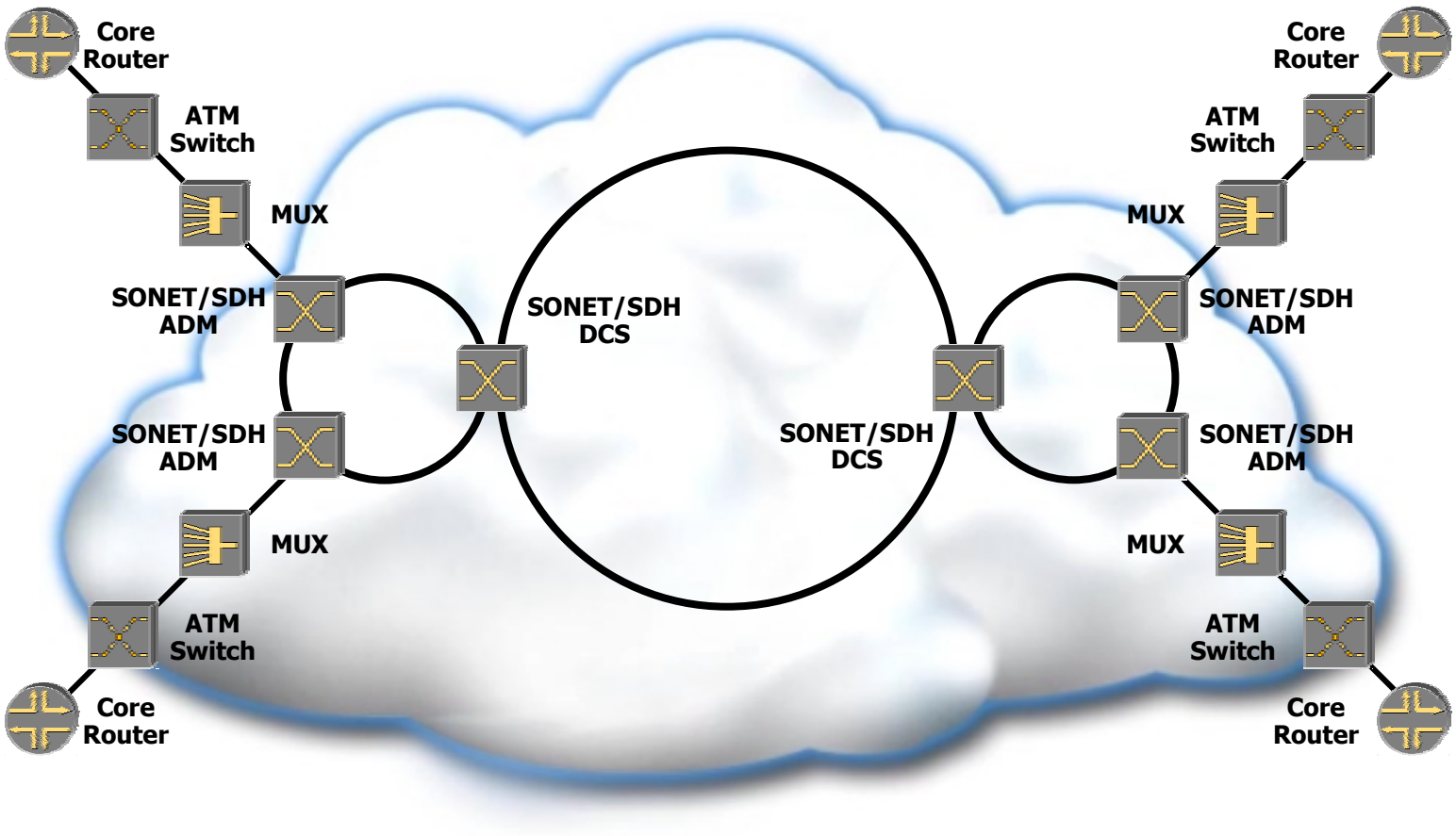
The MPLS Advantage

Part V:
Optical Applications for MPLS Signaling (GMPLS/MPλS)

