IP Over DWDM: Issues and Standards

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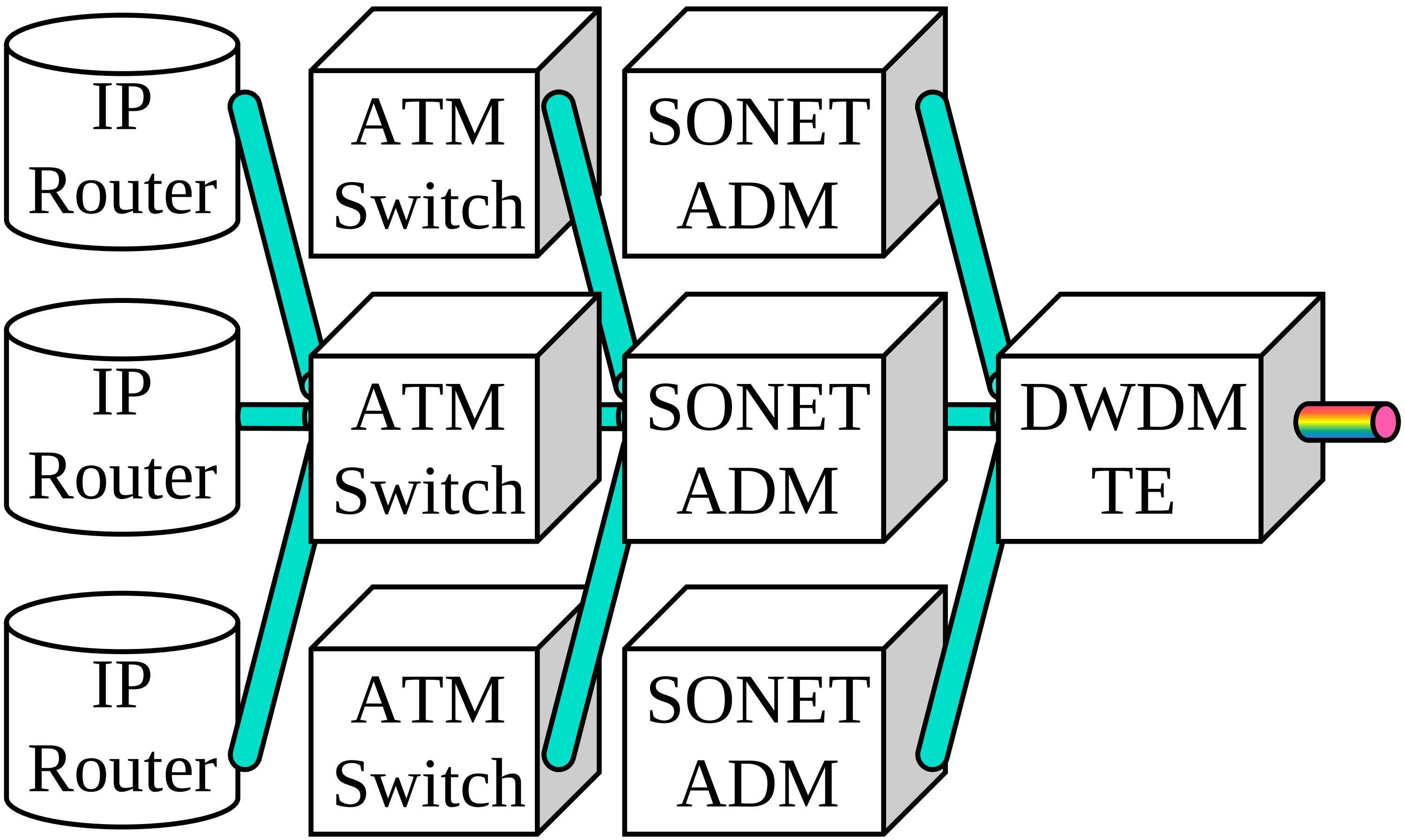
These slides are available at:
http://www.cis.ohio-state.edu/~jain/talks/itcom01.htm

IP over DWDM (Past)



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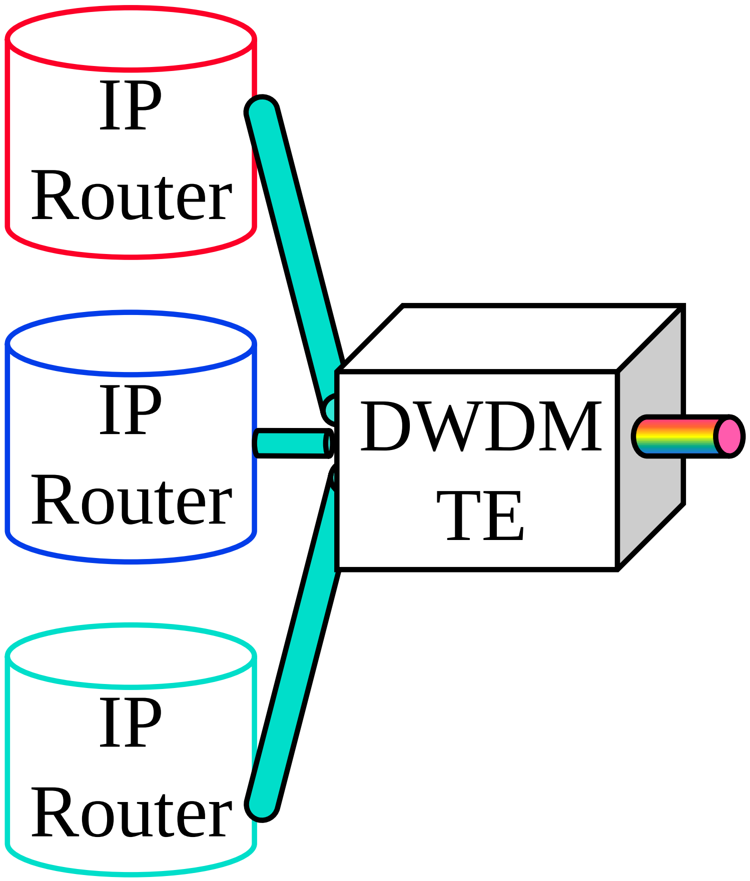
IP over DWDM: Protocol Layers

