

IP Optical Networking

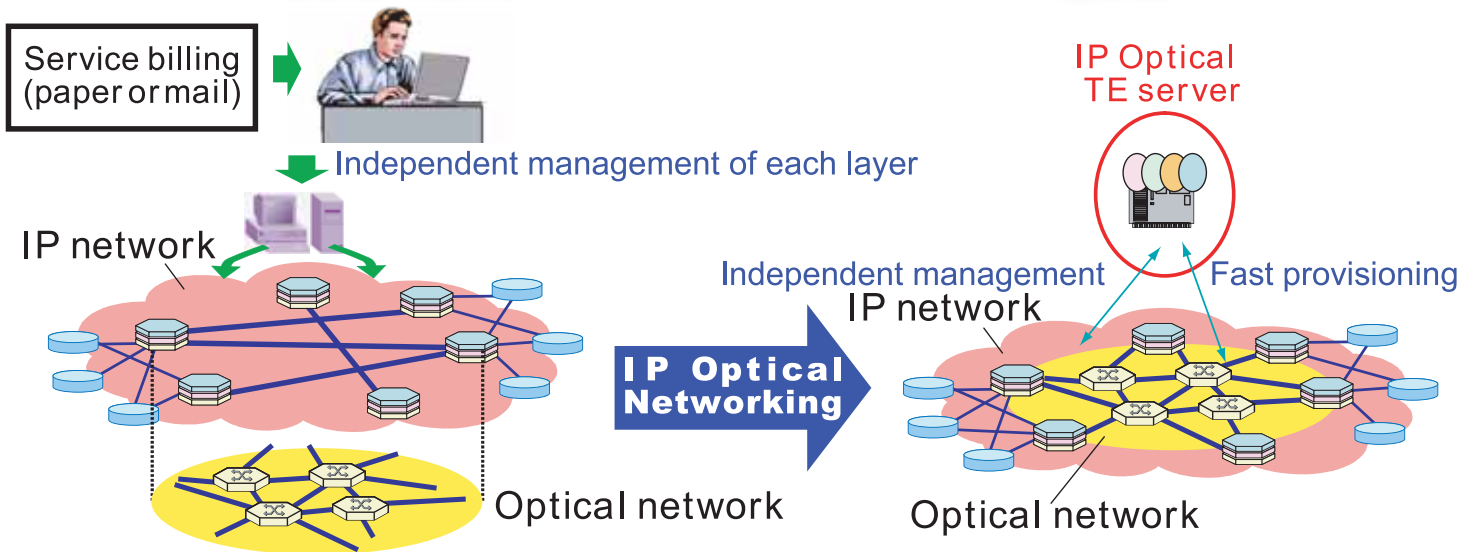
Network Architecture Evolution



- Conventional networking technology
 - Independent control & management of each layer
 - Manual operation, Off-lined network design (Non real-time control)
- **IP Optical networking**
 - Integrated control & management
 - Automatic operation, On-lined network design (Real-time control)
 - Interlayer Traffic Engineering based on standard protocols (GMPLS, PCE)

