A server-based traffic engineering method in IP+Optical multi-layer networks

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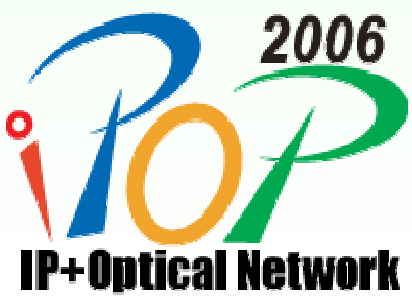
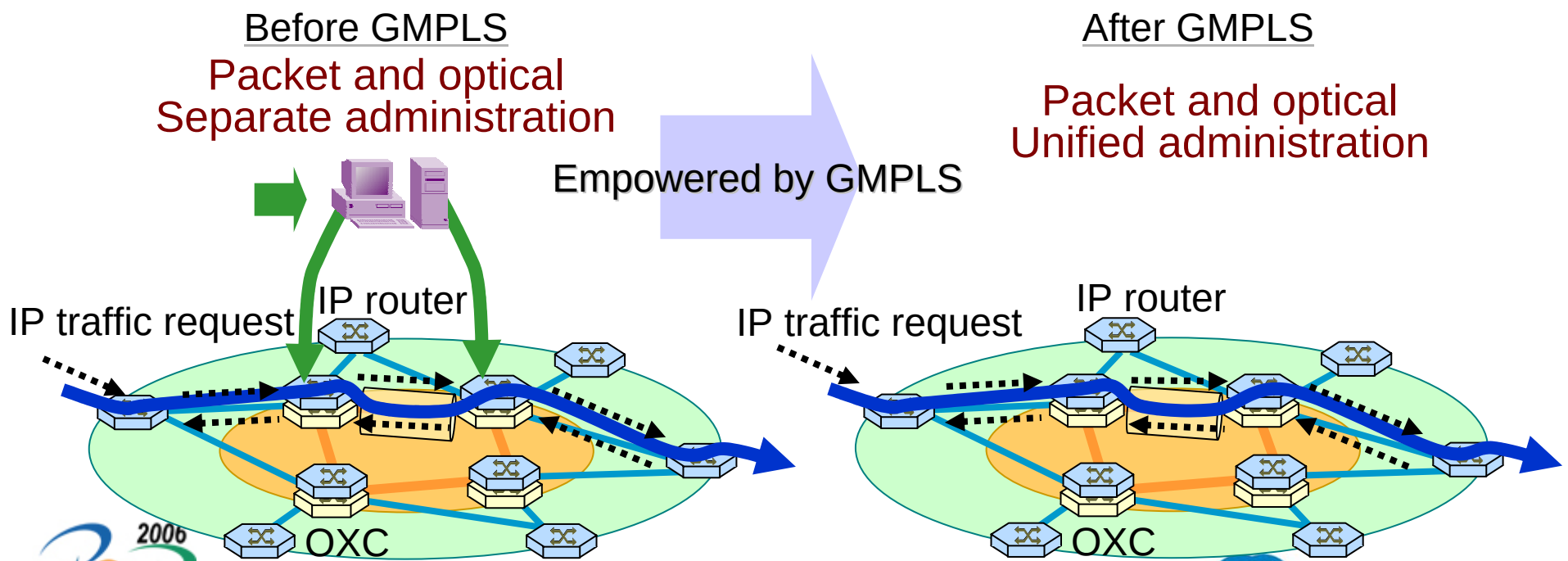