1993	1996	1999	2001	2003
IP	IP	IP/MPλS	IP/GMPLS	IP/GMPLS
ATM	PPP	PPP	Ethernet	Ethernet
SONET	SONET	SONET Framing	SONET Framing	
DWDM	DWDM	DWDM	DWDM	DWDM
Fiber	Fiber	Fiber	Fiber	Fiber

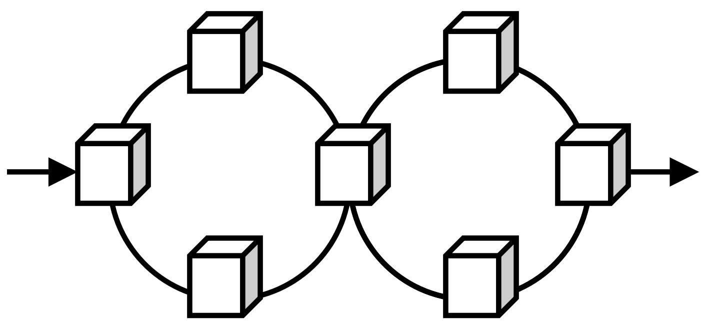
- IP is good for routing, traffic aggregation, resiliency
- ATM for multi-service integration, QoS/signaling
- SONET for traffic grooming, monitoring, protection
- DWDM for capacity
- Problem: Restoration in multiple layers, Sonet Manual
  $\Rightarrow$ Intersection of features and union of problems

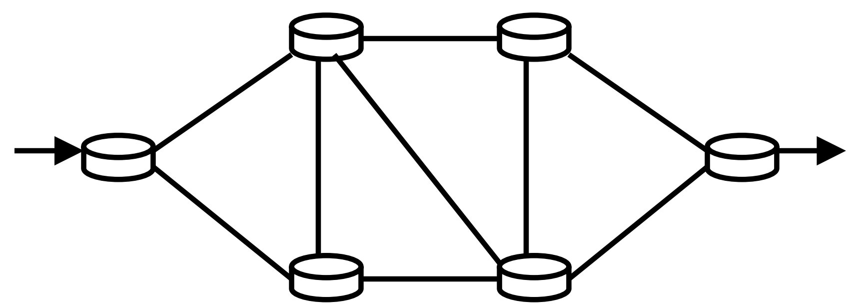
IP over DWDM (Future)



Telecom vs Data Networks

	Telecom Networks	Data Networks
Topology Discovery	Manual	Automatic
Path Determination	Manual	Automatic
Circuit Provisioning	Manual	No Circuits
Transport & Control Planes	Separate	Mixed
User and Provider Trust	No	Yes
Protection	Static using Rings	No Protection

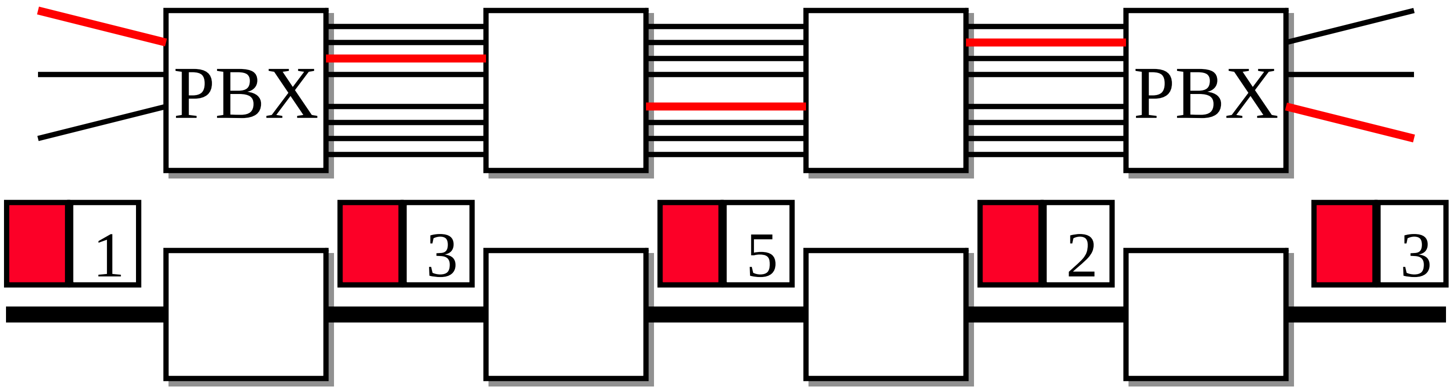




IP over DWDM Issues

1. Circuits
2. Data and Control plane separation
3. Signaling
4. Addressing
5. Protection and Restoration

Multiprotocol Label Switching (MPLS)



- Allows circuits in IP Networks (May 1996)
- Each packet has a circuit number
- Circuit number determines the packet's queuing and forwarding
- Circuits have be set up before use
- Circuits are called Label Switched Paths (LSPs)