Agenda: Optical Applications for MPLS Signaling

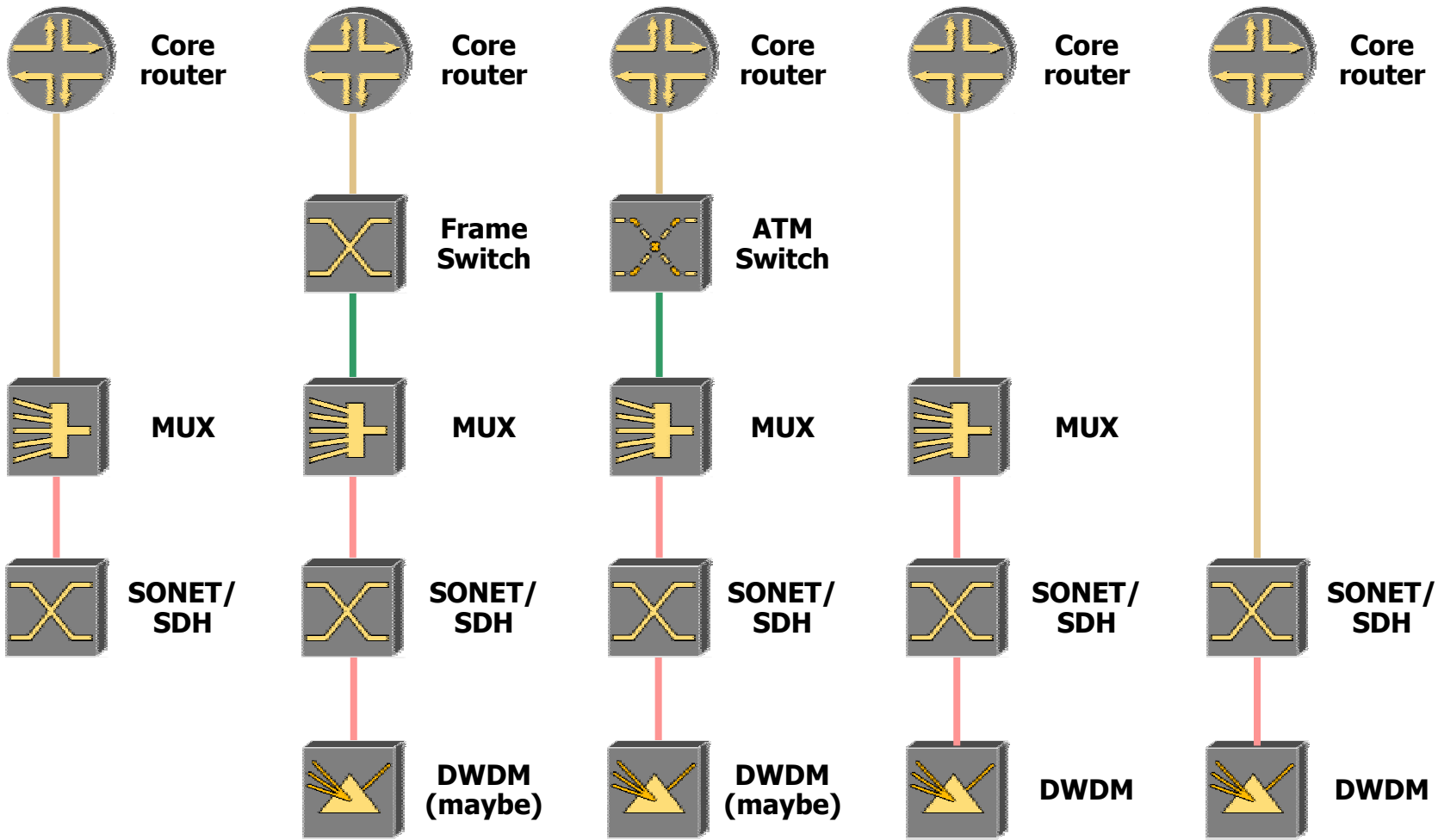
- Emerging Two-Layer Network
- Standards & Industry Forums
- Comparing LSRs and Optical Cross-Connects
- Generalized MPLS (GMPLS)
  - IGP Extensions
  - Forwarding Adjacency
  - LSP Hierarchy
  - Signaling Extensions
  - Link Management Protocol
  - Link Bundling
- GMPLS Benefits

Typical IP Backbone (Late 1990's)

