

GMPLS-based Traffic Engineering in Multi-Region / Multi-Layer Service Network

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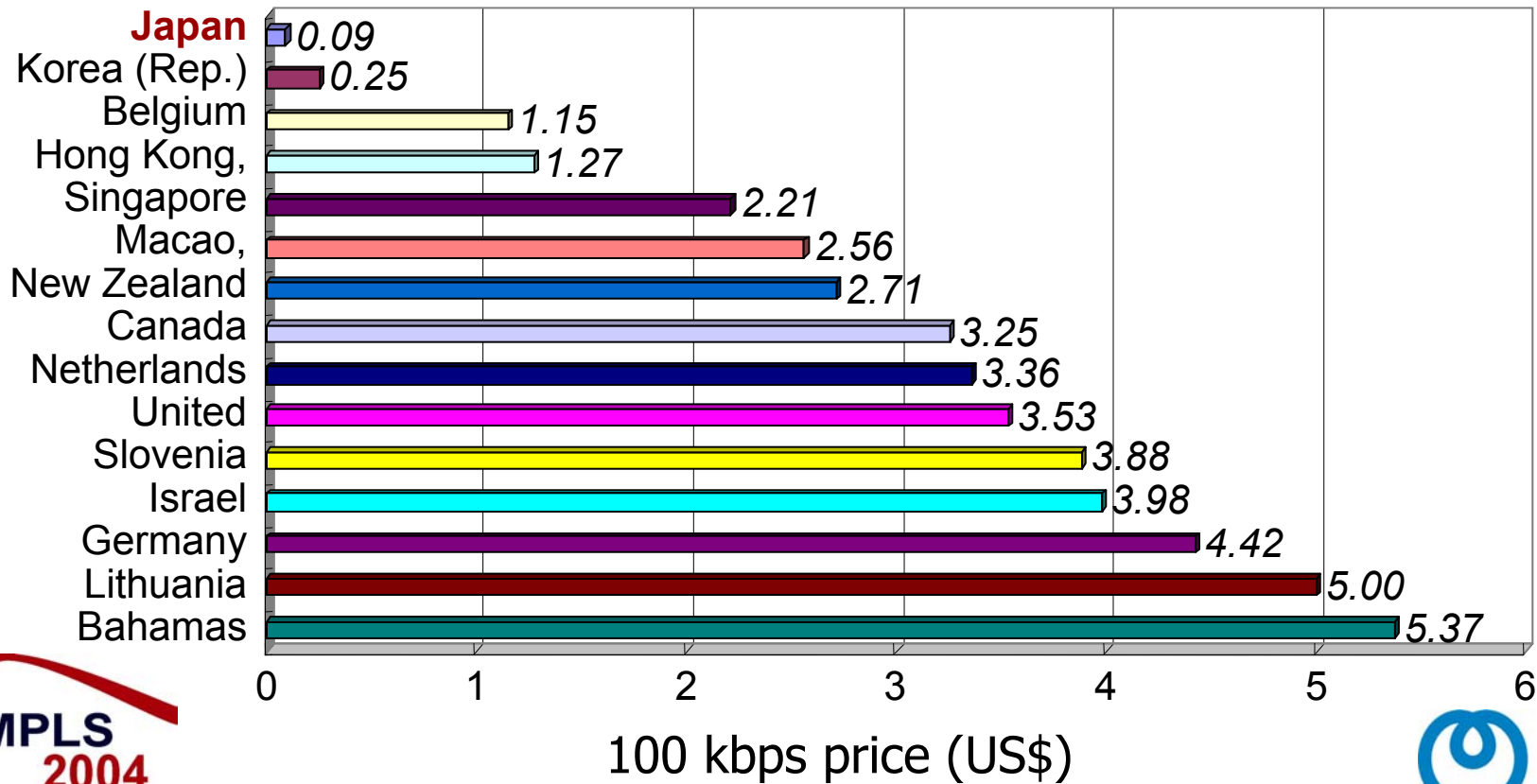


Outline

- IP optical network
- Multi-layer service networks
- IP optical multi-region traffic engineering