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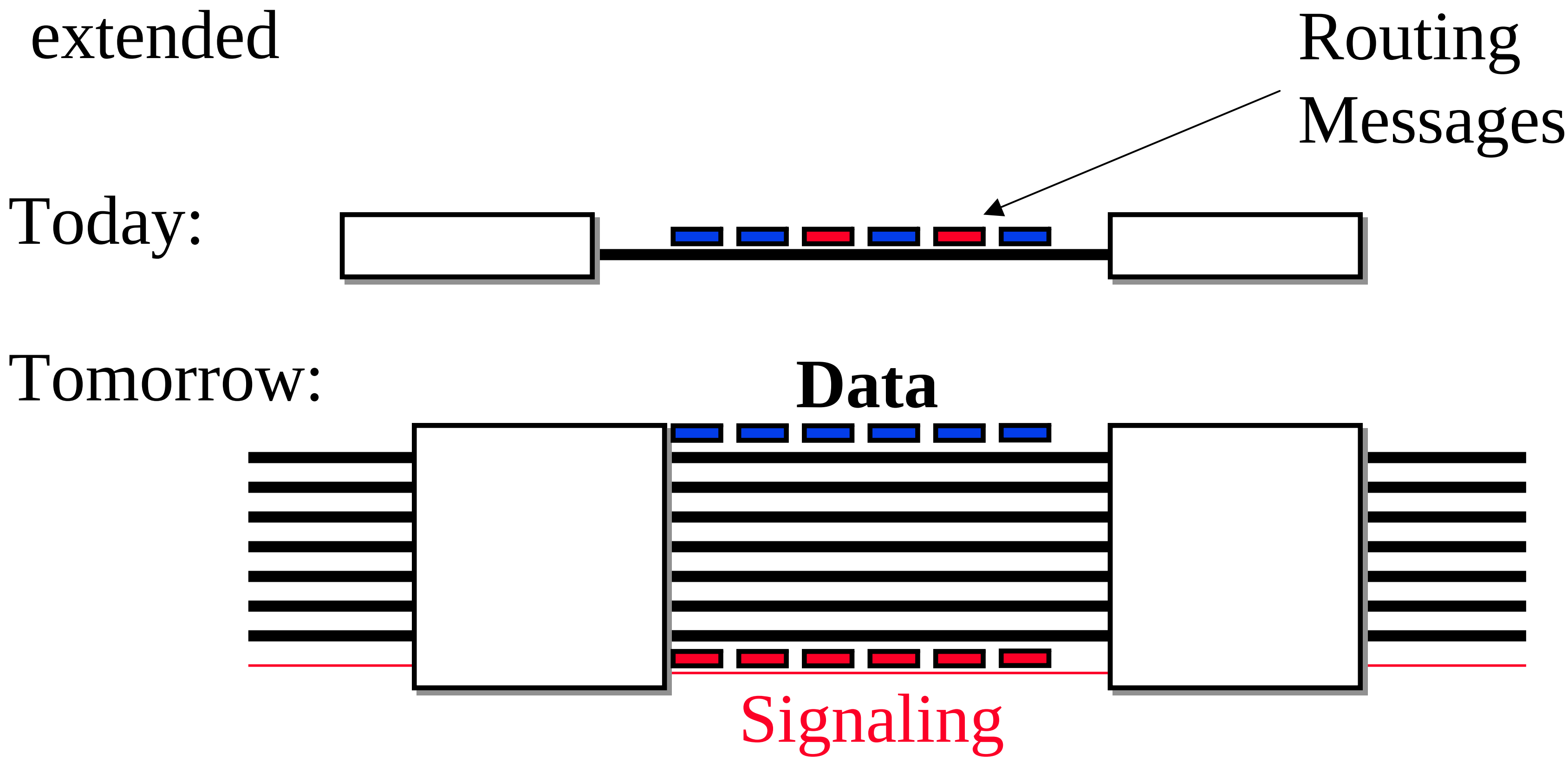
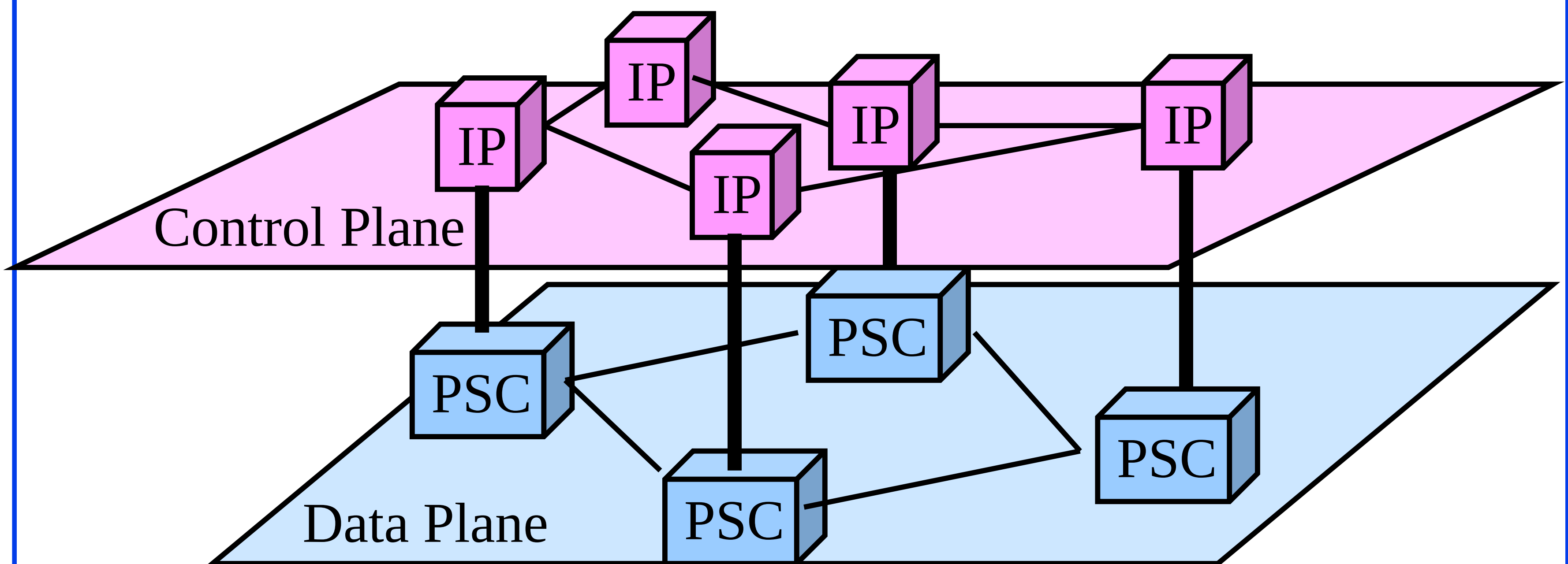
Issue: Control and Data Plane Separation

- Separate control and data channels
- IP routing protocols (OSPF and IS-IS) are being extended