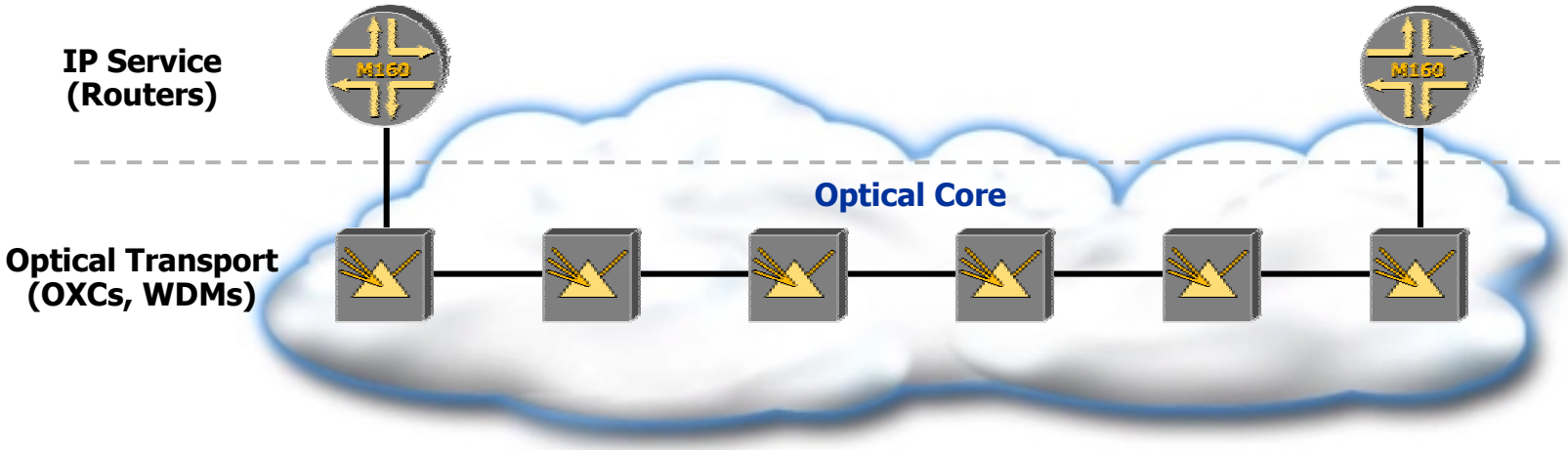


- **Data piggybacked over traditional voice/TDM transport**

A History of Equipment Layers



The Emerging Two-Layer Network

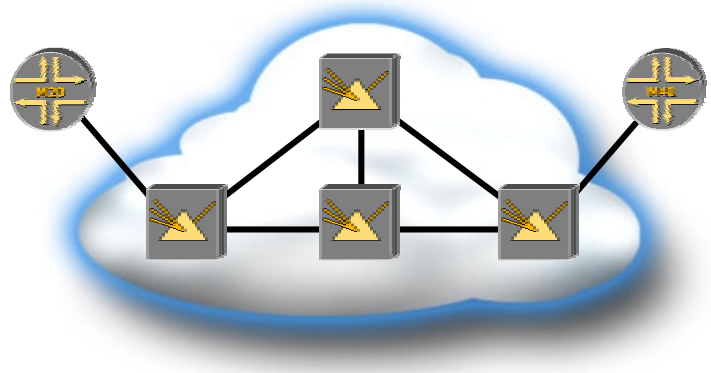


- Reduce complexity
- Reduce cost
- Router subsumes functions performed by other layers
  - Fast router interfaces eliminate the need for MUXs
  - MPLS replaces ATM/FR for traffic engineering
  - MPLS fast reroute obviates SONET APS restoration
- Dynamic provisioning of optical bandwidth is required for growth and innovative service creation

Operational Approaches: Overlay and Peer Models

- **Overlay Model**
  - Two independent control planes
    - IP/MPLS routing
    - Optical domain routing
  - Router is client of optical domain
  - Optical topology invisible to routers
  - Does this look familiar?

- **Peer Model**
  - Single integrated control plane
  - Router & optical switches are peers
  - Optical topology is visible to routers
  - Similar to IP/MPLS model



Standards and Industry Forums

- Internet Engineering Task Force (IETF)
  - Driving GMPLS standards development
    - Initial application is MPλS
  - Peer model
  - Extend MPLS traffic engineering to the optical control plane

- Optical Domain Service Interconnect (ODSI)
  - Industry forum (led by Sycamore)
  - Kick-off meeting January 2000
  - Overlay model
  - Standard UNI (Router-to-OXC)
    - Entirely new protocol over TCP
    - Does not operate as an NNI
  - Proprietary NNI (OXC-to-OXC)

Standards and Industry Forums

- Optical Internetworking Forum (OIF)
  - Industry forum
  - Kick-off meeting May 1998
  - Standard OIF UNI based on IETF work (LDP/RSVP)
    - Same signaling protocols used by the IETF
    - A proposal to use ODSI signaling for OIF UNI rejected (8/00)
  - Allows one protocol to support two different applications
    - OIF UNI: subscriber bandwidth requests (hide core topology)
    - GMPLS: scalable service provider provisioning