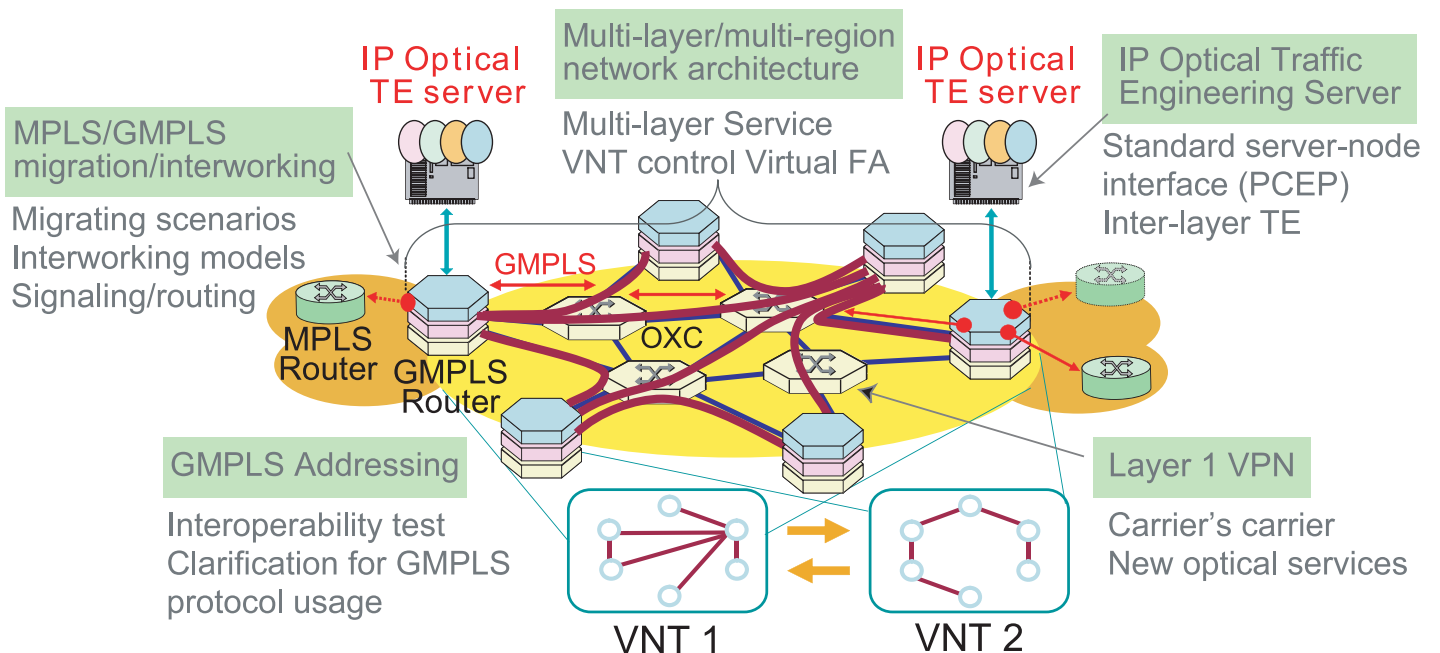
Conventional network

IP Optical network



NTT's IP Optical Networking Technical Map

VNT: Virtual Network Topology
 TE: Traffic Engineering
 FA: Forwarding Adjacency



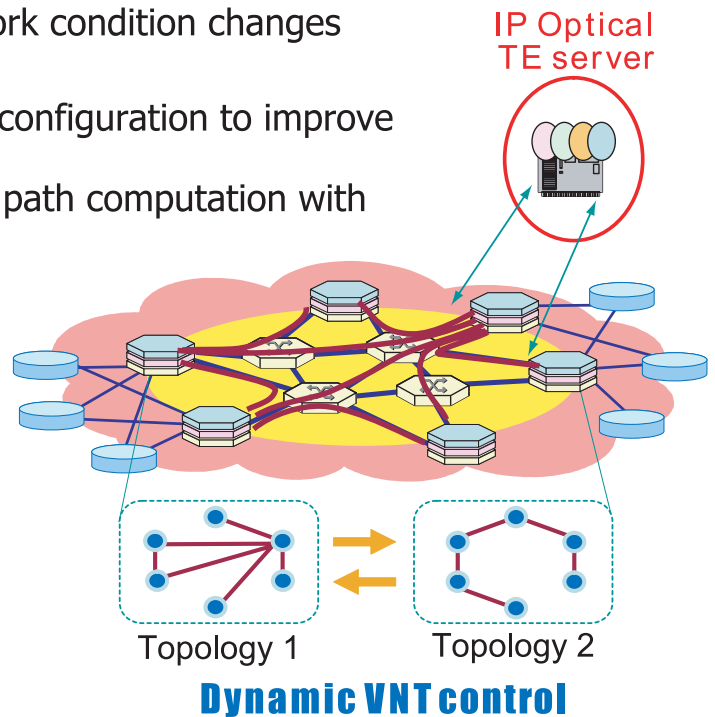
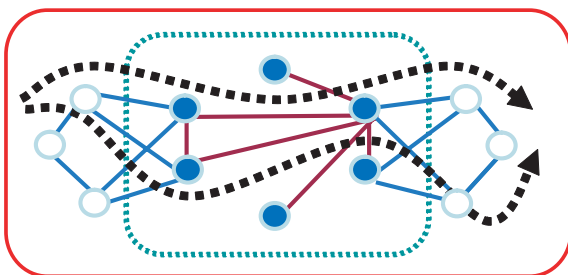
IP Optical TE Server