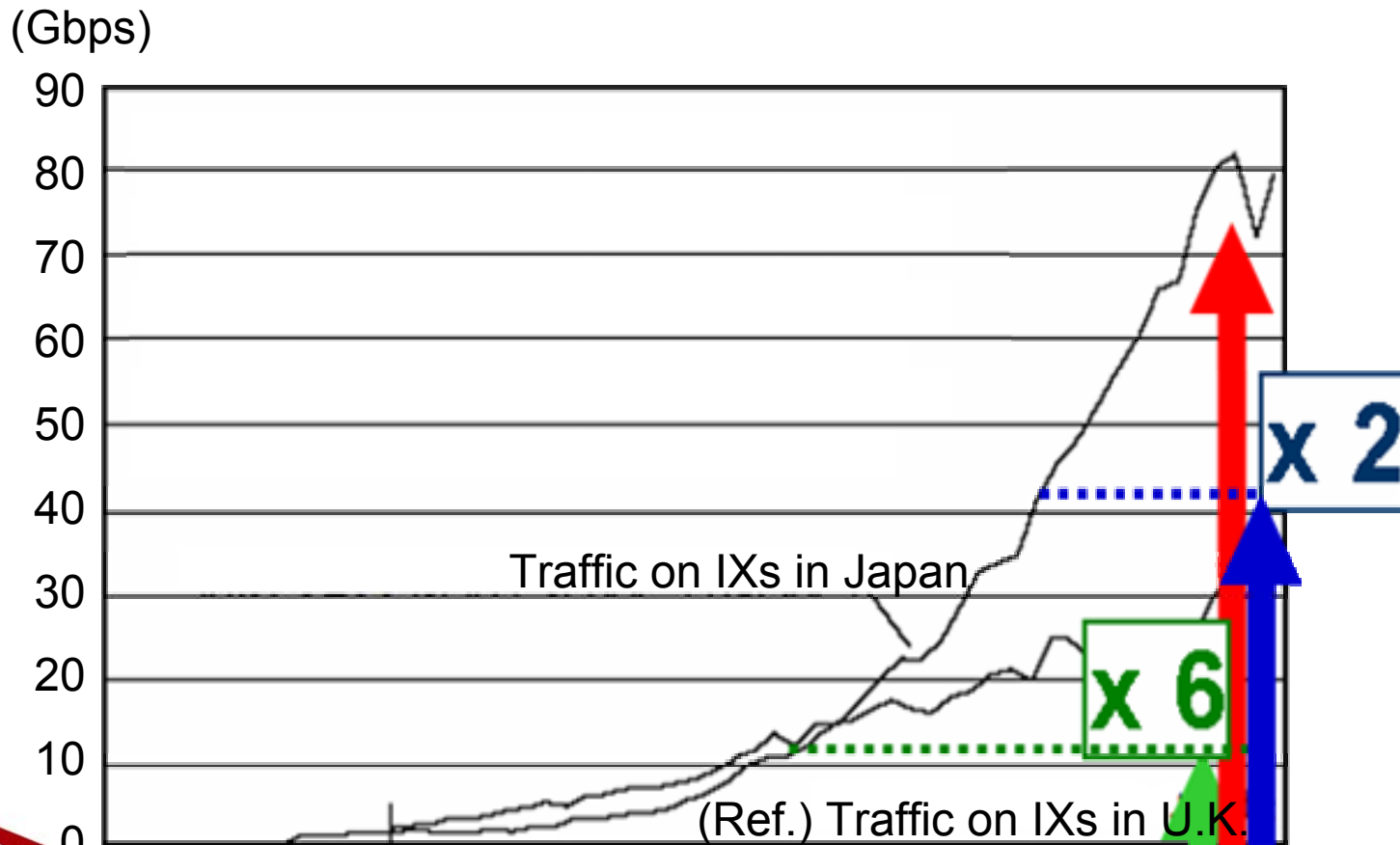
Broadband service price comparison

- Cheapest in the world thanks to fierce competition
- But, no ISPs can profit enough money to invest new tech.



Traffic on IXs of Japan

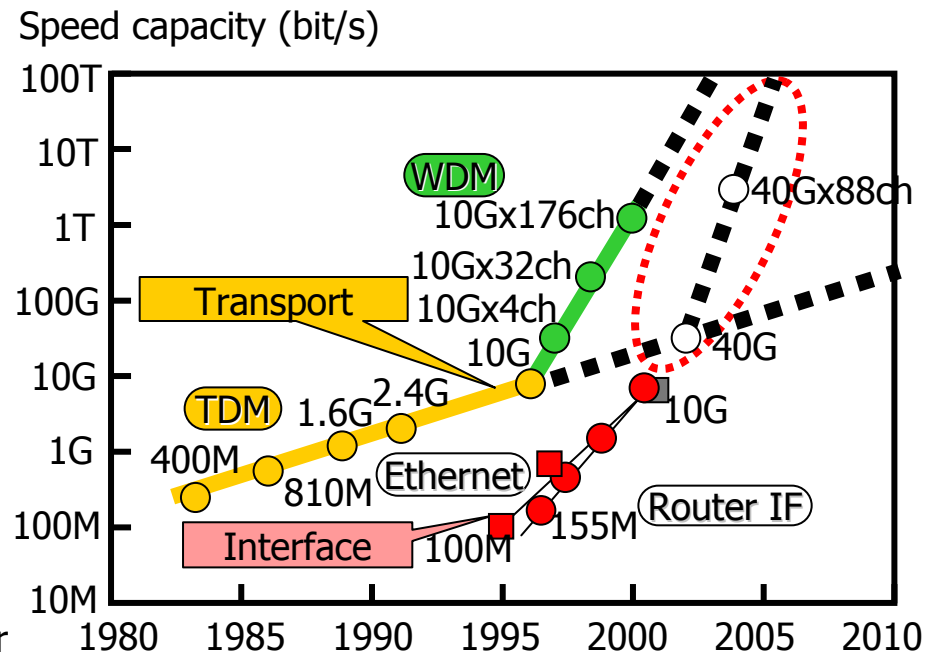
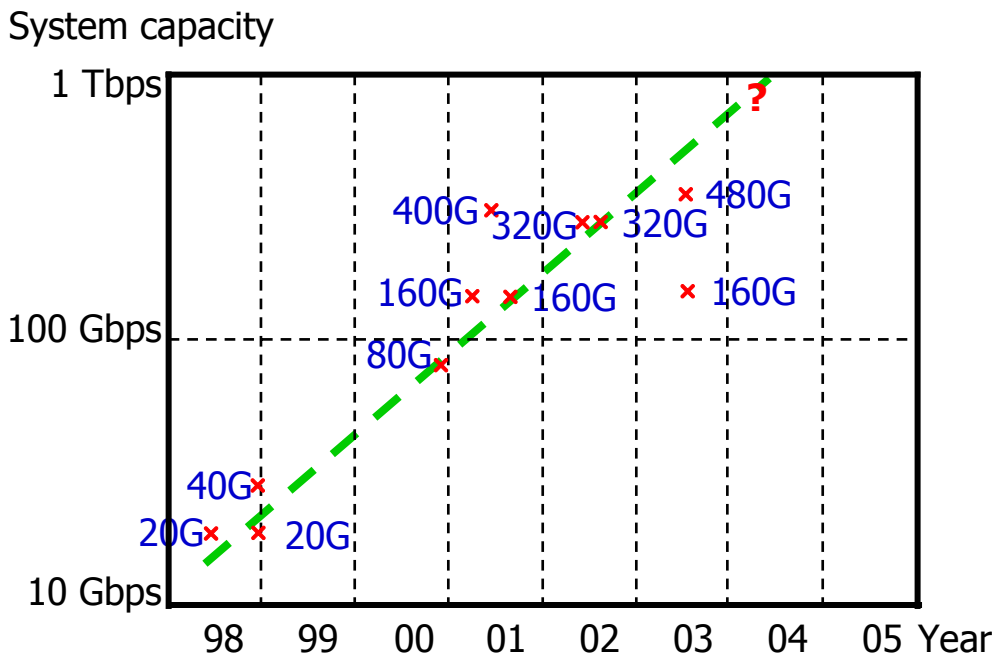
- The amount of traffic has been increasing rapidly