IP-Based Control Plane

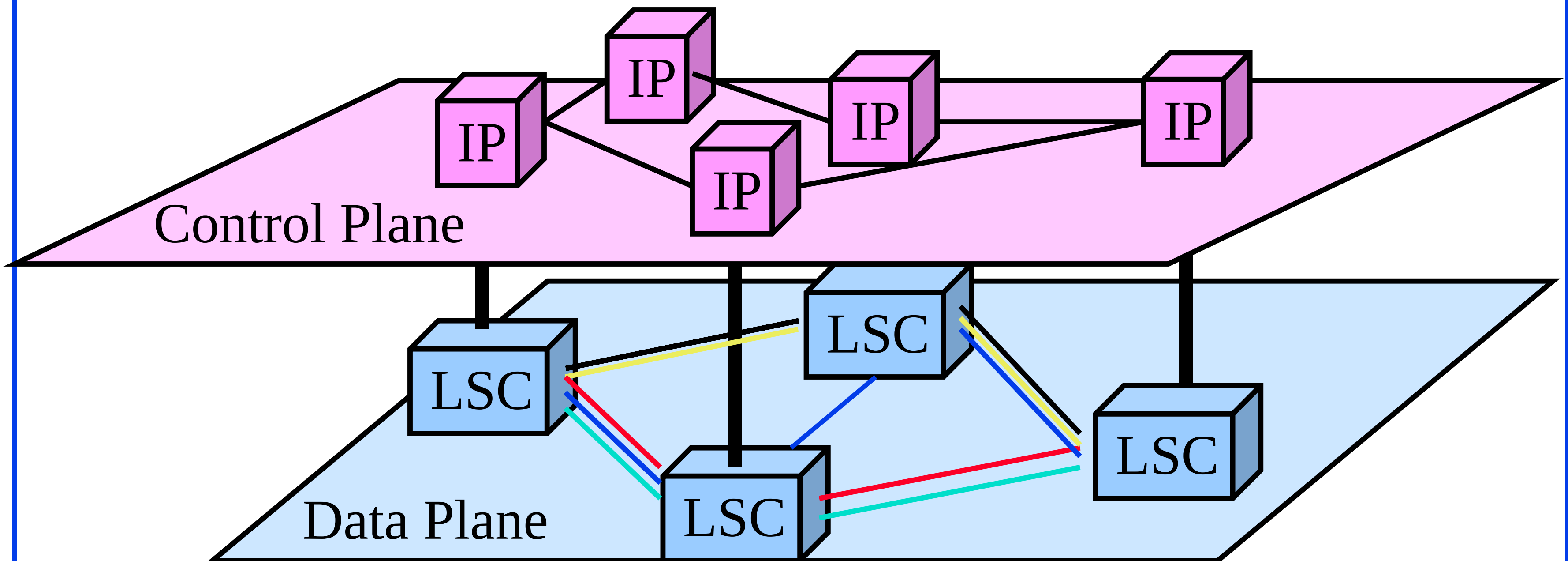
- Control is by IP packets (electronic).
  Data can be any kind of packets (IPX, ATM cells).
  $\Rightarrow$ MPLS



PSC = Packet Switch Capable Nodes

MPλS

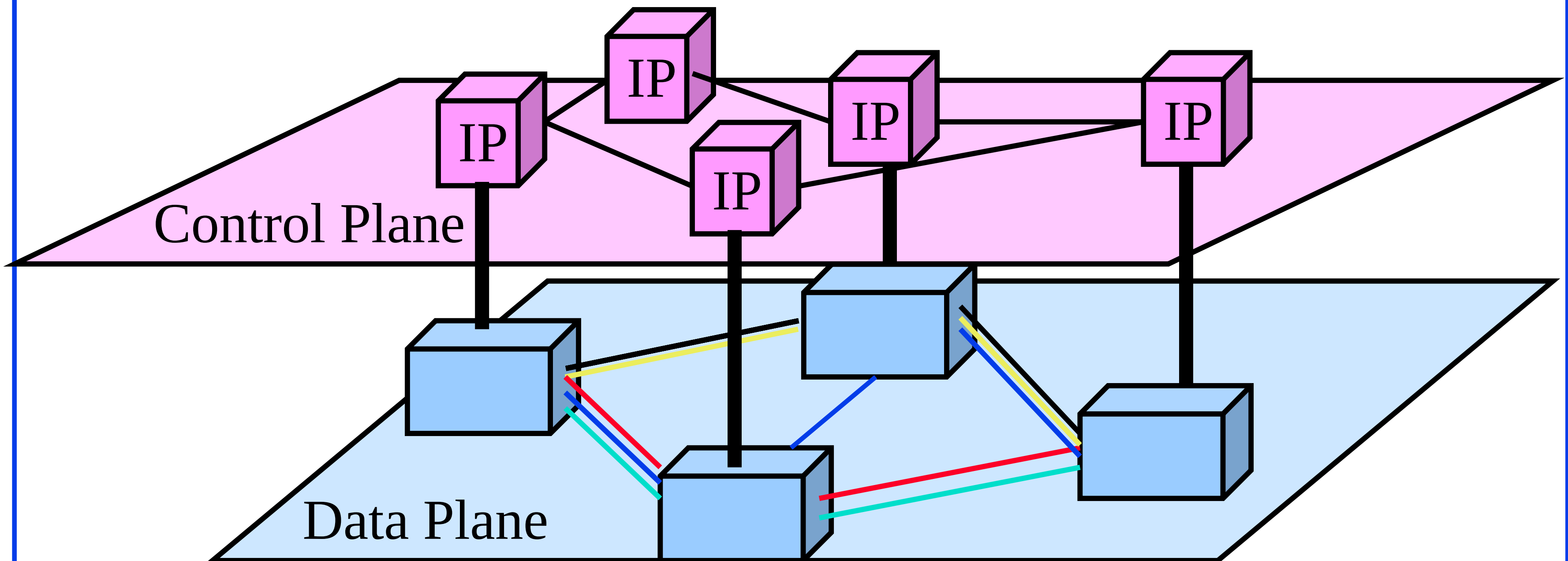
- Control is by IP packets (electronic).
  Data plane consists of wavelength circuits
  ⇒ Multiprotocol Lambda Switching (October 1999)



