G-MPLS
The Universal Control Plane

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What is a Control Plane?

- Networks can be divided functionally into a:
  - User Plane: transfer of user information (also called bearer channels);
  - Control Plane: connection coordination and control (also called control channel);
  - Management Plane: network supervision (also called network management systems).

Present Overlay Networks

- Data transport networks are typically designed with four layers:
  - IP for applications and services;
  - ATM for QoS;
  - SONET/SDH for transport and survivability;
  - DWDM for increased capacity.

Collapsed IP and Optical Domains

- The present overlay architecture to transport IP is too complex therefore is not cost effective.
- As a result the core must be contracted to a new one where IP runs efficiently over optical transport networks.

The New Optical Core

- Core optical transport architecture are evolving towards:
  - Meshes of DWDM transport systems;
  - Optical Switches (OXC): providing path switching, OEO-based, interconnecting transparent sub networks;
  - Photonic Switches (PXCs): providing wavelength switching, OOO-based, for all-optical sub networks.

IP and Optical Functions

- IP/MPLS layer function:
  - IP service creation;
  - Link subscribers to transport;
  - Any-to any connections;
  - Traffic engineering and QoS/CoS.
- Optical transport layer function:
  - Bandwidth;
  - Service transparency;
  - Service differentiation;
  - Survivability.

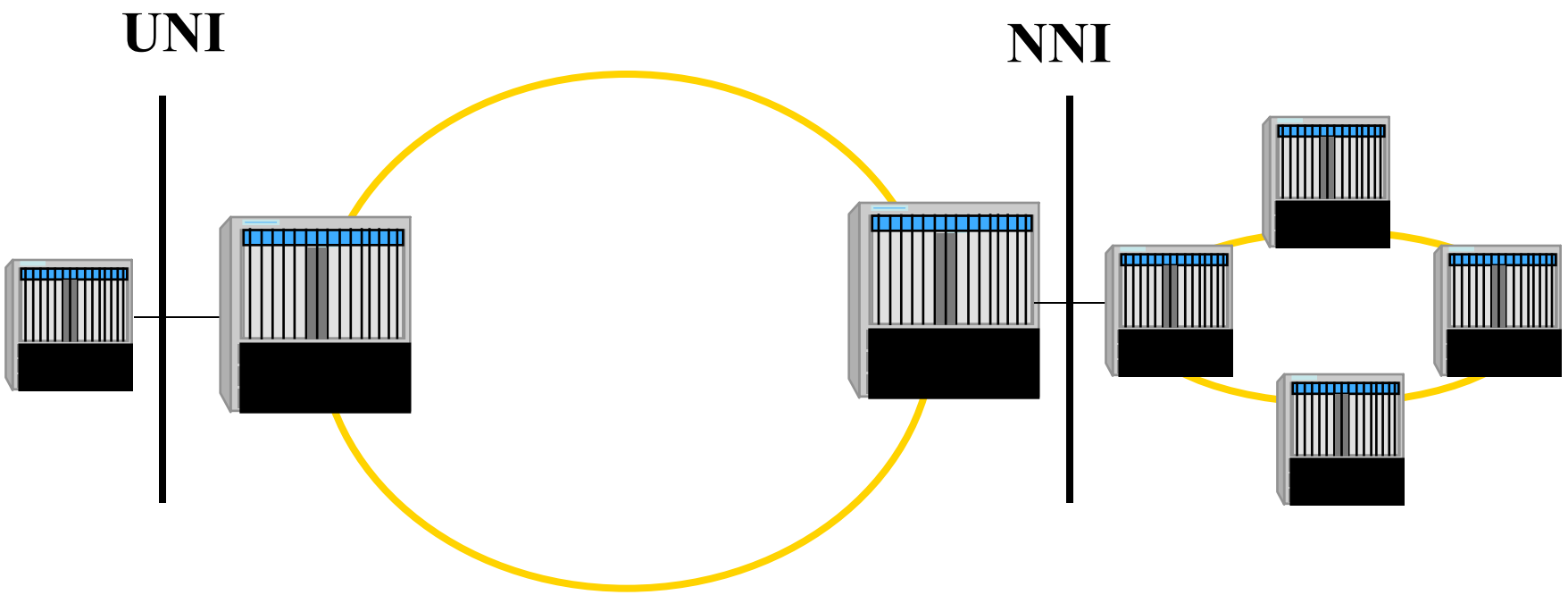
Extending MPLS Traffic Engineering

- To facilitate the required interactions between the IP and optical layer, a consensus has emerged to extend MPLS traffic engineering for optical networks.
- The same traffic engineering architecture between the IP and Optical domains will facilitate network inter-working and simplify network operations.