Excerpt from report from Study Group on Next Generation IP-based Info-communications Infrastructure set up by MPHPT

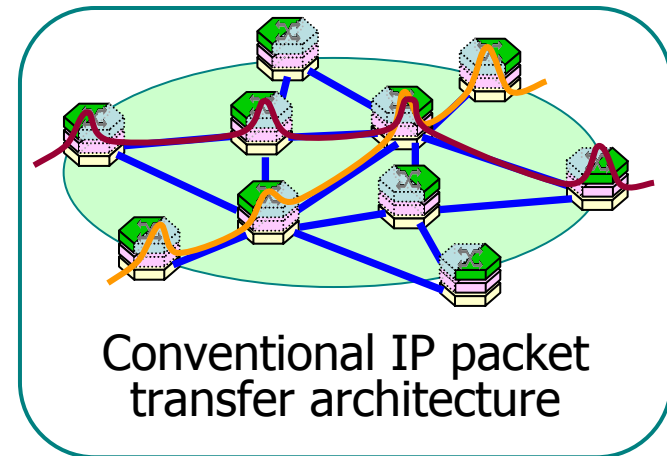
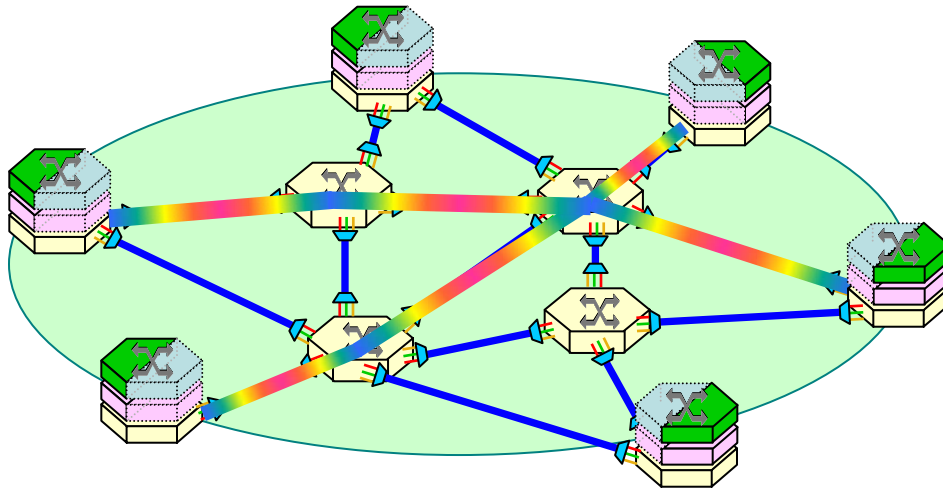
Trend of router throughput

- Limitation of electrical processing beyond 40Gb/s



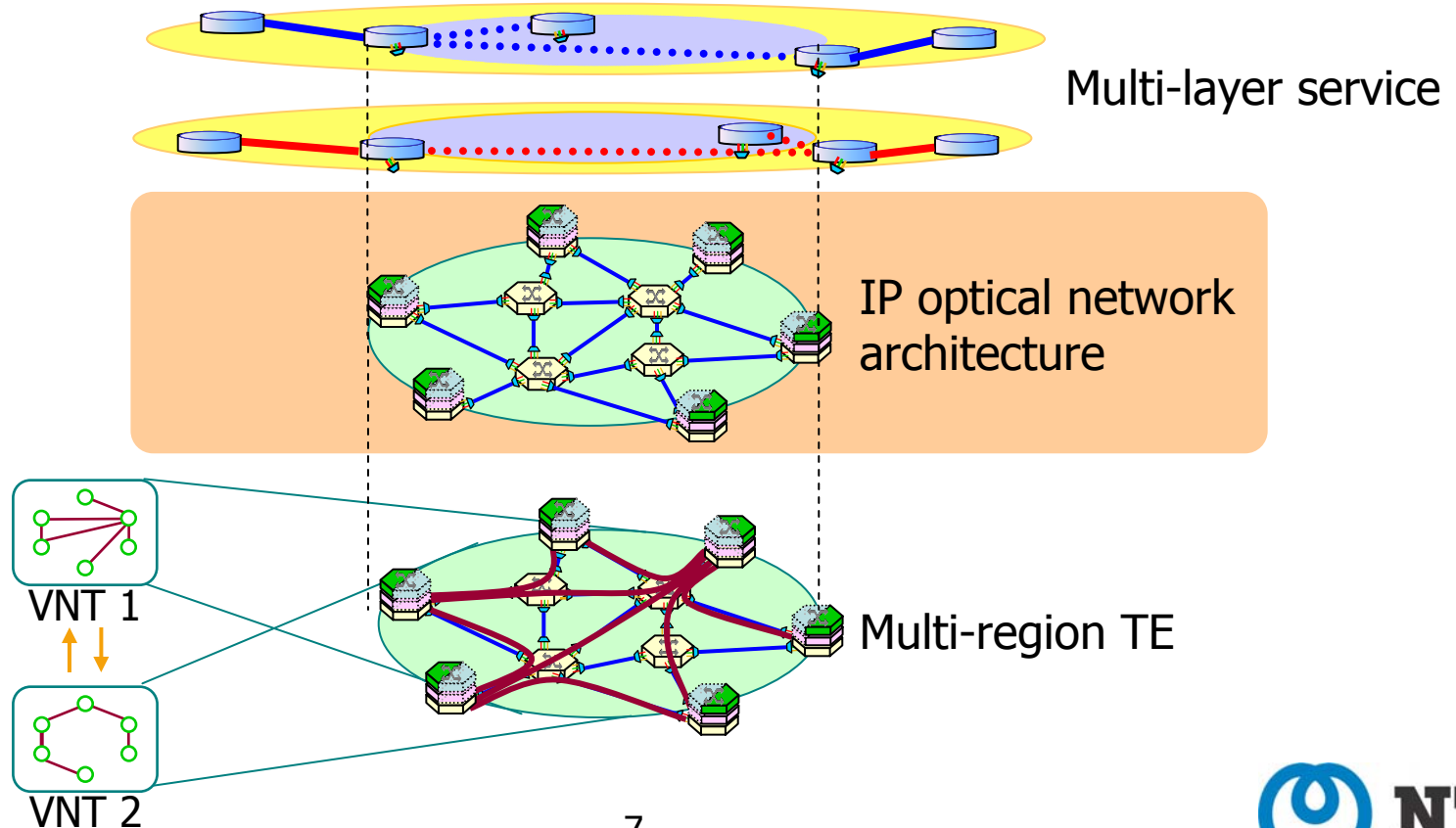
IP optical network architecture

- Direct optical path setup among edge nodes without electrical IP processing in transit nodes. (cut-through by optical path)