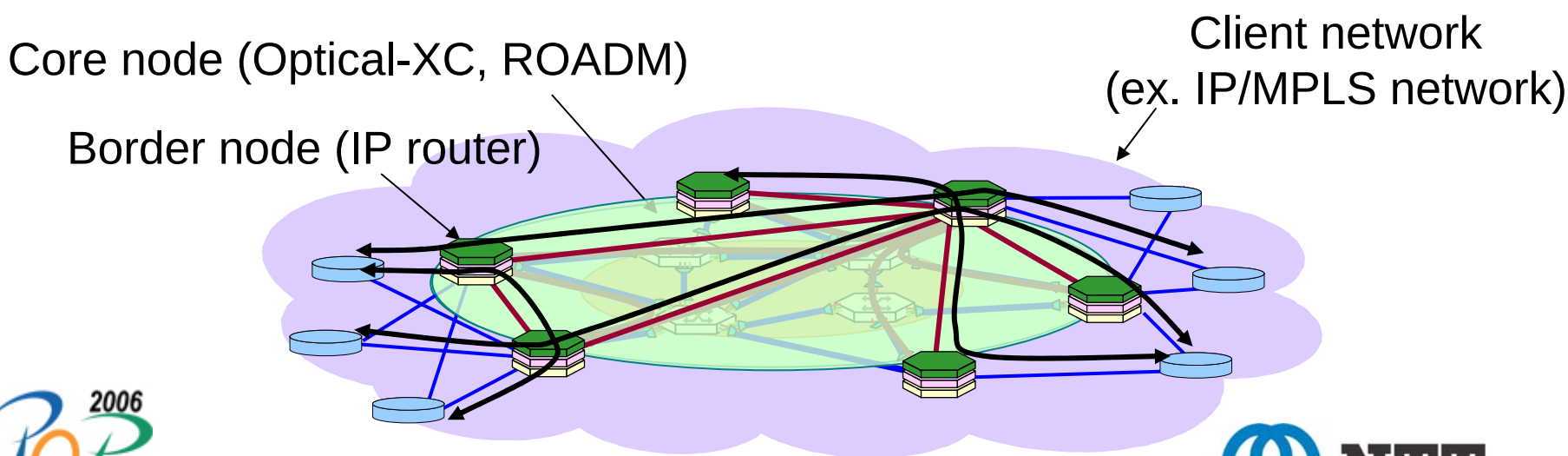
GMPLS innovation

- Unified control plane.
- Rapid path provisioning across multiple technology domains: IP and optical.



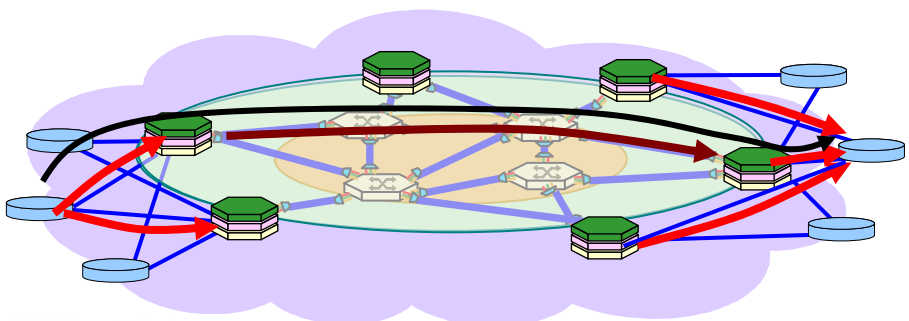
GMPLS-based IP+Optical MLN (Multi-Layer Networks)

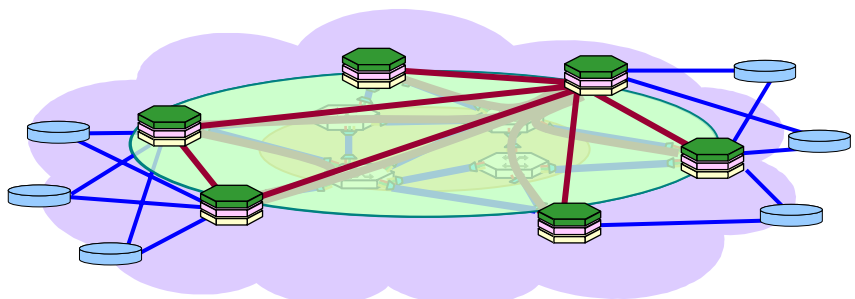
- IP+Optical MLN consists of border and core nodes.
- Optical label switched path (OLSP) is used to carry traffic.
- Client network (ex. IP/MPLS) may be provided on top of MLN.
- Traffic engineering is needed for efficient network operations.



Traffic engineering in IP+Optical MLN

- Path computation
  - Compute the “best” route for LSP using packet and optical TE-links, which satisfies the constraints (bandwidth, class of service, inclusive route, excusive route, protection type, etc).
- Path control
  - Create LSP to carry traffic between nodes as needed as a result of manual or automatic operation (manual-driven, topology-driven, traffic-driven, failure-driven, etc).