OIF Operational Approaches for Optical/IP Internetworking

- Overlay Model:
  - Two administrative domains (optical domain/ IP routing domain) divided by a UNI;
  - Two independent control planes;
- Peer Model (superset of the overlay model):
  - One administrative domain;
  - One control plane;
  - Similar to the Internet of today's.
- Augmented Model:
  - Separated routing instances between the two domains but exchange of routing information.

Network Topology



Generalized MPLS

- GMPLS aims to create a universal IP control plane for multiple types of switching systems that can be found in an end-to-end network:
  - Packet Switching;
  - TDM Switching;
  - Lambda Switching;
  - Fiber Switching.

GMPLS Requirements

- Secure: since it is Service Provider specific;
- Reliable: since it must be guaranteed;
- Performance: since it involves time sensitive operations;
- And, of course, scalable…

GMPLS Components

- Link Management Protocol (LMP) for NE adjacencies in transparent networks;
- Link-state routing protocols OSPF or IS-IS with extensions for network topology discovery;
- IP/MPLS signaling protocols CR-LDP or RSVP-TE with extensions for path controls.

GMPLS Key Features

- Support hierarchical LSPs like MPLS but GMPLS LSPs can include intermix of links with heterogeneous labels;
- GMPLS LSPs start and end through the same interfaces types;
- Support bi-directional LSPs;
- Type of payloads: SONET/SDH, G.709, GbE
- Suggested label: labels can be suggested by the upstream node;
- Label set: labels selected by the downstream node can be restricted by the upstream node.

Scalability of Addressing

- For photonic switching, it is not practical to associate an IP address to each link knowing that they might be thousands of them.
- For that purpose, GMPLS supports:
  - Unnumbered links e.g. links that do not have an IP address;
  - Link bundling between LSRs.

Link Management Protocol (1)

- In GMPLS, the control plane is separated from the data plane. Therefore, a specific neighbor discovery protocol is required in particular for photonic switches.
- LMP provides both link provisioning and fault isolation between adjacent nodes and their ports.
- All LMP messages are IP encoded.

Link Management Protocol (2)

- Control channel management: establish and maintain control channels between nodes using an Hello protocol;
- Link property correlation: bundle data bearing links and can exchange link parameters;
- Link connectivity verification: verification of the physical connectivity of the data-bearing links;
- Fault localization:notification of fiber, link or channel failures.

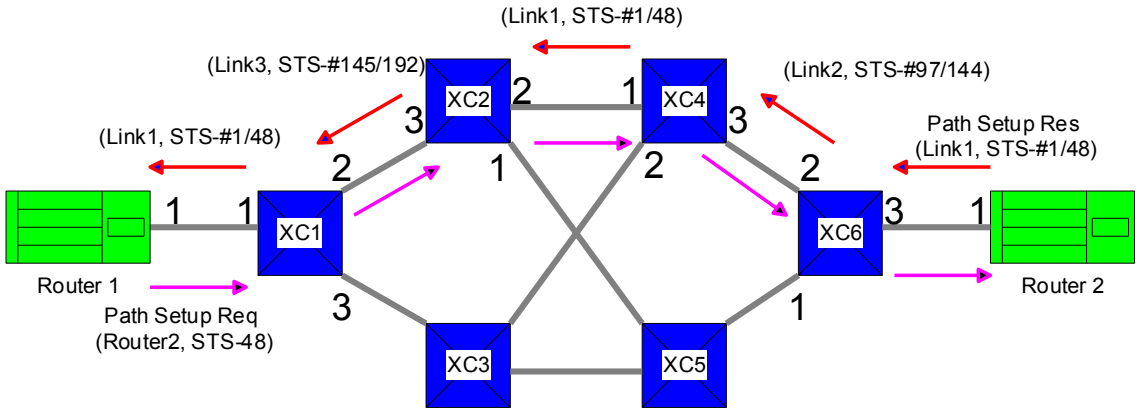
Extensions to OSPF and IS-IS for GMPLS

- New link types:
  - Non-packet links;
  - Protection types;
  - Shared Risk Link Group (SRLGs);
- Support for unnumbered interfaces;
- Link bundling can be advertised as a single link;
- Forwarding Adjacency (FA): an LSP can be advertised into the IGP.