Multilayer Traffic Engineering

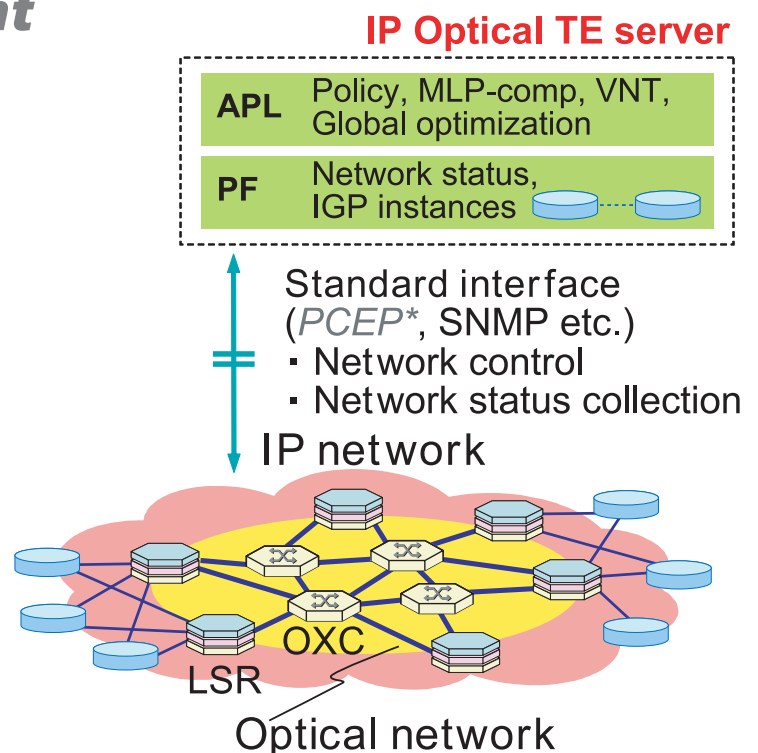
- Overview
 - Enable more advanced provisioning and sophisticated operations by considering both of optical network and IP networks
 - IP Optical TE server provides multilayer TE function
- Merits
 - OPEX & CAPEX reduction
 - Improve robustness under sudden network condition changes
- Example
 1. Dynamic VNT control: Dynamic VNT reconfiguration to improve network performance
 2. Multilayer path computation: Multilayer path computation with various constraints

Multilayer path computation



Prototype Development

- Policy customization
- Multi-layer path computation
 - Packet / Optical
- VNT reconfiguration
 - Traffic-driven
 - Failure-driven
- Multiple IGP instances
 - IP/MPLS
 - GMPLS
- Network status collection
 - TE topology
 - Traffic volume
 - LSP attribute (route, bandwidth, etc)



* *PCEP* is now being standardized in IETF. Thus, in the current implementation, we deployed vendor-specific CLI.

Layer 1 VPN



Concept and Business Scenarios

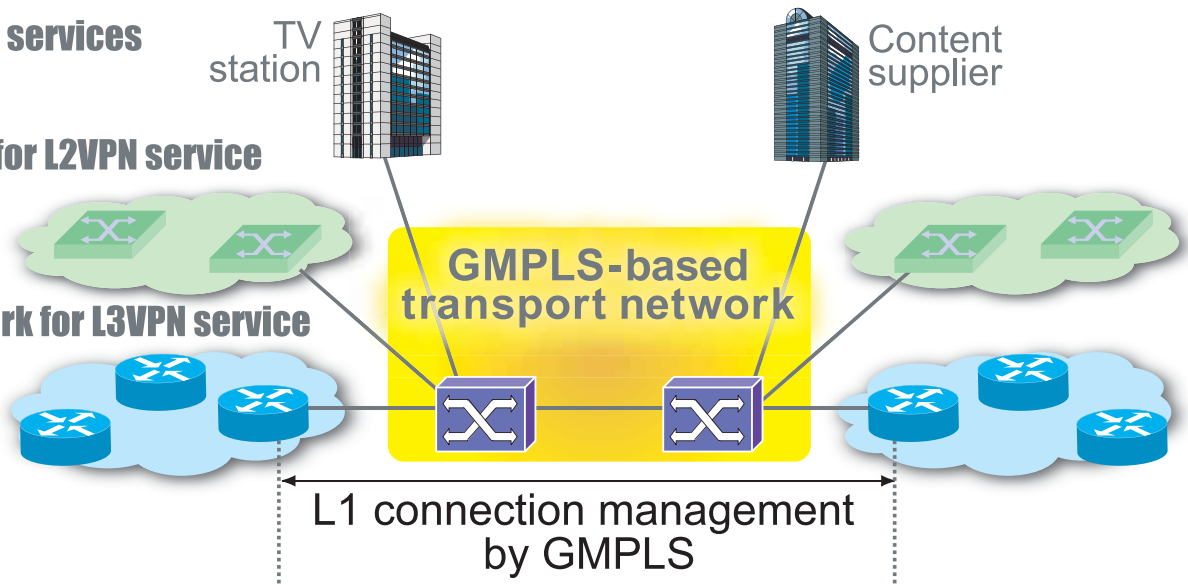
- L1VPN Concept
 - Logical separation of GMPLS-based transport network
- L1VPN Business Scenarios
 - Support of multiple service networks over GMPLS-based transport network (carrier' s carrier, multi-service backbone)
 - New optical services (switching service, scheduling service)

New optical services



L2 network for L2VPN service

MPLS network for L3VPN service



Layer 1 VPN Solution Aspects

- L1VPN Framework
 - (1) Management mode
 - (2) Basic mode
 - (3) Enhanced mode
- L1VPN Basic Mode
 - Current focus within the IETF
 - Allows client networks to request connections, yet keeping administrative separation
 - Combination with TE server provides enhanced TE capabilities