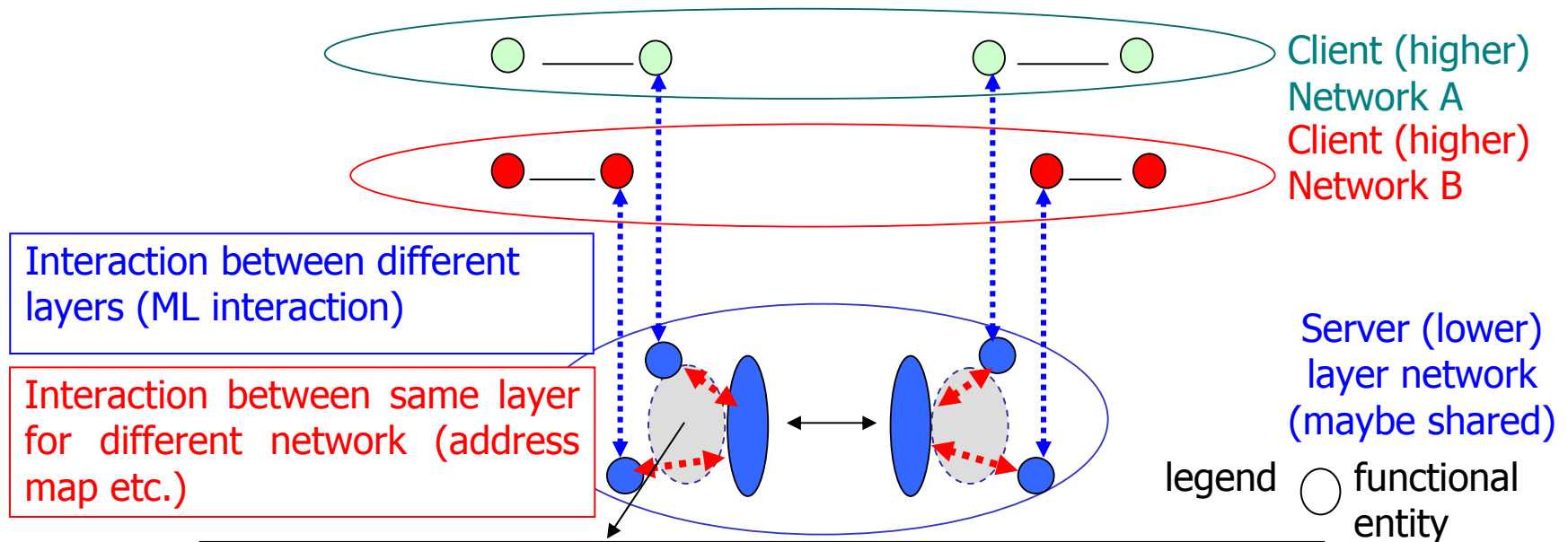
IP optical network architecture

- Multi-layer service networks
- IP optical multi-region traffic engineering



Multi layer network architecture concept

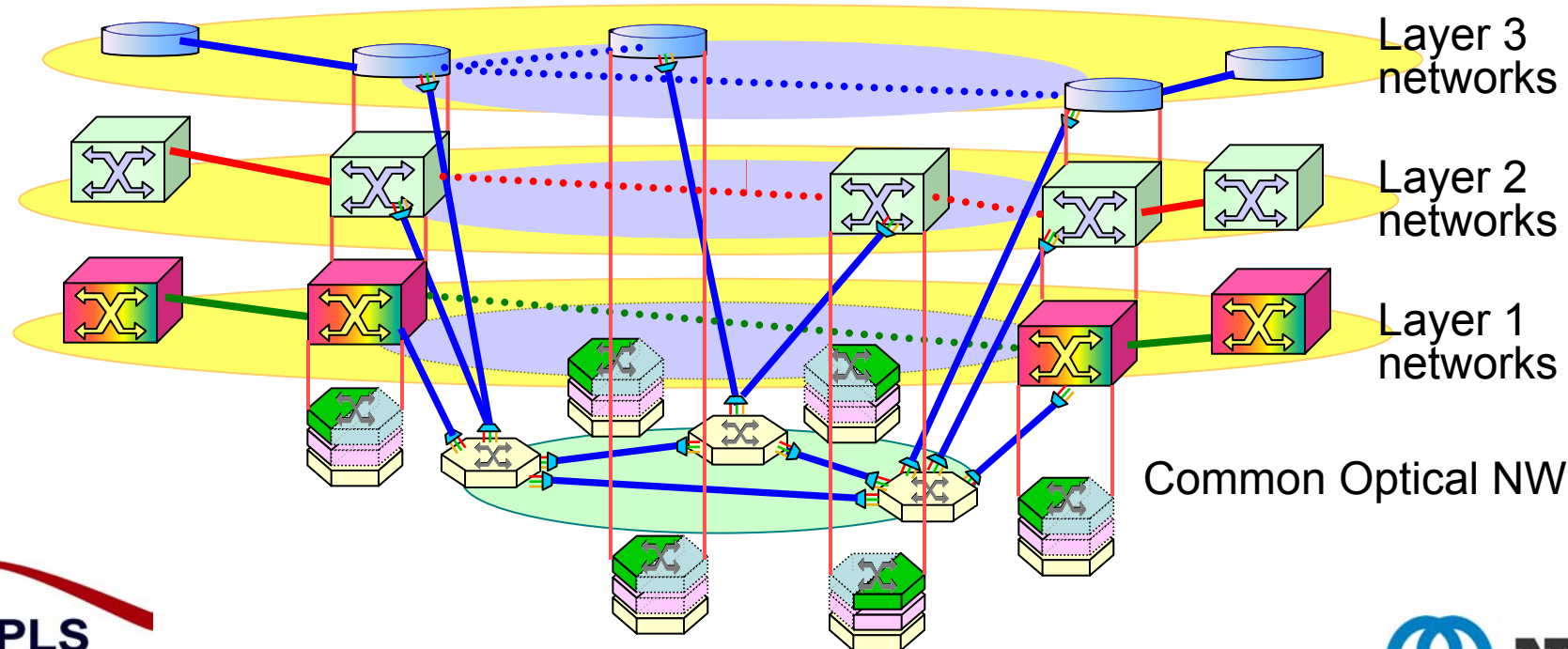
- ITU-T has agreed on a new recommendation called Y.2011. There is a section to conceptually include the multi layer network architecture.
- This is a natural extension of GMPLS multi regional network concept.