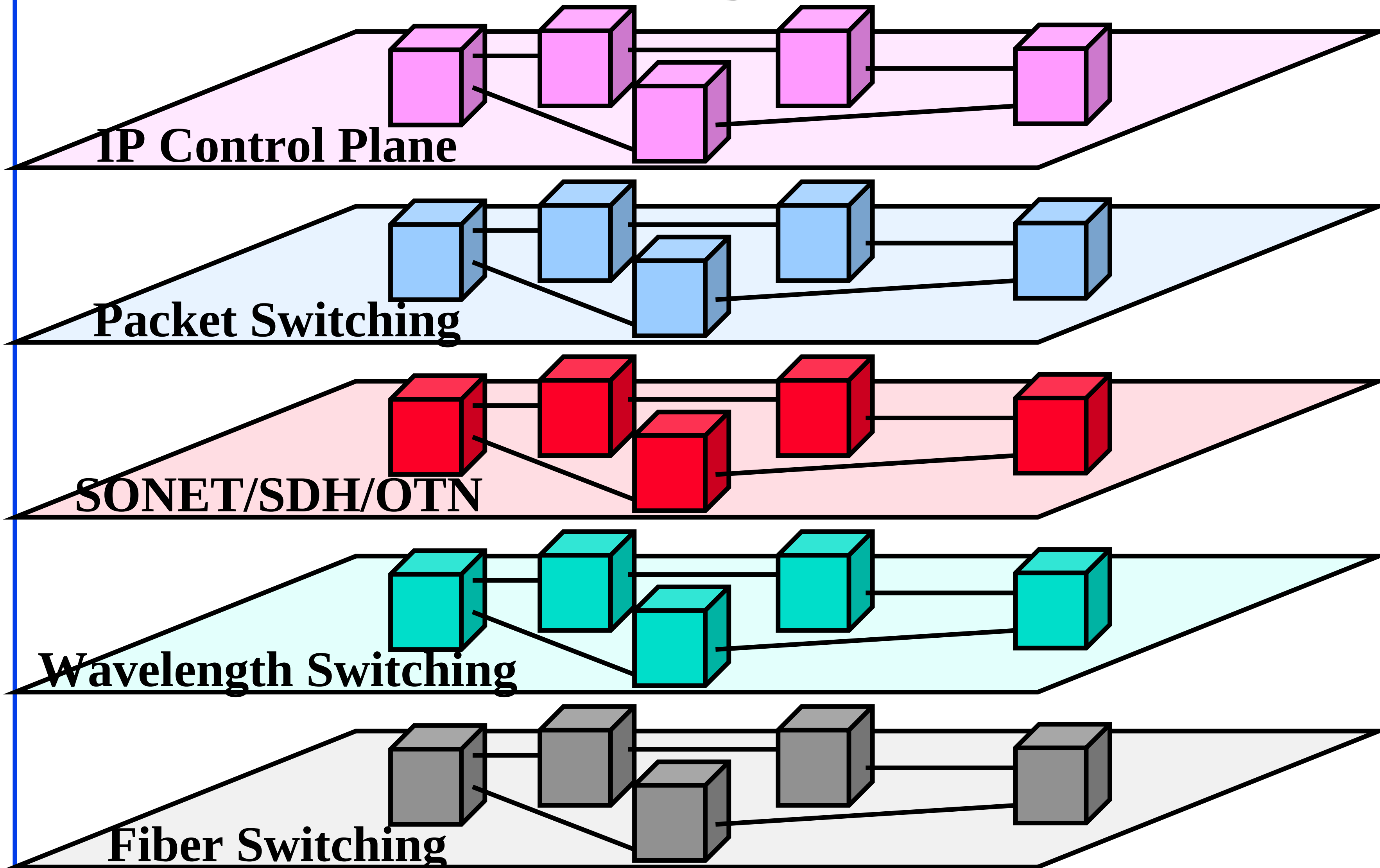
LSC = Lambda Switch Capable Nodes
= Optical Cross Connects = OXC

GMPLS

- Data Plane = Wavelengths, Fibers, SONET Frames, Packets (October 2000)



GMPLS: Layered View



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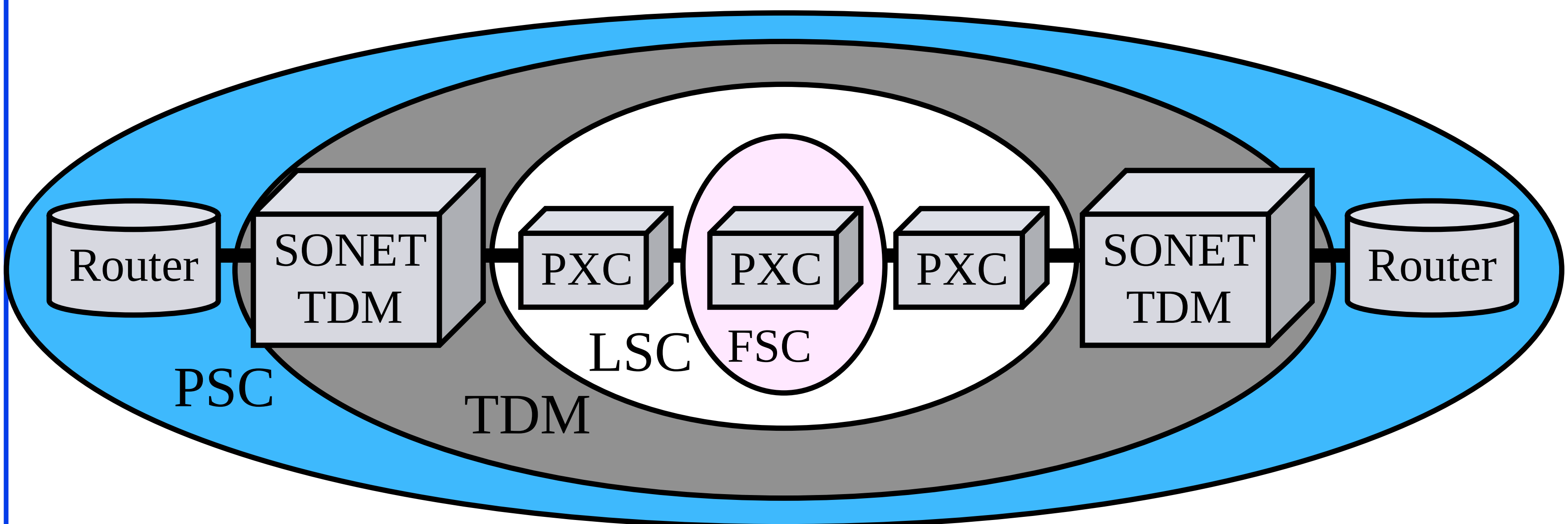
GMPLS: Hierarchical View

