Optical Networking: What is Its Future?

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Introduction - Network Architecture

Service Layer (data + voice)

Service
Transport
Packet/Cell/circuit
Circuit

Optical transport layer
WDM transmission and wavelength circuit switching

OXCs
What do Carriers Want?

- Adding capacity when & where needed
- Flexibility in managing/provisioning
- Reliability & Survivability
- Low cost (starting & operational)
Optical Networking: What is Its Future?

- High capacity (each channel can be up to 40G)
- Agile / automated provisioning
- Consolidated control / management
- Emerging new services (such as Direct Wavelength Service)
- Guaranteed, fast recovery so that higher layers are oblivious to failures in the physical layer
- Differentiated services
Roles of Optics vs. Electronics vs. Software

- Optics & Electronics offer more capacity
- Optics may increase transmission distance, electronics may still be required for regeneration
- Software required to manage the capacity
- Software required to fill the gap between channel capacity and provisioning granularity
- Software can be designed to alleviate some of the regeneration needs
Next Generation Optical Switches

- OOO/OEO Hybrid
  - regeneration when necessary
- Hierarchical
  - Fiber switching
  - Waveband switching
  - Wavelength switching
  - TDM switching
- Unified control plane / management plane
- Optical wavelength conversion possible
OXC architecture (1)

OXC

Wavelength Switch Fabric
(W-Fabric)

Demux

Local add...

G-Fabric

Local drop...

Mux

Fiber in...

...Fiber out

Local add...

G-Fabric

Local drop...

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INFOCOM, San Francisco, CA, March 2003
Network design problem: what kind of switch is required where?

- Subject to
  - geographical location
  - Traffic forecast
- Objective:
  - Feasibility
  - Resource efficiency
  - Scalability
Bandwidth Provisioning & Protection

- **Given:**
  - Physical topology
  - Connection (LSP) request set (either static or dynamic)

- **To solve:**
  - Determine virtual topology (setup lightpaths).
  - Route the lightpaths over physical topology.
  - Assign wavelengths to the lightpaths.
  - Route the low-speed connection requests over the virtual topology.
  - Protect low-speed connections by backup LSPs or backup wavelength LSPs
Research Challenges (Cont)

- Subject to:
  - Wavelength conversion constraints
  - Regeneration constraints
  - Shared-risk-link group constraints
  - SLA (service interruption time, availability)

- Objective:
  - Satisfy connection requests
  - Satisfy SLAs
  - Minimize the usage of wavelength conversion ports, regeneration ports, grooming ports
  - Resource efficiency