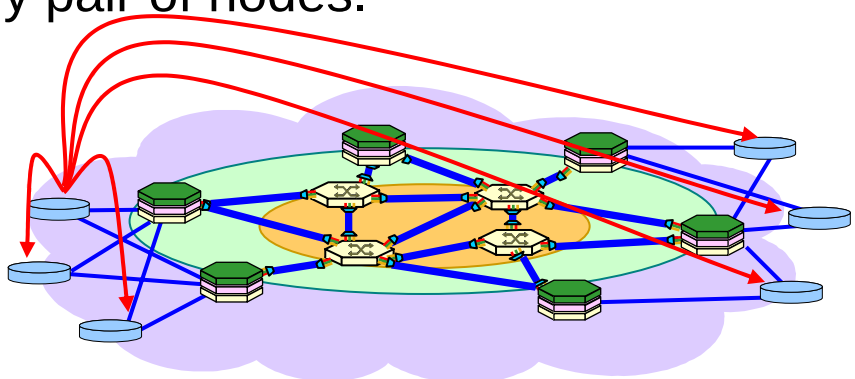
Traffic engineering in IP+Optical MLN (Cont'd)

- Network status needs to be collected to perform TE.

- TE topology
  - Network graph consisting of packet and optical TE-links.
  - Information on TE-links: residual bandwidth, protection type, SRLG.
- Traffic matrix
  - The amount of traffic between every pair of nodes.
- LSP info.
  - Route, bandwidth

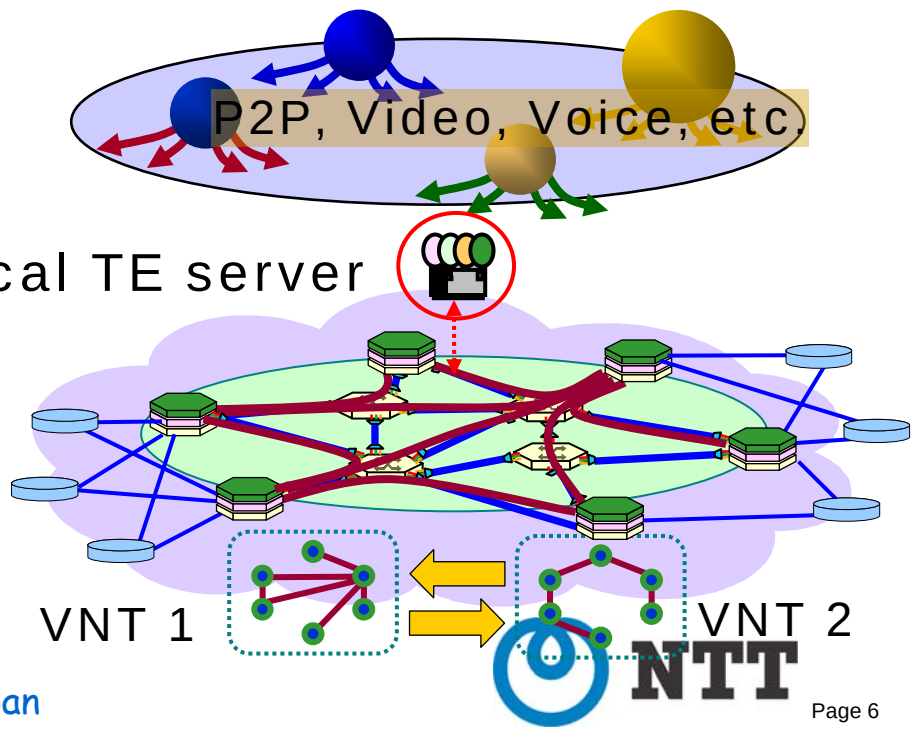
Traffic matrix

$$\begin{pmatrix} r_{1,1} & r_{1,2} & \cdots & r_{1,n} \\ r_{2,1} & r_{2,2} & \cdots & r_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n,1} & r_{n,2} & \cdots & r_{n,n} \end{pmatrix}$$



Virtual network topology (VNT)