- Packets over SONET over Wavelengths over Fibers
- Packet switching regions, TDM regions, Wavelength switching regions, fiber switching regions



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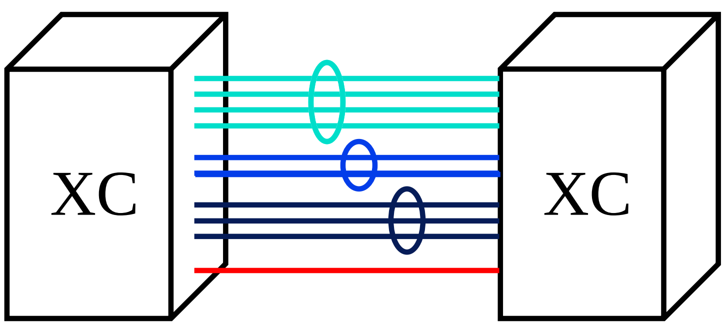
MPLS vs GMPLS

Issue	MPLS	GMPLS
Data & Control Plane	Same channel	Separate
Types of Nodes and labels	Packet Switching	PSC, TDM, LSC, FSC, …
Bandwidth	Continuous	Discrete: OC-n, λ's, ..
# of Parallel Links	Small	100-1000's
Port IP Address	One per port	Unnumberred
Fault Detection	In-band	Out-of-band or In-Band



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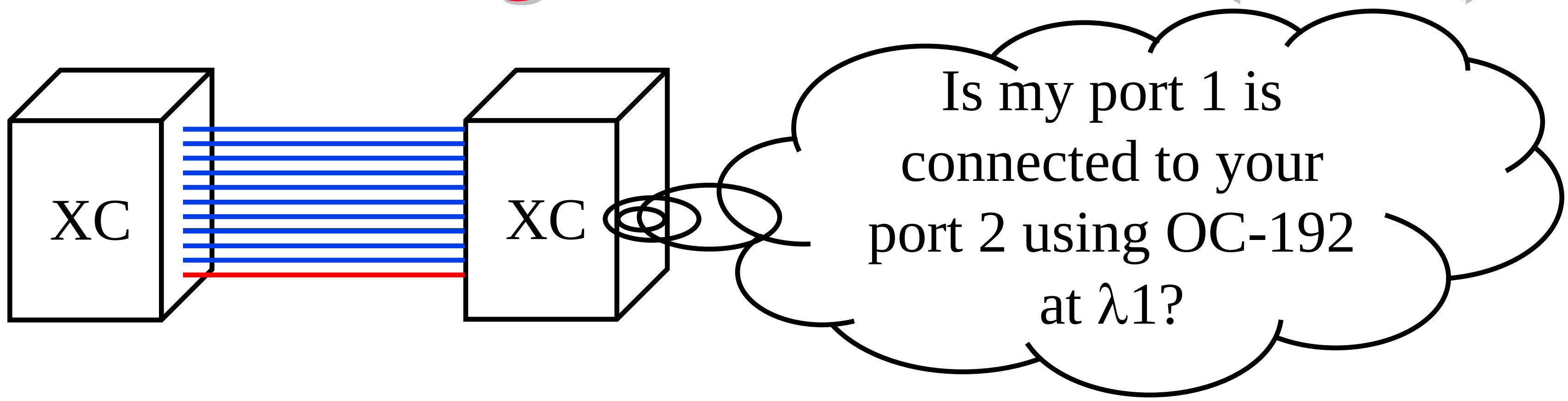
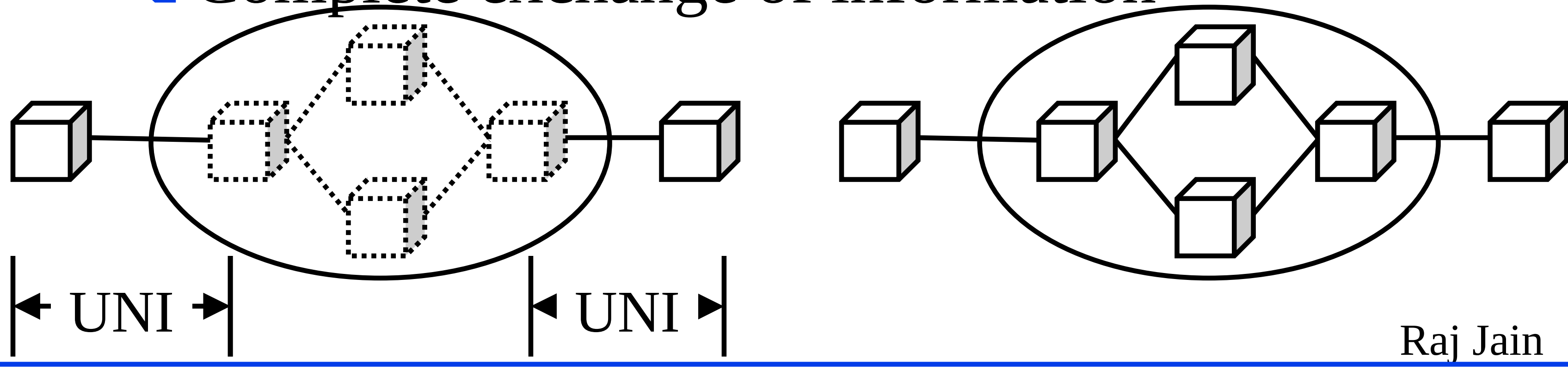
Link Management Protocol (LMP)



- Too many channels between crossconnects
- LMP allows connectivity verification, link parameter correlation, fault notification
- All communication takes place on control channel
- Only test messages on data channels to verify connectivity (optional)