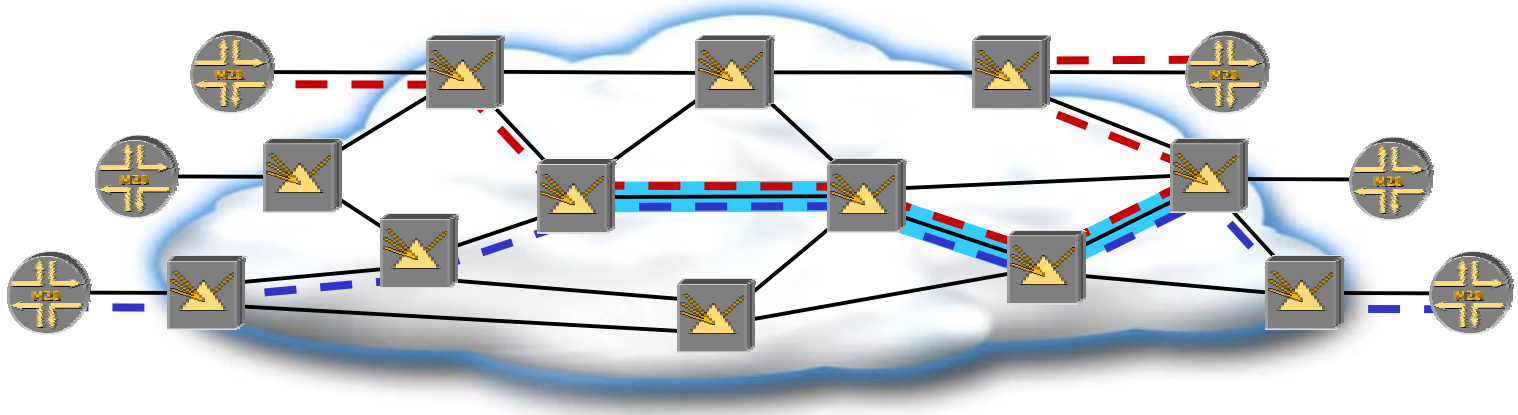
Routers vs Optical XCs

- Optical cross-connects
  - High bandwidth, ease of provisioning
  - No statistical gain, no multiplexing
  - Limited, but great for connecting large routers
- Routers
  - Massive multiplexing
  - Huge statistical gain (buffering)
  - Supports IP Services (CoS, VPNs)
- MPLS signaling, constraint-based routing
  - Allows common control
  - Simplifies management of combined network

Generalized MPLS (GMPLS)

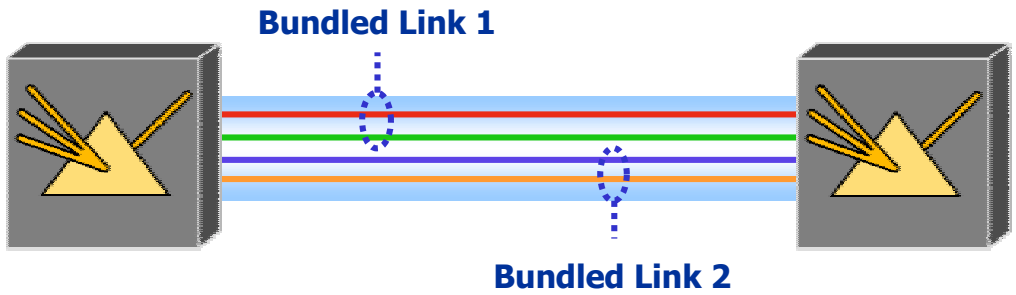
- Extends MPLS to support multiple switching types
  - TDM switching (SONET)
  - Wavelength switching (Lambda)
  - Physical port switching (Fiber)
- Peer model
- Uses existing and evolving technology
- Facilitates parallel evolution in the IP and optical transmission domains
- Enhances service provider revenues
  - New service creation
  - Faster provisioning
  - Operational efficiencies

GMPLS: Mechanisms



- IGP extensions
- Forwarding adjacency
- LSP hierarchy
- Constraint-based routing
- Signaling extensions
- Link Management Protocol (LMP)
- Link bundling
- OIF Optical UNI Signaling

GMPLS: Link Bundling



- Allows multiple parallel links between nodes to be advertised as a single link into the IGP
- Enhances IGP and traffic engineering scalability
- Component links must have the same type / metric
- (Max bandwidth request) ≤ (bandwidth of a component link)
- Link granularity can be as small as a λ

GMPLS Benefits

- Open standards allow use of best-of-breed equipment
  - Promotes parallel evolution of UNI and NNI standards
- Routers have visibility into full topology
  - Better scaling, Better routes
- Leverages operational experience with MPLS
- Facilitates growth of bandwidth, services
  - 21st Century, IP is the dominant application
  - Enables rapid development & deployment of OXCs

Obrigado!

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