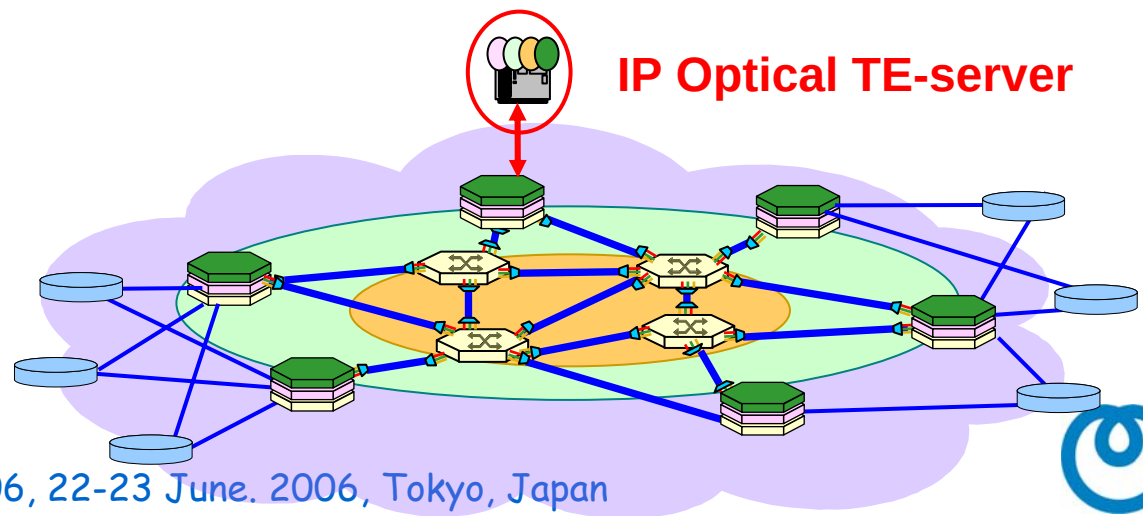
- VNT provides an IP network topology.
  - Optical LSP connects IP routers.
- VNT is reconfigured
  - by setting up/tearing down Optical LSPs.
  - in response to change (ex. traffic, failure).



IP Optical TE server: Proposed server-based TE solution

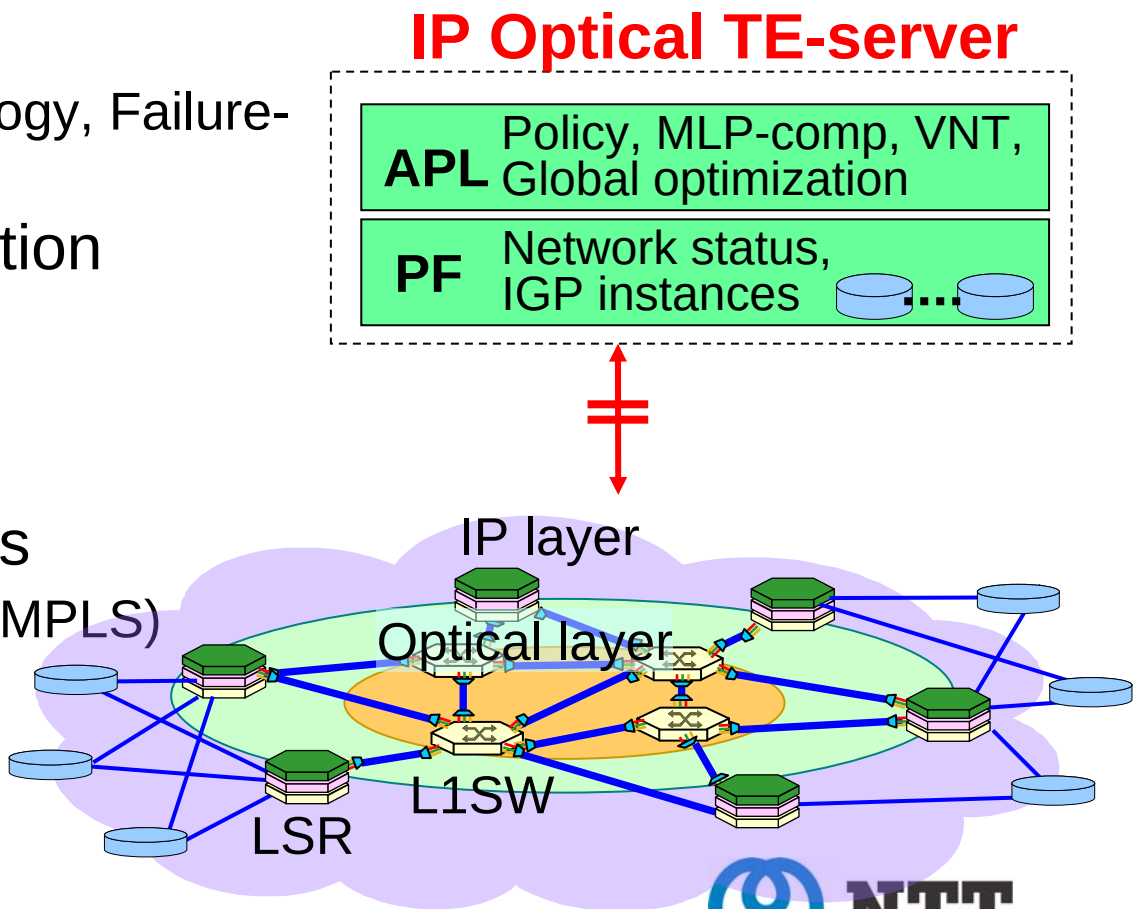
- Traffic engineering mechanisms are separated from IP routers.