Server layer function provides independent control of multiple parameters including address spaces, control parameters, policies and other algorithms for different client layer networks.

Multi-layer service network architecture utilizing IP optical network concept

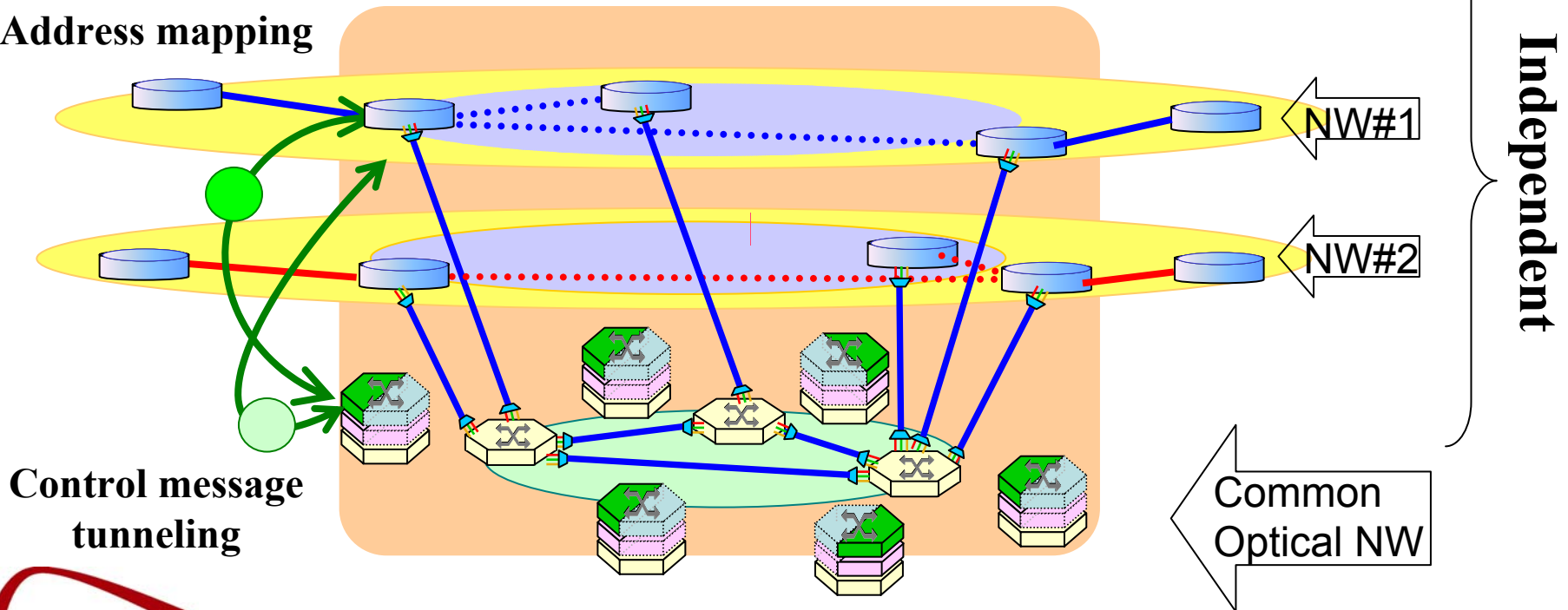
- Accommodate Multiple different layer network service, different type of service, in different control technologies (i.e., address spaces)
- Dynamic optical path control enabling advanced service realization



Accommodate Multiple service-networks

- Accommodate multiple service-networks utilizing independent control technologies and address spaces

