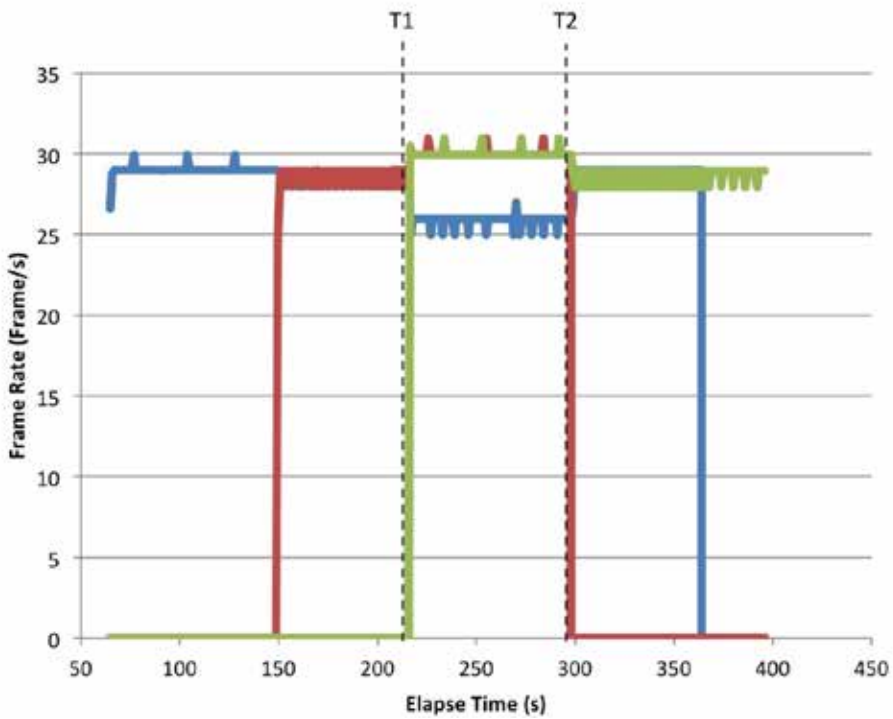
- Got better performance than the Internet
  - Through PRAGMA-ENT testbed (end to end SDN)
  - TWAREN and JGN-X direct peering in Los Angeles
  - Using a dedicated 622 Mbps lightpath

Flow Control for Streamings on Tiled Display Wall



Results of Flow Control for Streamings on Tiled Display Wall





T1: App #2 window is moved to the border of displays from Display D1

T2: App #2 window is moved to Display D2

Without flow control

With flow control

Conclusion & Future Plan

- We have been developing a network testbed for use by different PRAGMA researchers and institutes
- The network testbed offers complete freedom for researchers to access network resources with SDN

- Future Plan
  - Expanding network (Direct L2 and/or virtual overlay)
  - Monitoring testbed
  - Scheduler for users' experiments
  - ENT operation center (NOC)