- Why?
  - Traffic engineering policy could be too complex to be implemented in IP routers.
    - Bandwidth, delay, GMPLS parameters, bi-directionality, disjointness (node, link, SRLG), link protection type, resource color, inclusive route, exclusive route
  - Different carriers may need different traffic engineering policies.



Proto-type IP Optical TE-server: Overview

- Path computation / Path control
  - Packet/Optical TE links
- VNT reconfiguration
  - Manual, Traffic, Topology, Failure-driven
- Network status collection
  - TE topology
  - Traffic demand matrix
  - LSP info.
- Multiple IGP instances
  - Client network (ex. IP/MPLS)
  - GMPLS MLN

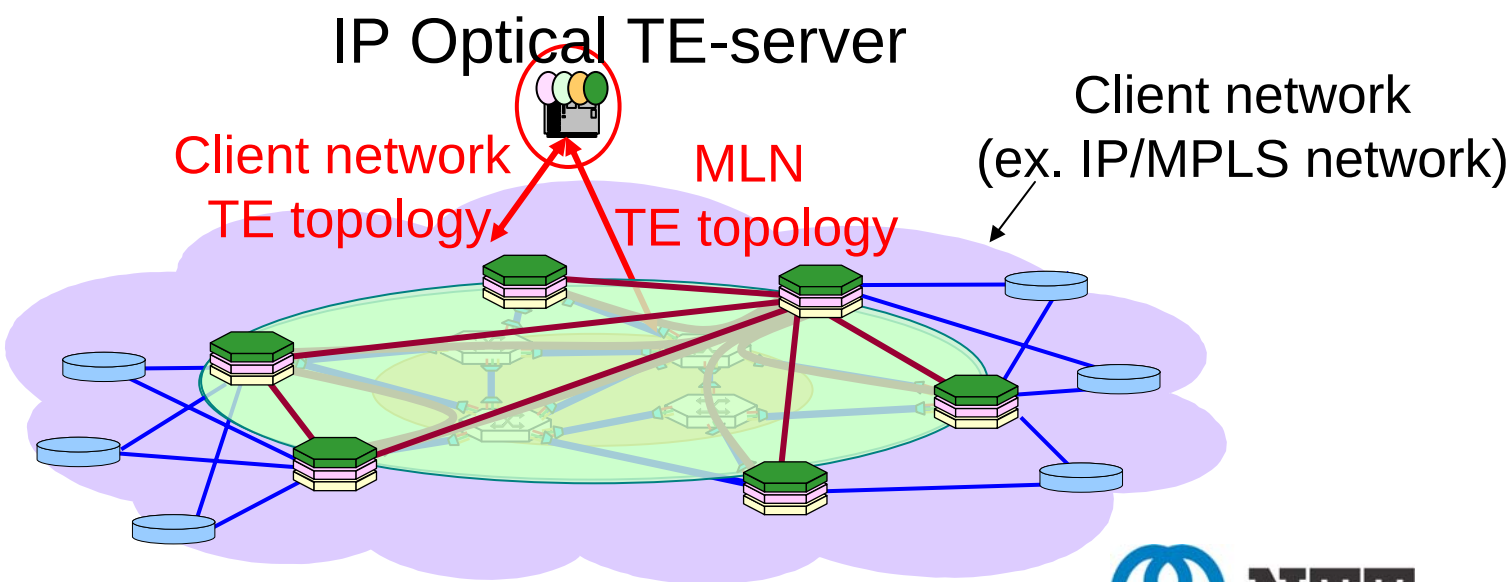


Proto-type IP Optical TE-server: Interface between IP Optical TE-server to Border node