Address mapping



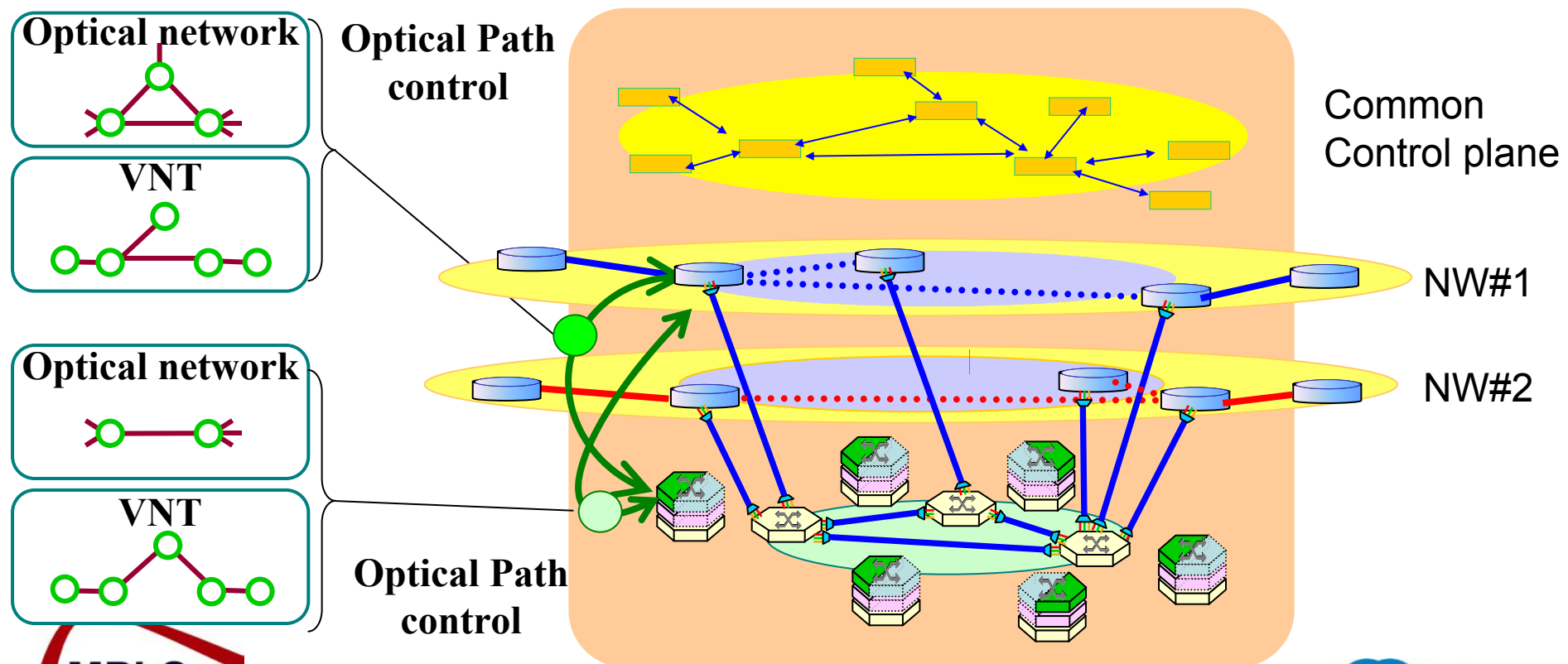
Control message tunneling

Common Optical NW

Independent

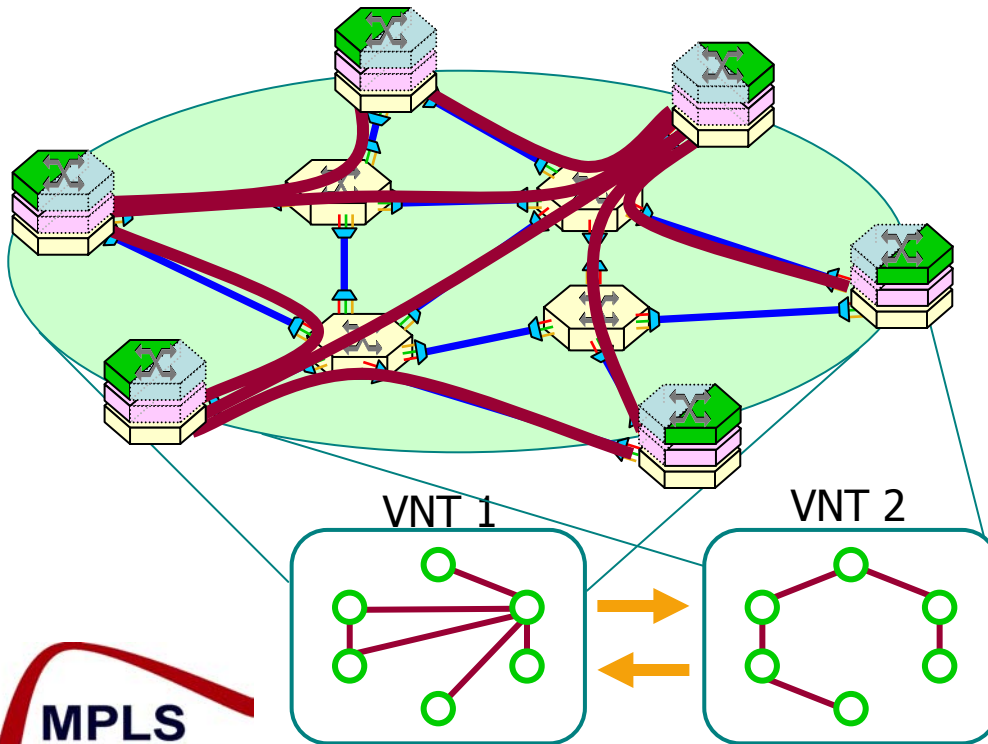
Autonomous optical path control

- Autonomous optical path control according to different conditions in each service network



IP optical multi-region traffic engineering

- TE based on dynamic reconfiguration of VNT
 - Lambda-layer provides VNT for packet-layer
 - VNT is re-configured by LSP setup/teardown.
 - Lambda-LSP is routed over the fiber topology.



Traffic demand

$$\begin{pmatrix} r_{1,1} & r_{1,2} & \Lambda & r_{1,n} \\ r_{2,1} & r_{2,2} & \Lambda & r_{2,n} \\ M & M & O & M \\ r_{n,1} & r_{n,2} & \Lambda & r_{n,n} \end{pmatrix}$$

Current VNT

$$\begin{pmatrix} P_{1,1} & P_{1,2} & \Lambda & P_{1,n} \\ P_{2,1} & P_{2,2} & \Lambda & P_{2,n} \\ M & M & O & M \\ P_{n,1} & P_{n,2} & \Lambda & P_{n,n} \end{pmatrix}$$

