Optical Packet Switching

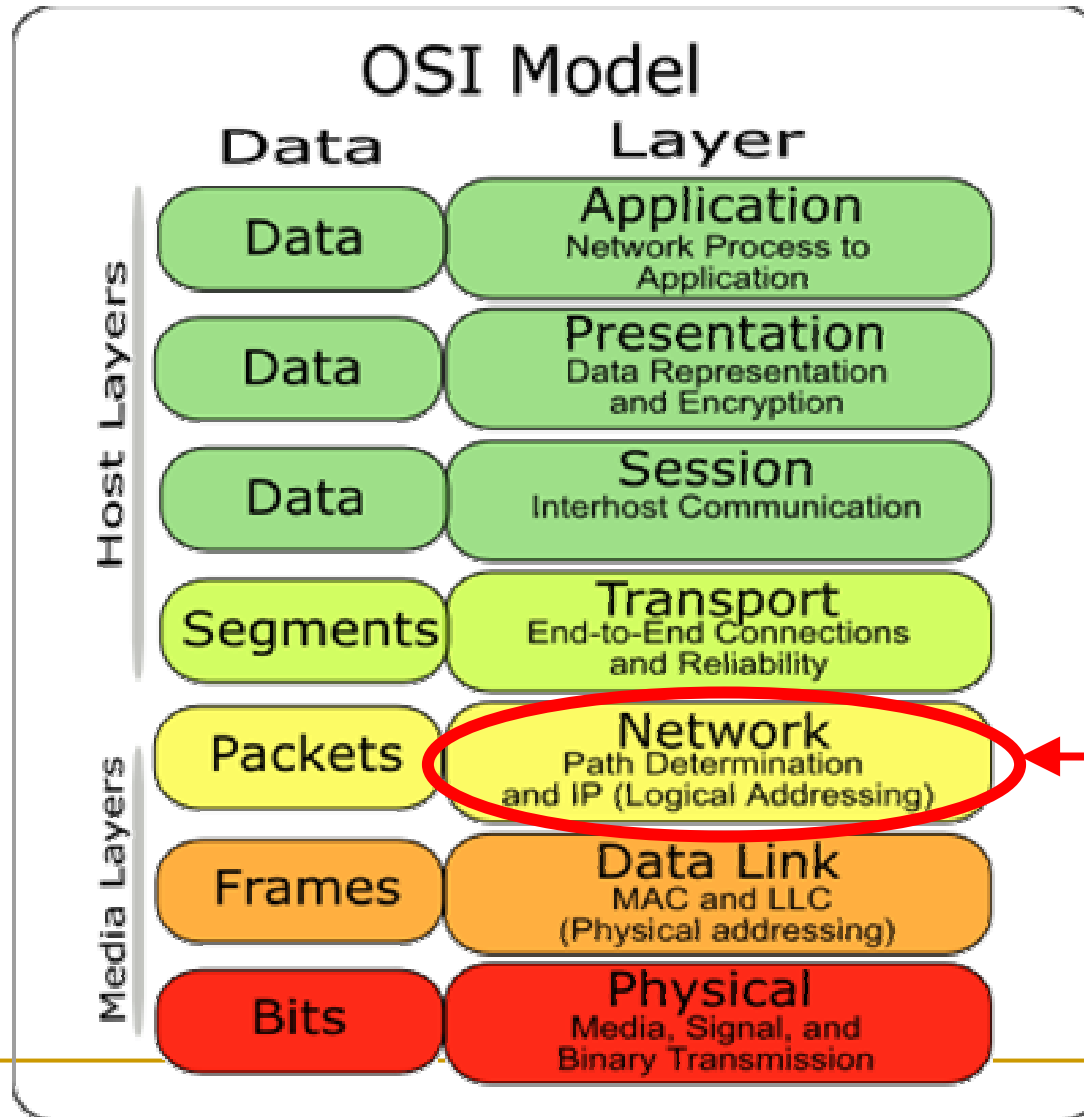Yu Ben, Qian Ying Tang

May 2, 2006

Outline

- **Packet Switching Overview**
- **Optical Packet Switching**

  SJ Yoo (UC Davis)

  - Architecture
  - Benefits
  - Social and Economic Impacts
- **Conclusion**

What is Packet Switching

- ## A set of rules
  - Governs how messages should be transmitted between two points
  - Divides long message into pieces-PACKETS.
  - Transmission is connectionless
  - Requires routers and routing algorithms

