

# Optical Networking: What is Its Future?

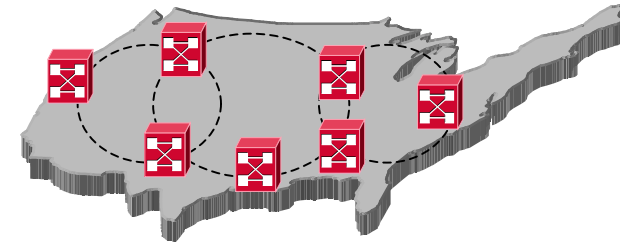
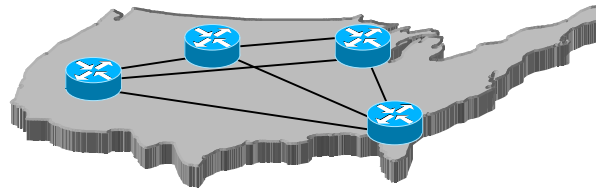
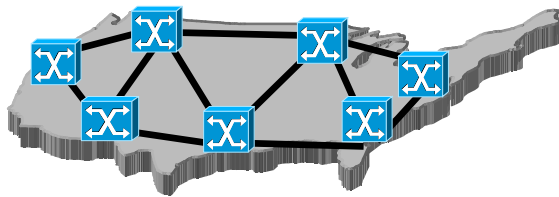
Hui Zang

*Sprint Advanced Technology Laboratories*



# Introduction - Network Architecture

Service Layer (data + voice)