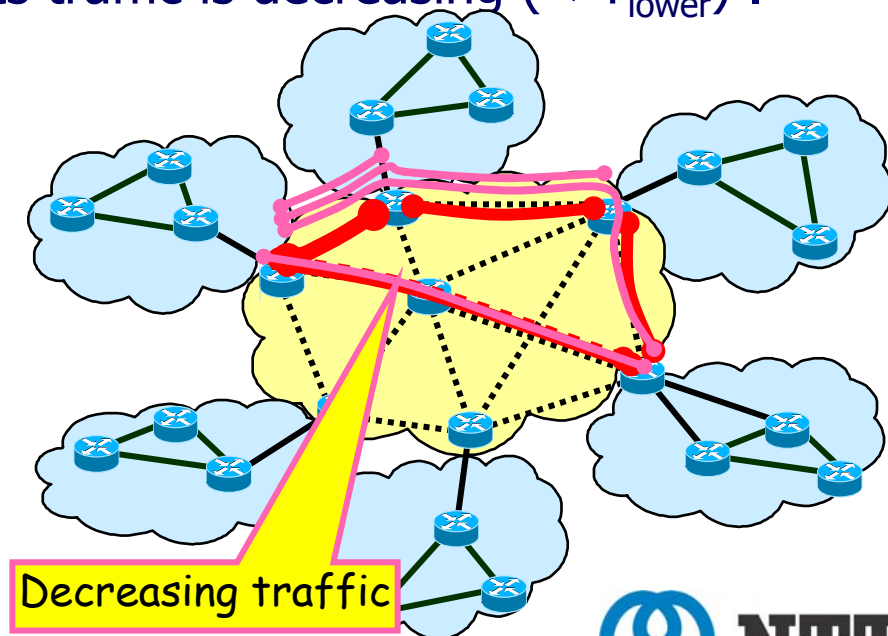
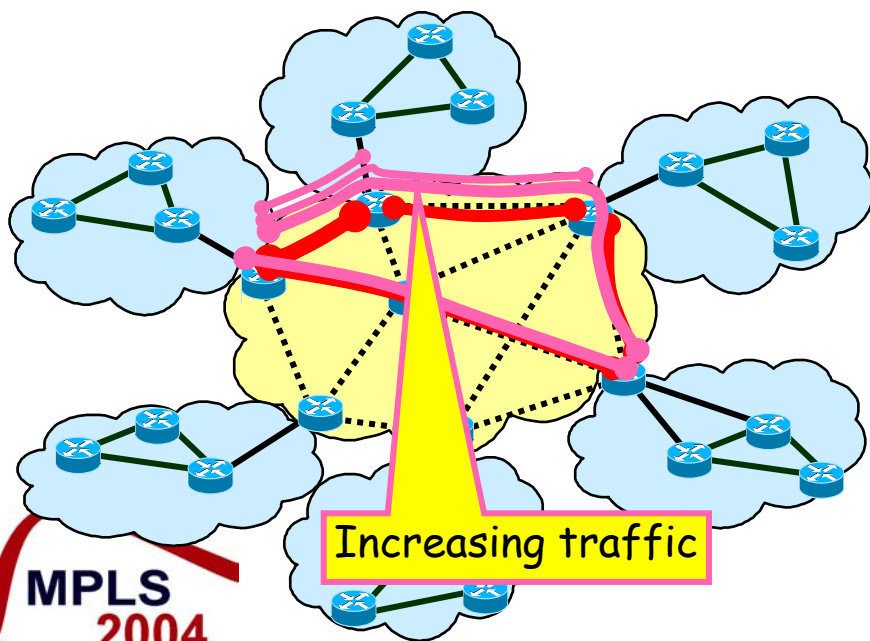


New VNT

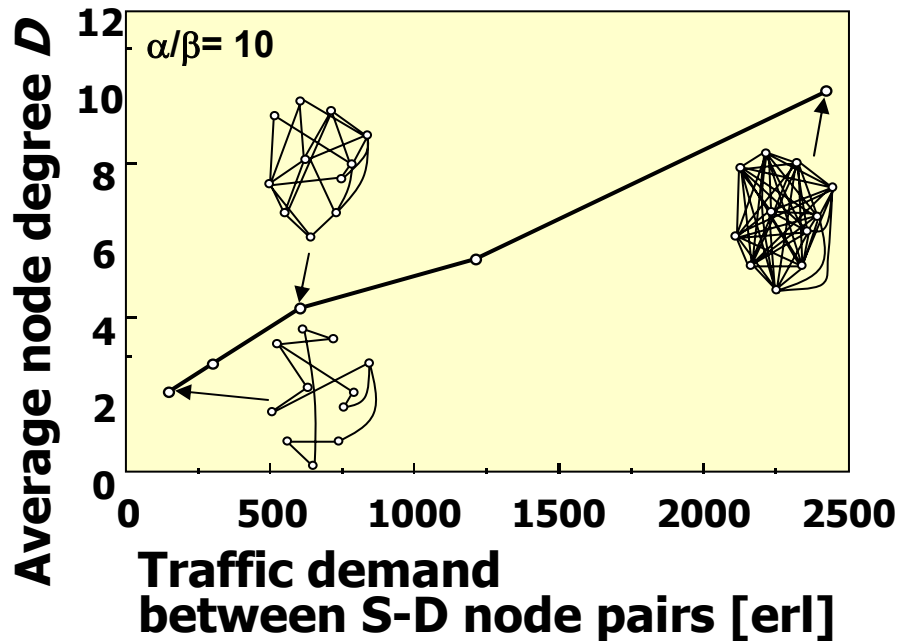
$$\begin{pmatrix} P_{1,1} & P_{1,2} & \Lambda & P_{1,n} \\ P_{2,1} & P_{2,2} & \Lambda & P_{2,n} \\ M & M & O & M \\ P_{n,1} & P_{n,2} & \Lambda & P_{n,n} \end{pmatrix}$$

Heuristic VNT calculation algorithm

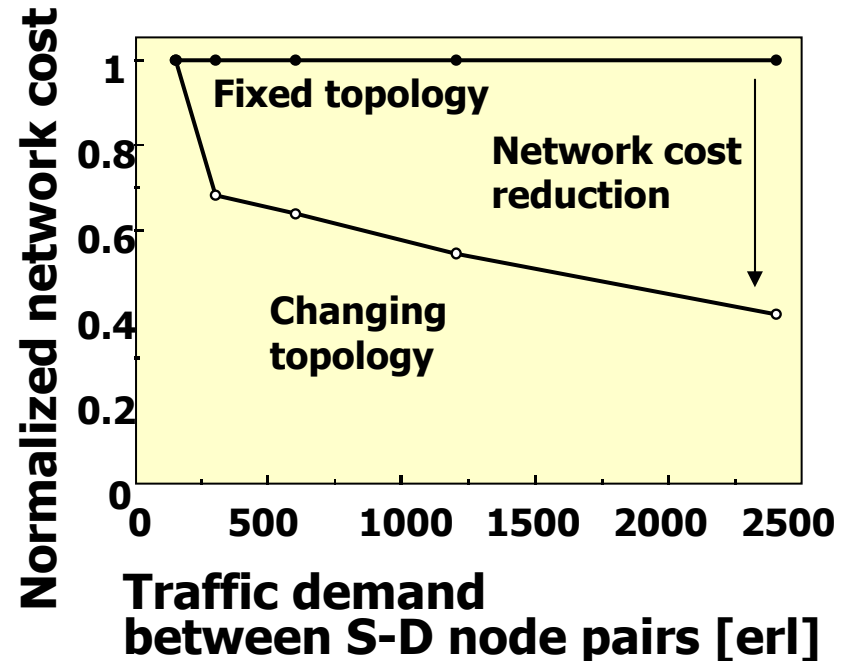
- LSP setup for increasing traffic
 - New lambda-LSP is set up so that multi-hop packet LSPs over the congested lambda-LSP ($> T_{upper}$) can get routed.
- LSP teardown for decreasing traffic
 - Lambda-LSP is torn down if its traffic is decreasing ($< T_{lower}$).