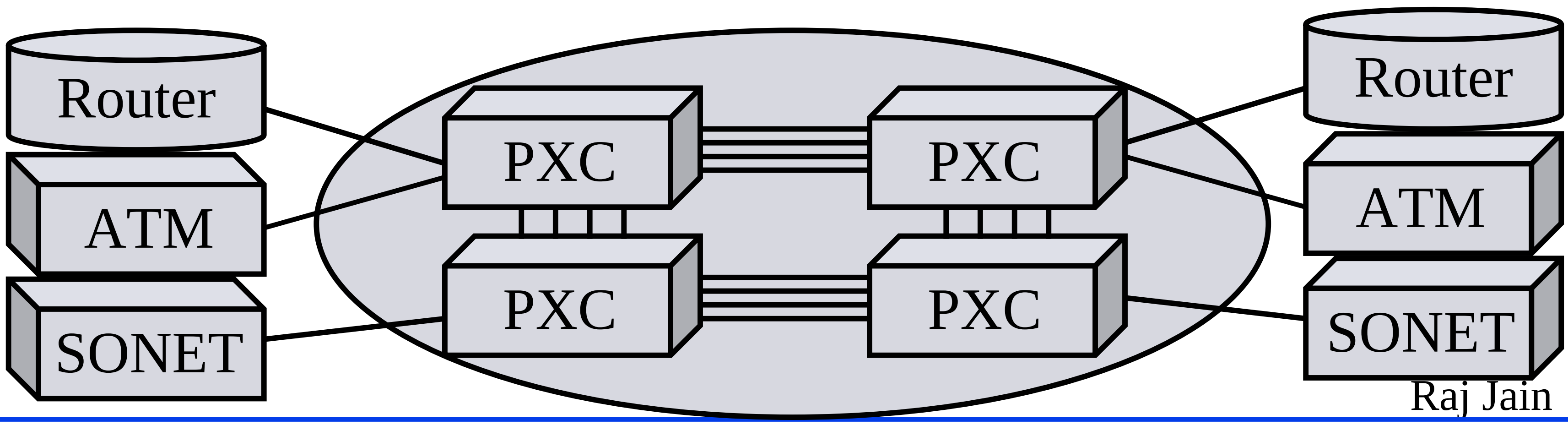
Issue: UNI vs Peer-to-Peer Signaling

- Two Business Models:
  - Carrier: Overlay or cloud
    - Network is a black-box
    - User-to-network interface (UNI) to create/destroy light paths (in OIF)
  - Enterprise: Peer-to-Peer
    - Complete exchange of information



Addressing

- Many different client types IP, ATM, SONET, … Each type has its own address: IPv4, IPv6, ATM, …
- Should a client be addressed by Switch and Port #?
- **Answer**: Optical Network Assigned Address (ONA) Globally Unique. Like Phone Number.
- Address Resolution Protocol to register and resolve name to ONA. Connect using ONA.



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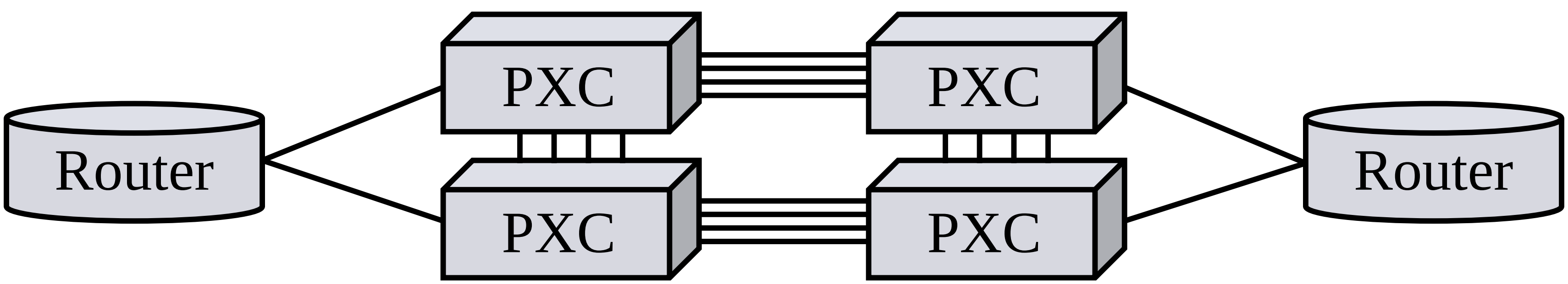
Current Issues

- Protection and Restoration
- Fault detection and isolation
- All-Optical networks
- Network-network Interface

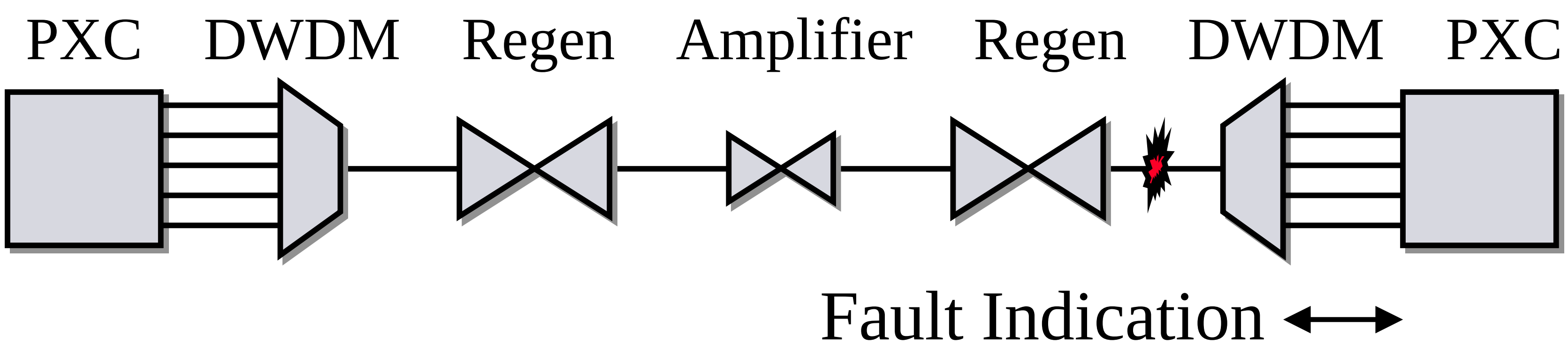
Protection and Restoration

- Extent: SPAN vs PATH
- Topology: Ring vs Mesh
- Redundancy: 1+1, 1:1
- Finding Paths that do not share the same risk
  Each link has to be assigned a risk group
  Shared Risk Group (**SRG**) = All paths sharing a risk