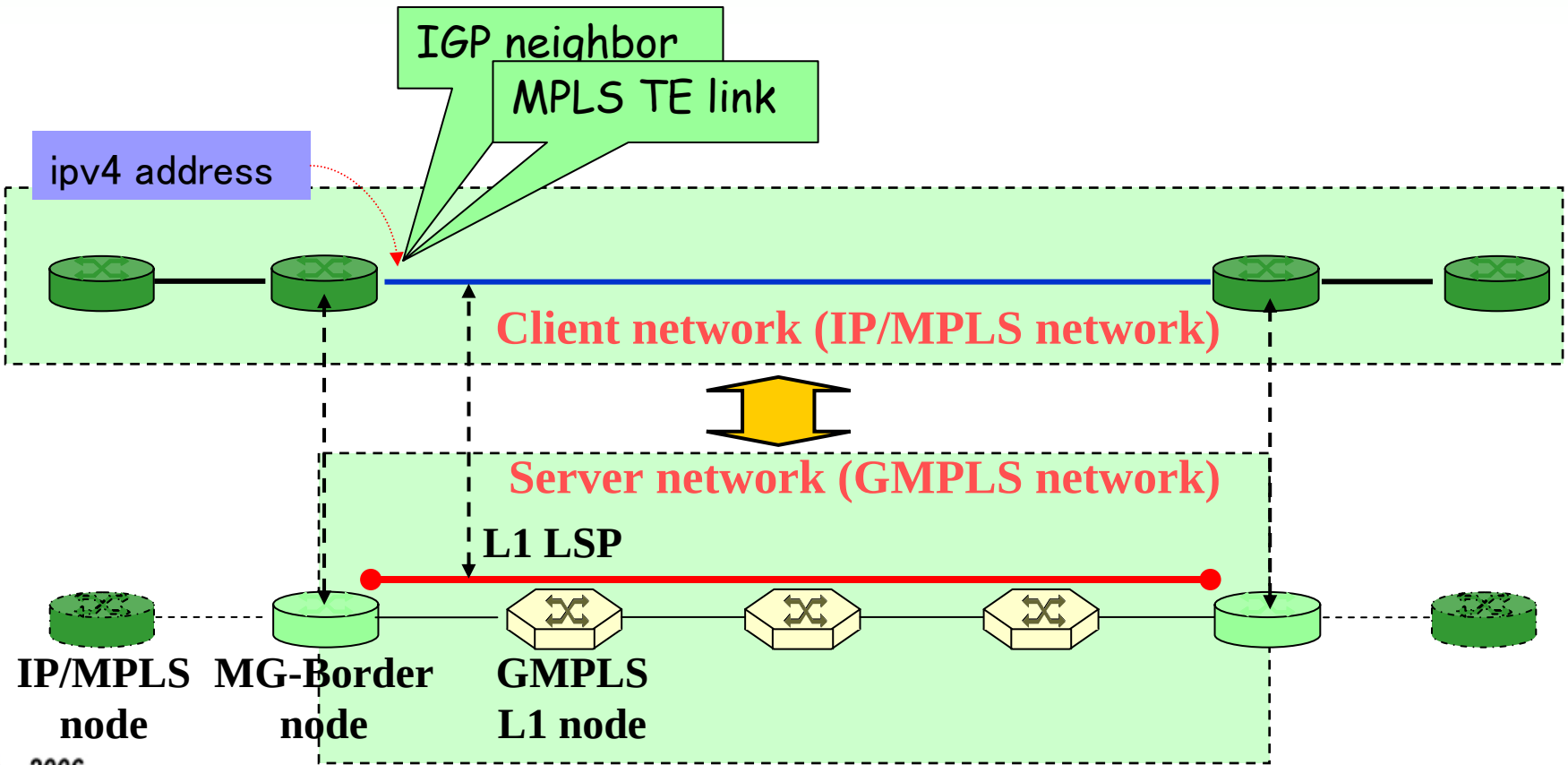
Functions		Protocols	Note
Path computation	Single layer	PCEP	draft-ietf-pce-pcep
	Multiple layer	PCEP ext.	draft-ietf-pce-inter-layer-req draft-ietf-pce-inter-layer-frwk
Path control			draft-oki-pce-vntm-def-00.txt
Network status collection	TE topology	OSPF-TE, GMPLS OSPF-TE	RFC3630 RFC4203
	Traffic volume	SNMP	RFC3812 (MPLS-TE-MIB) RFC3813 (MPLS-LSR-MIB) RFC2011 (IP-MIB) RFC2863 (IF-MIB)
	Path attribute (route, bandwidth..)	SNMP	RFC3812 (MPLS-TE-MIB)