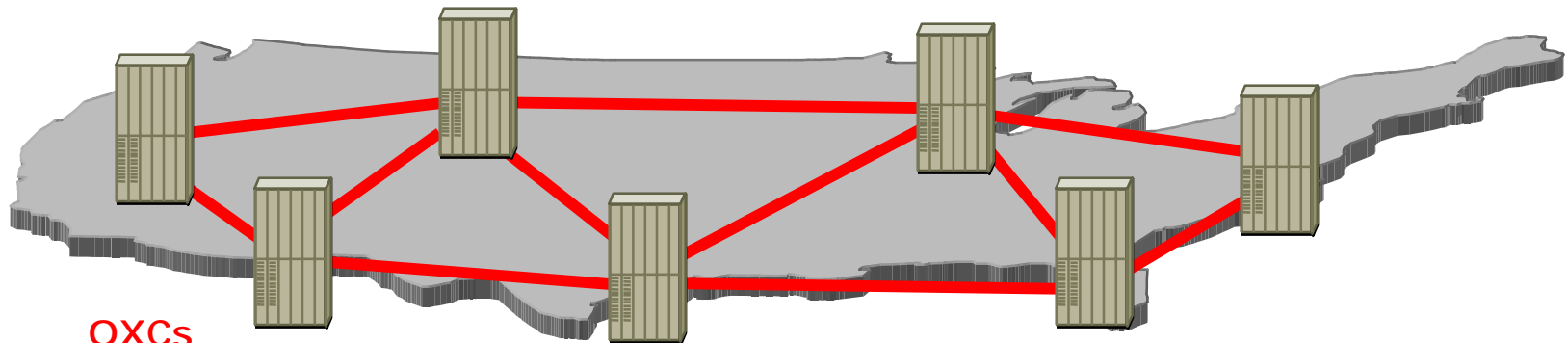


Service

Packet/Cell/circuit

Transport

Circuit



OXC's

Optical transport layer

WDM transmission and wavelength circuit switching



# 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

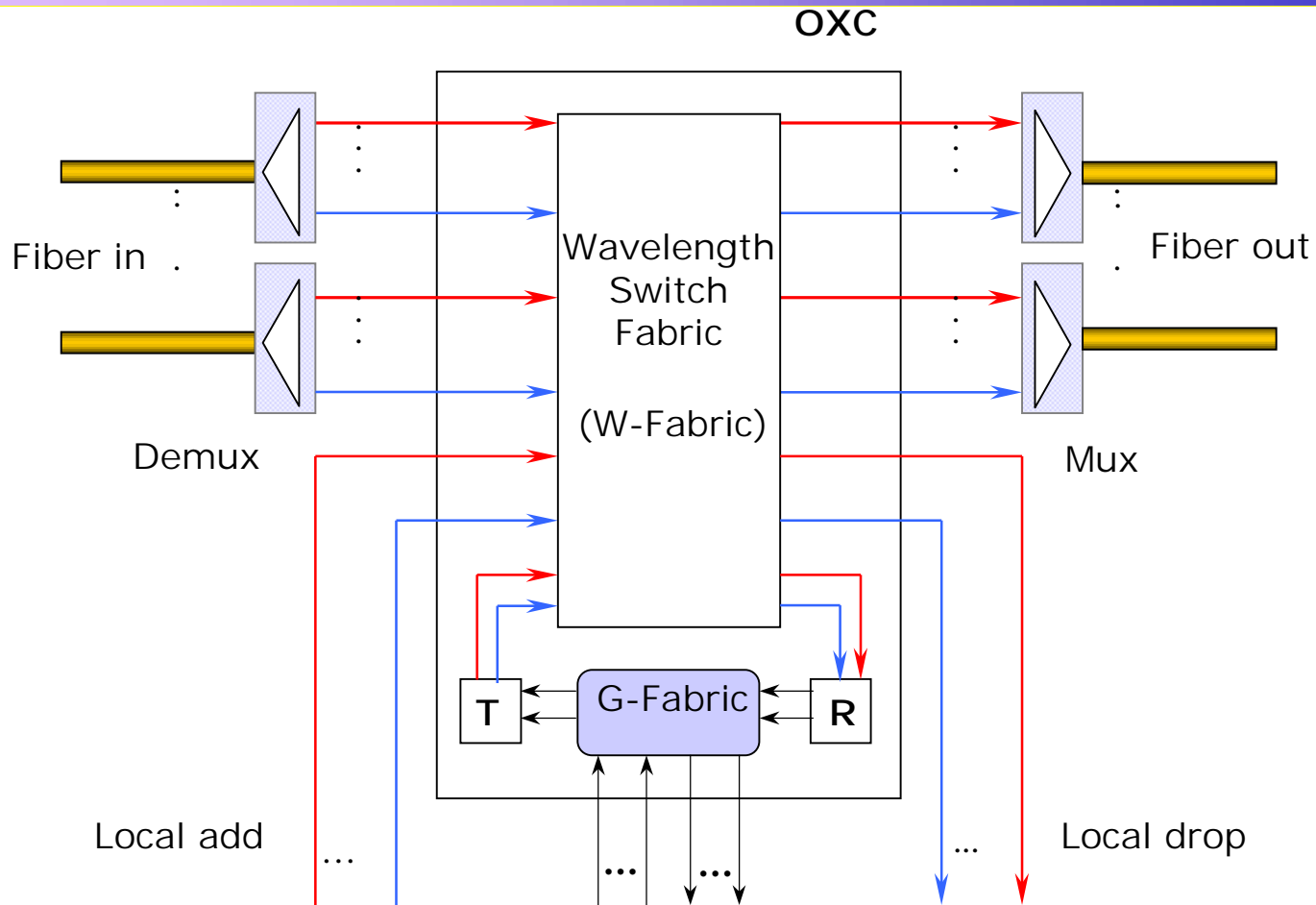


# Next Generation Optical Switches

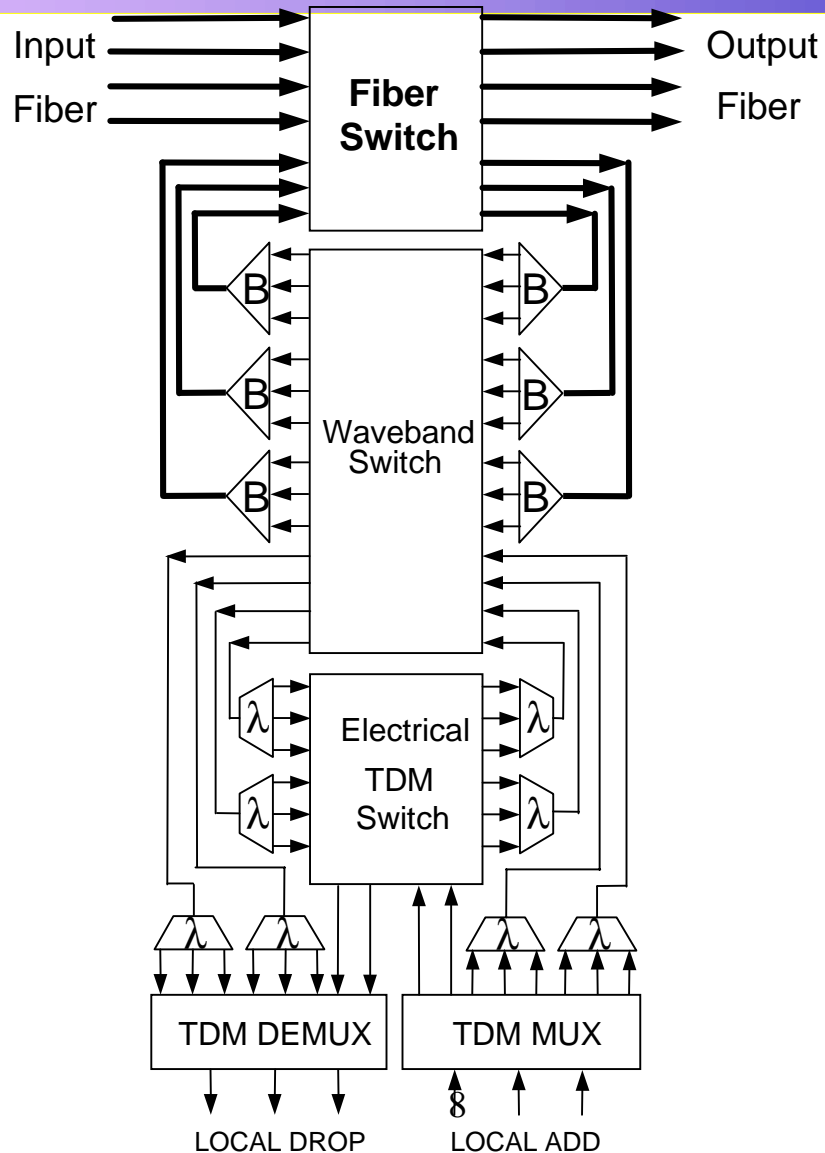
- OOO/OEO Hybrid
  - regeneration when necessary
- Hierarchical
  - Fiber switching
  - Waveband switching
  - Wavelength switching
  - TDM switching
- Unified control plane / management plane
- Optical wavelength conversion possible



# OXC architecture (1)



# OXC architecture (2)





# Research Challenges

Network design problem: what kind of switch is required where?

- Subject to
  - geographical location
  - Traffic forecast
- Objective:
  - Feasibility
  - Resource efficiency
  - Scalability



# Research Challenges (Cont)

## 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