Effect of dynamic VNT reconfiguration



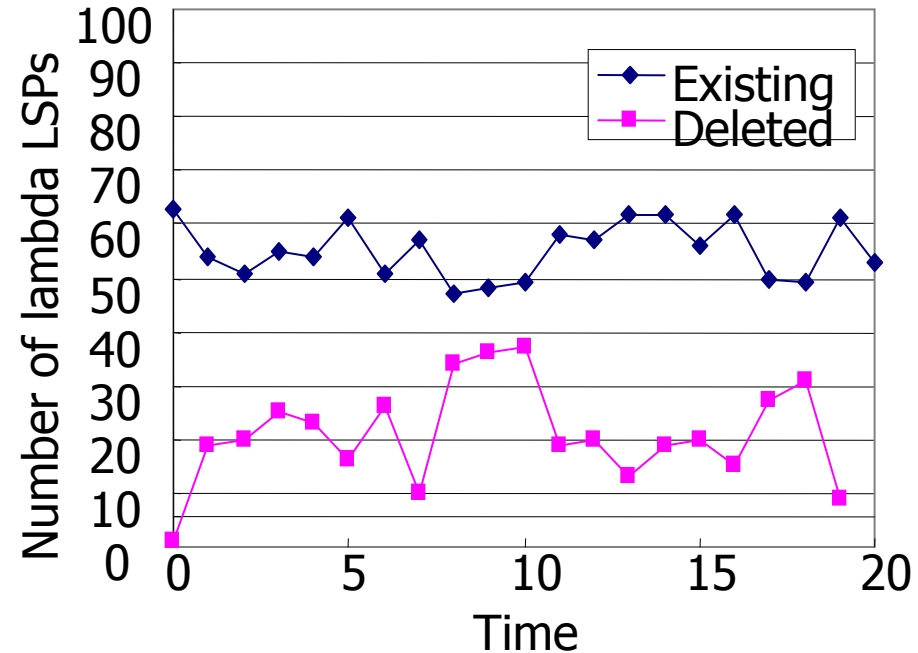
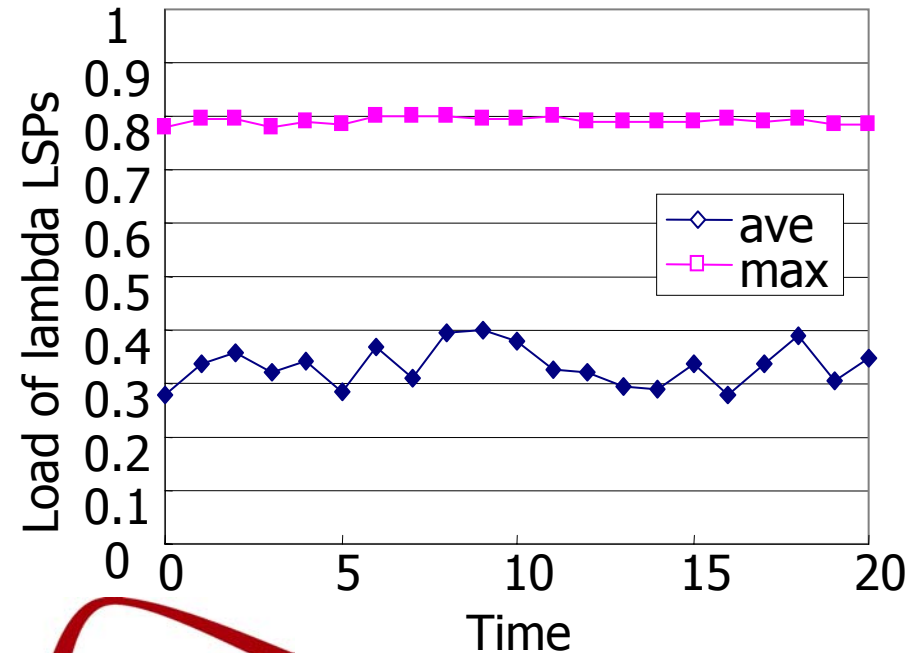
Topology : LATA network model
 Lambda path cap. : 2.5 Gb/s



$t(i,j)$: fixed uniform
 Cost : proportional to # of ports (E and O)

Simulation example $(r_0, r_1)=(0,0.3)$

- Assumption
 - Traffic demand r_{ij} is assumed to be uniformly distributed in the range (r_0, r_1) .
- Observation
 - Maximum load of lambda LSPs is well controlled by establishing and releasing lambda LSPs. (Tupper=0.8)



Summary

- IP optical network
 - Traffic growth
 - Electrical processing limitation
- Multi-layer service networks
 - Different service network is overlaid over GMPLS-based IP optical networks
 - Address space separation
 - Autonomous optical path control
- Multi-region traffic engineering in IP optical networks
 - VNT is reconfigured by setting up /tearing down optical LSP using GMPLS protocols
 - Network resource information in different regions (IP and optical) are consolidated into a single database using GMPLS protocols.
 - VNT calculation (traffic demand & current VNT)
 - Network cost is reduced while achieving the network performance.

Thanks!