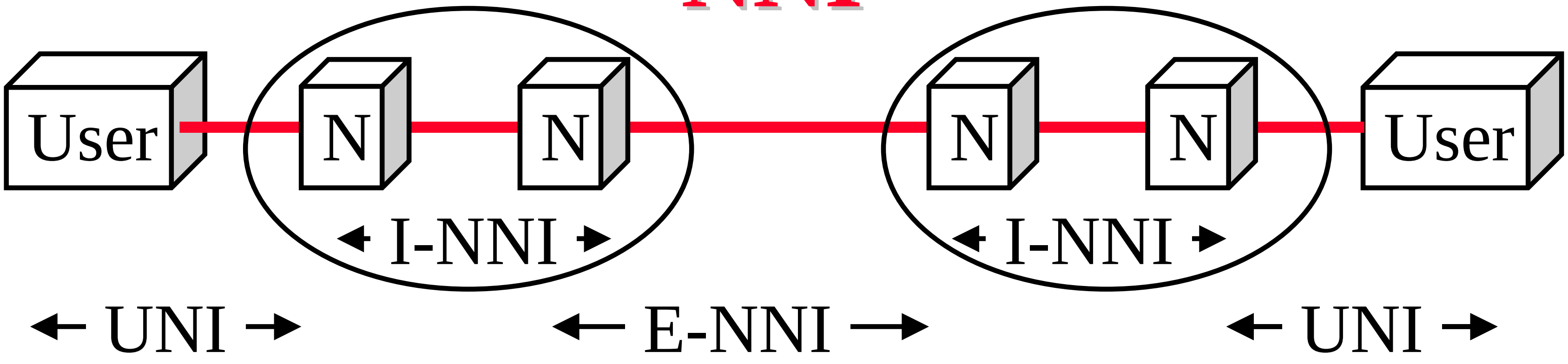


Fault Detection and Isolation

- SONET: Remote Defect Indicator, Alarm Indication Signal, Bit Interleaved Parity
- Photonic: Loss of signal, Optical degradation of signal
- Solution: A protocol for active devices to communicate fault information to Photonic switches
  Examples: LMP-DWDM, NTIP



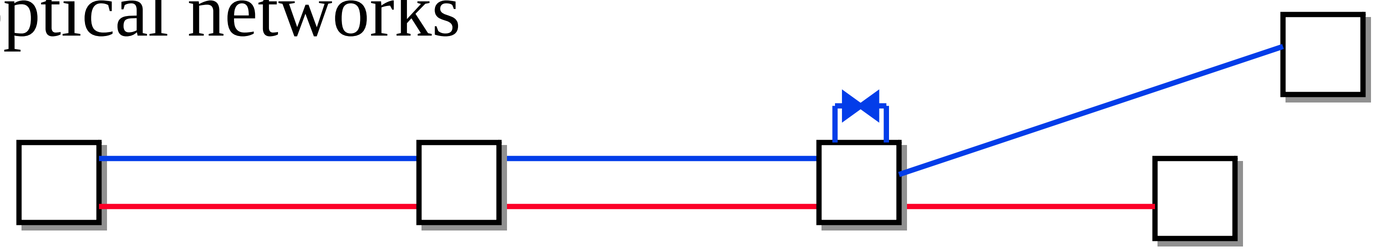
NNI



- NNI = Network to Network or
  Node-to-Node or
  Network-to-Node Interface
- Examples: Open Shortest Path First (OSPF)
  Private Network to Node Interface (PNNI)
- OIF is starting a new project on NNI

All-Optical Networks

- All-Optical ⇒ No electronic conversion
  ⇒ No wavelength conversion
  ⇒ No 3R regeneration
- Optical degradations (attenuation, chromatic dispersion, Polarization Mode Dispersion, …) limit the paths
- Non-linear function of distance and non-additive
- OIF is about to start a new project to address all-optical networks



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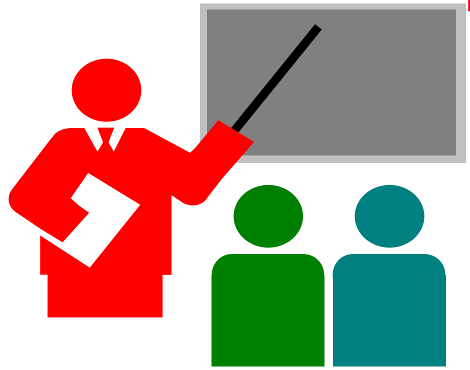
Summary



1. Separation of control and data plane
   IP-Based control plane
2. Transport Plane = Packets $\Rightarrow$ MPLS
   Transport Plane = Wavelengths $\Rightarrow$ MPλS
   Transport Plane = λ, SONET, Packets $\Rightarrow$ GMPLS
3. UNI allows users to setup paths on demand
4. Starting on all-optical networks, protection, fault management, and NNI

IP over DWDM: Key References

- Detailed references in http://www.cis.ohio-state.edu/~jain/refs/opt_refs.htm
- Recommended books on optical networking, http://www.cis.ohio-state.edu/~jain/refs/opt_book.htm
- Optical Networking and DWDM, http://www.cis.ohio-state.edu/~jain/cis788-99/dwdm/index.html
- IP over Optical: A summary of issues, (internet draft) http://www.cis.ohio-state.edu/~jain/ietf/issues.html
- Lightreading, http://www.lightreading.com

Standards Organizations

- IETF: www.ietf.org
  - Multiprotocol Label Switching (MPLS)
  - IP over Optical (IPO)
  - Traffic Engineering (TE)
  - Common Control and Management Plane (CCAMP)
- Optical Internetworking Forum (OIF): www.oiforum.com
- ANSI T1X1.5: http://www.t1.org/t1x1/_x15-hm.htm
- ITU, www.itu.ch, Study Group 15 Question 14 and Question 12
- Optical Domain Service Interface (ODSI) - Completed December 2000