Optical Networking: What Is Its Future?

IEEE Infocom ’03 Panel

**Panelists:**
Chris Rust, CEO, Mahi Networks
Rajiv Ramaswami, CTO, Optical Networking, Cisco
Hui Zang, Sprint Advanced Technology Lab.
Young-Chon Kim, Chonbuk Natl. Univ., Korea
Biswanath Mukherjee, UC Davis (Moderator)

April 2, 2003
What Is An Optical Network?

• It is **NOT NECESSARILY** all optical
  
  " " " " " " packet switched

• **Characteristics of an optical network**
  
  – **Transmission**: optical
  – **Switching**: could be optical, could be electronic, could be hybrid
    
    could be circuit, could be packet, could be burst

• **Most Promising Approach Today**
  
  – Electronic circuit switching with sub-lambda granularity (STS-1, OC-3, …)

• **Example Utility for IP Networking**
  
  – Connect any two IP routers (geographically far apart) with a direct
    
    ("virtual") bandwidth pipe… of whatever capacity (STS-1, … OC-192)
  – Increase (or decrease or delete) the capacity on demand
  – Dynamically control the “topology” connecting the IP routers
  – Create a “separated control network” (of whatever bandwidth)
  – …
An Example Network

Network Management System (NMS)

IP Router

ADM

UNI

Proprietary NNI

Standardized NNI
System/Network : Value Proposition

Current state of the art

Optical Science & Engineering

Electronic (Computer) Engineering

Software Engineering

“My” system + Yours too (?)

System A

My system

Yours too (?)

System VALUE
Optical Network Architecture:
Extending Our “Boundaries”

Applications

Network Architect

Physical Layer

(“Customer” needs)

**Differentiated Services:**
**Bandwidth:** OC-192, OC-48, ..., STS-1, VT1.5, ...
**Failure-Recovery Delay:** The “50-ms myth!”
**Network Economics:** Pricing, SLA, ...

(you and I)

+ routing protocols to combat optical channel impairments
+ breakthroughs needed in device technologies?
  - optical RAM, ultra-wideband amp, “tunable” AWG, ...

(optical comm. channel) -- materials, devices, subsystems
Emerging Business Paradigms

• “Wave Services”
  – “transparent” lambdas: run whatever you like
    (OC-48, OC-192, OC-768, GigE, 10GigE, …)

• Carrier-Neutral Internet-Exchange Points
  – “Carrier Hotels”

• Fast Bandwidth Provisioning
  – With a variety of user-configurable features
  – GMPLS for control plane?

• Bandwidth Brokers
  – Sell sub-lambda services as well (e.g., STS-1, OC-3, …)
Some Thoughts…

- Optical networking:
  - Three “pillars” for optical network architecture
    - Optics, electronics, software
  - All-optical networking
    - (When) will it happen?
    - Is it needed?
  - Circuit vs. packet vs. “burst”
  - Dynamic bandwidth management
  - Access vs. metro vs. long haul
    - Optical access: free-space optics
  - What revolutions/breakthroughs are needed in device technologies?
    - Optical RAM, ultra-wideband amplifier, “tunable” AWG, …
R&D Priorities

- **Access:** EPON architectures, Free-space optics
- **Metro:** ROADM-based architectures
- **Long-Haul:**
  - * Provisioning Connections of Different Bandwidth Granularities
    - Hierarchical Optical Switch (Crossconnect) Architectures
    - Traffic Grooming in WDM Mesh Networks
  - * Fault Monitoring and Restoration
    - Provisioning with Guaranteed SLA
    - “X-ms” guaranteed protection-switching time
  - * Dynamic Network Planning, Topology Engineering
    - Network Architectures and Algorithms to Combat Optical Signal-Quality Impairments
    - Optical Multicasting and “Light-Trees”
    - Optical Packet Switching (OPS) and Optical Burst Switching (OBS)