Proto-type IP Optical TE-server: Support of MLN

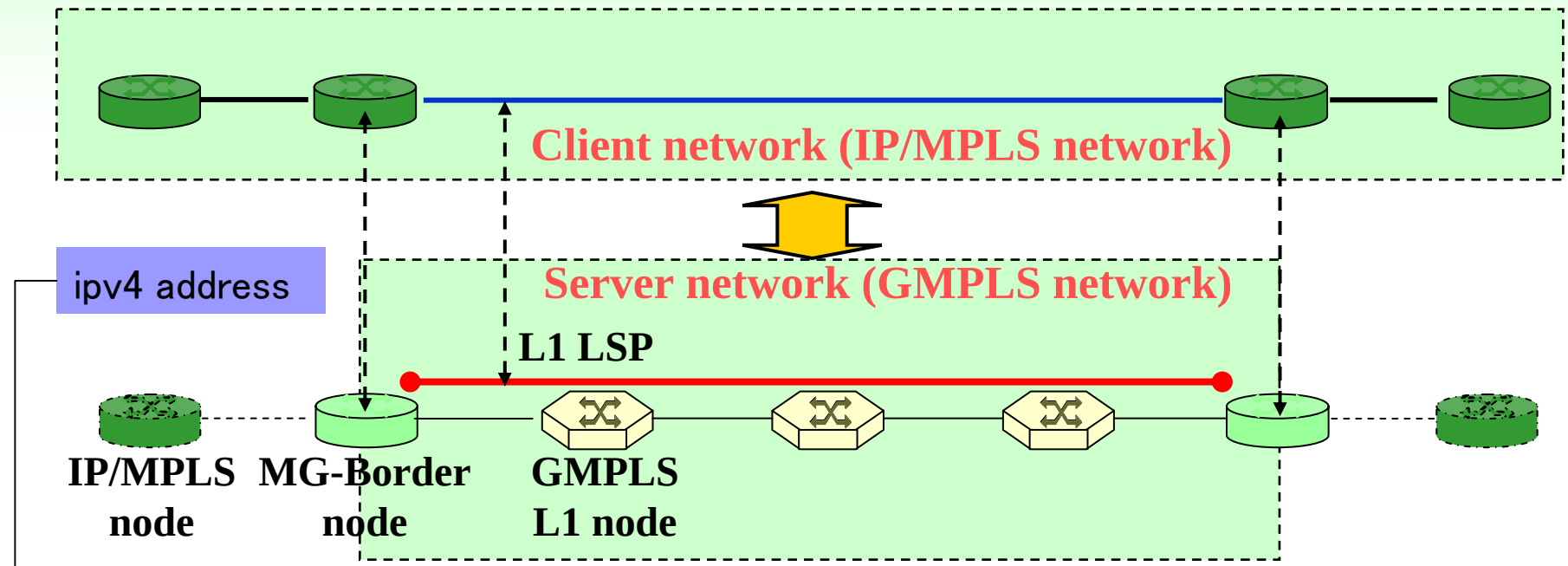
- Client network (ex. IP/MPLS) may be provided on top of MLN.
- Administrative boundary may exist between Client IP/MPLS network and MLN.
- Client IP/MPLS network and MLN may run different IGP instances.
- IP Optical TE-server collects TE topology from Client network and MLN.