Extensions to RSVP-TE and CR-LDP for GMPLS

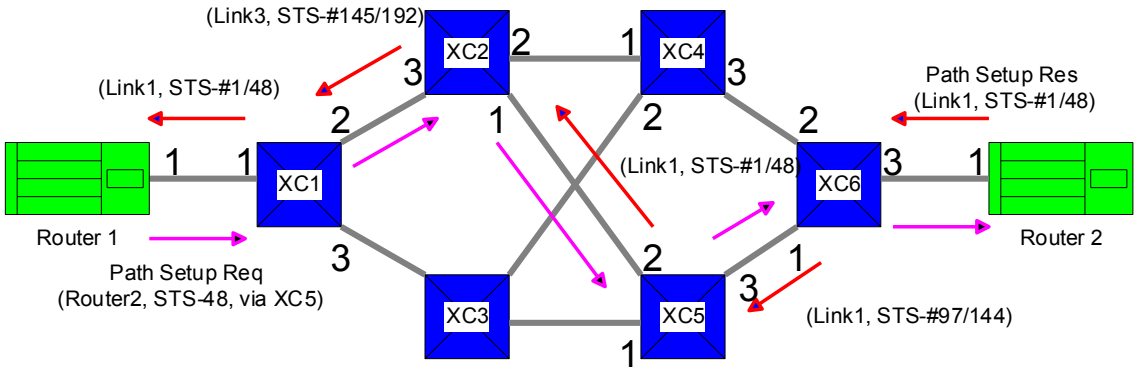
- Generalized label that includes for non-packet LSPs:
  - Type of signal;
  - Circuit bandwidth;
  - Desired protection;
  - Position in a particular multiplex;
- Support for Bi-directional LSPs;
- Explicit routing with explicit label control;
- Support for unnumbered links and link bundling.

Traffic Engineering Example: Regular Path Setup



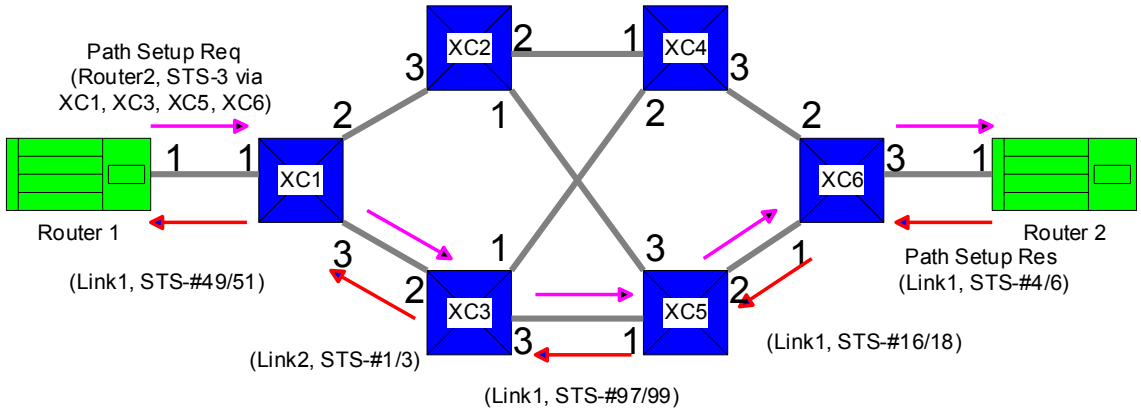
	From	To
XC1	Link 1, STS-#1/48	Link 2, STS-#145/192
XC2	Link 3, STS-#145/192	Link 2, STS-#1/48
XC4	Link 1, STS-#1/48	Link 3, STS-#97/144
XC6	Link 2, STS-#97/144	Link 3, STS-#1/48

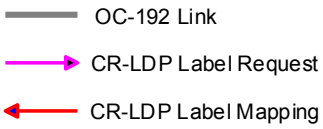
Traffic Engineering Example: Partial Explicit Route Path Setup



	From	To
XC1	Link 1, STS-#1/48	Link 2, STS-#145/192
XC2	Link 3, STS-#145/192	Link 1, STS-#49/96
XC5	Link 2, STS-#49/96	Link 3, STS-#97/144
XC6	Link 1, STS-#97/144	Link 3, STS-#1/48

Traffic Engineering Example: Complete Explicit Rte Path Setup





	From	To
XC1	Link 1, STS-#49/51	Link 3, STS-#1/3
XC3	Link 2, STS-#1/3	Link 3, STS-#97/99
XC5	Link 1, STS-#97/99	Link 2, STS-#16/18
XC6	Link 1, STS-#16/18	Link 3, STS-#4/6

References

- IETF: www.ietf.org
  - Sub IP Working Groups:
    - MPLS, CCAMP, IPO
- OIF: www.oiforum.com
  - Working Groups:
    - Architecture, Signaling, Carrier, OAM&P.

Thank you for your attention