Proto-type IP Optical TE-server: IP link setup



Proto-type IP Optical TE-server: IP link traffic measurement



ipv4 address

IP-MIB (RFC2011) → index

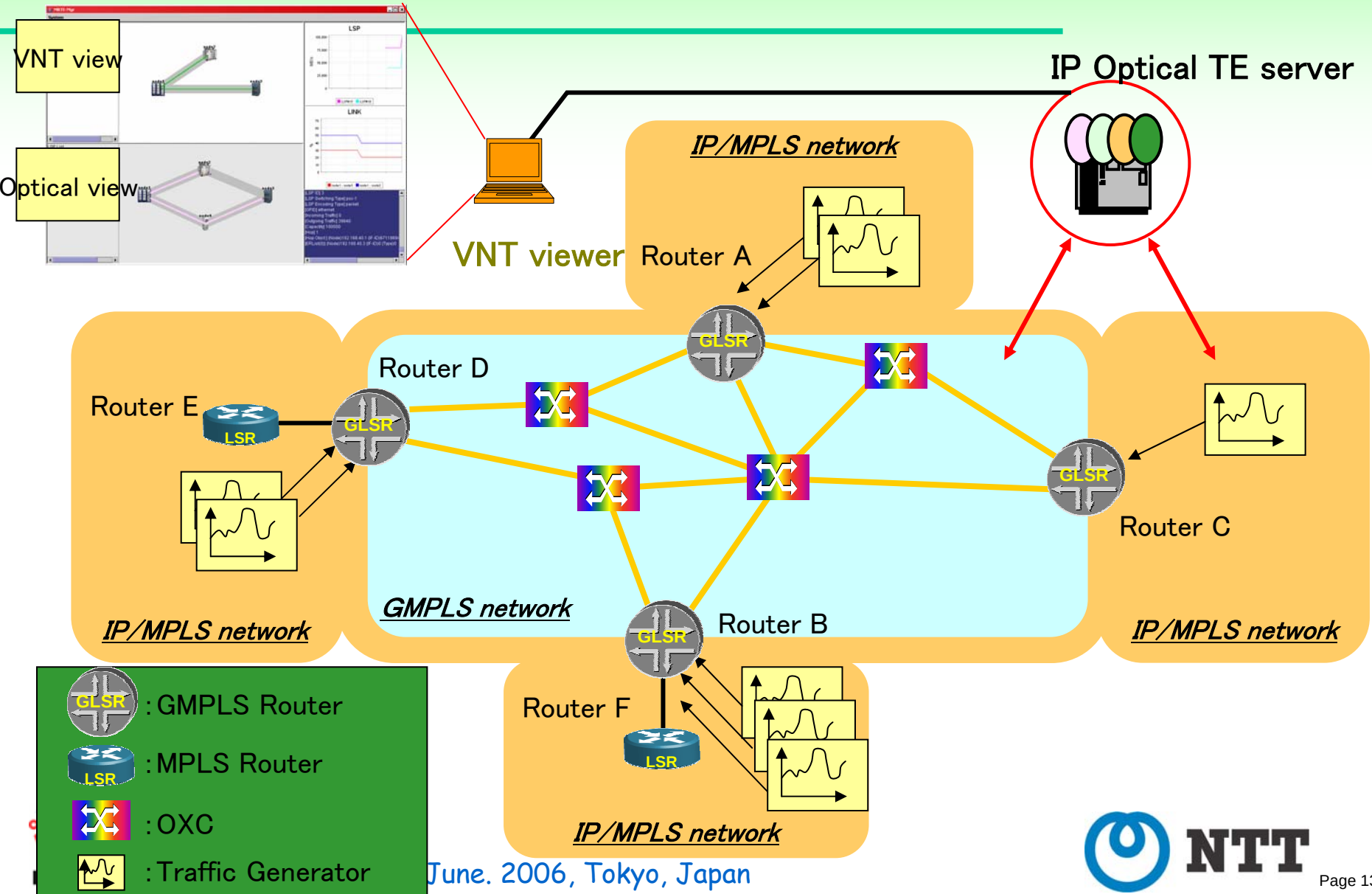
IP-MIB::ipAdEntIfIndex.100.0.0.22 = INTEGER: 54

index

IF-MIB (RFC2863) → ifInOctets, ifInUcastPkts, ifOutOctets, ifOutUcastPkts

IF-MIB::ifInOctets.54 = Counter32: 21113940
IF-MIB::ifInUcastPkts.54 = Counter32: 421794
IF-MIB::ifOutOctets.54 = Counter32: 25991248
IF-MIB::ifOutUcastPkts.54 = Counter32: 419736

Diagram of MLN experimental system



Summary

- GMPLS-based IP+Optical MLN.
- Traffic engineering
  - Path computation
  - Path control
  - Network status collection (TE topology, traffic matrix, LSP info.)
- Virtual network topology reconfiguration
  - Manual-driven, traffic-driven, topology-driven, failure-driven
- Server-based approach
- Proto-type system

References

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[2] K. Shiomoto, et al., “MPLS and GMPLS interworking,” in Proc. MPLS 2005, Washington DC, USA, October 2005.

[2] Requirements for GMPLS-based multi-region and multi-layer networks (MRN/MLN) <draft-ietf-ccamp-gmpls-mln-reqs-00.txt > (work in progress), January 2006.

[3] Evaluation of existing GMPLS Protocols against Multi Layer and Multi Region Networks (MLN/MRN), <draft-ietf-ccamp-gmpls-mln-eval-00.txt>, January 2006.

[4] Framework for IP/MPLS-GMPLS interworking in support of IP/MPLS to GMPLS migration <draft-ietf-ccamp-mpls-gmpls-interwork-fmwk-00.txt>, April 2006.

[5] PCC-PCE Communication Requirements for Inter-Layer Traffic Engineering, <draft-ietf-pce-inter-layer-req-00.txt> (work in progress), November 2005.

[6] PCE Applicability for Inter-Layer MPLS and GMPLS Traffic Engineering, <draft-oki-pce-inter-layer-app-00.txt> (work in progress), February 2006.

Thank you.

Any questions/comments?