# Open Systems Interconnection Model

OSI Model

Data	Layer
	Application — Network Process to Application
Data	
	Presentation — Data Representation and Encryption
Data	
	Session — Interhost Communication
Data	
Segments	**Transport** — End-to-End Connections and Reliability
Packets	**Network** — Path Determination and IP (Logical Addressing)
Frames	**Data Link** — MAC and LLC (Physical addressing)
Bits	**Physical** — Media, Signal, and Binary Transmission

Host Layers: Application, Presentation, Session, Transport

Media Layers: Network, Data Link, Physical
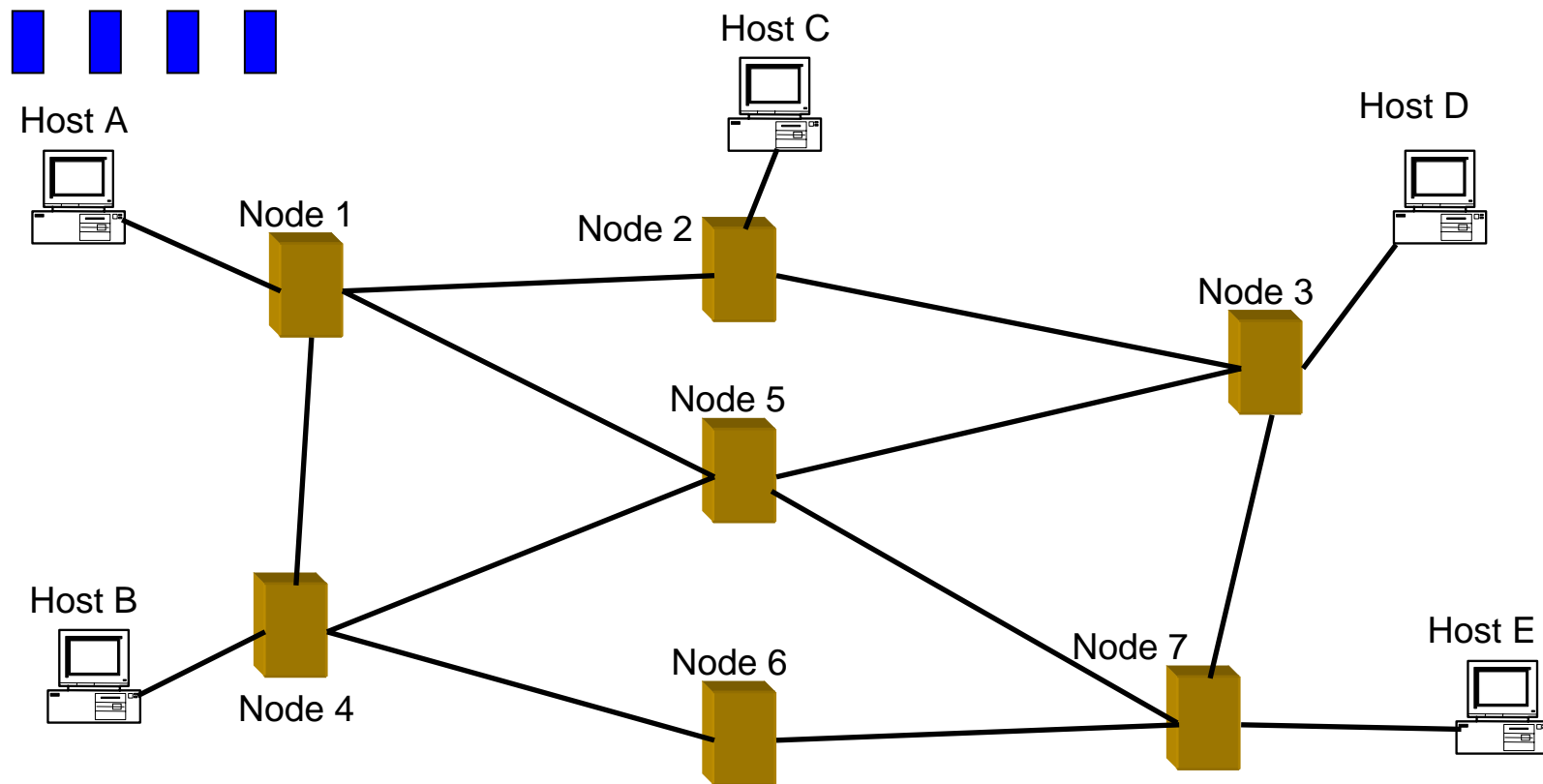
Packet switching
Fits in Here

Packet Switching-Demo

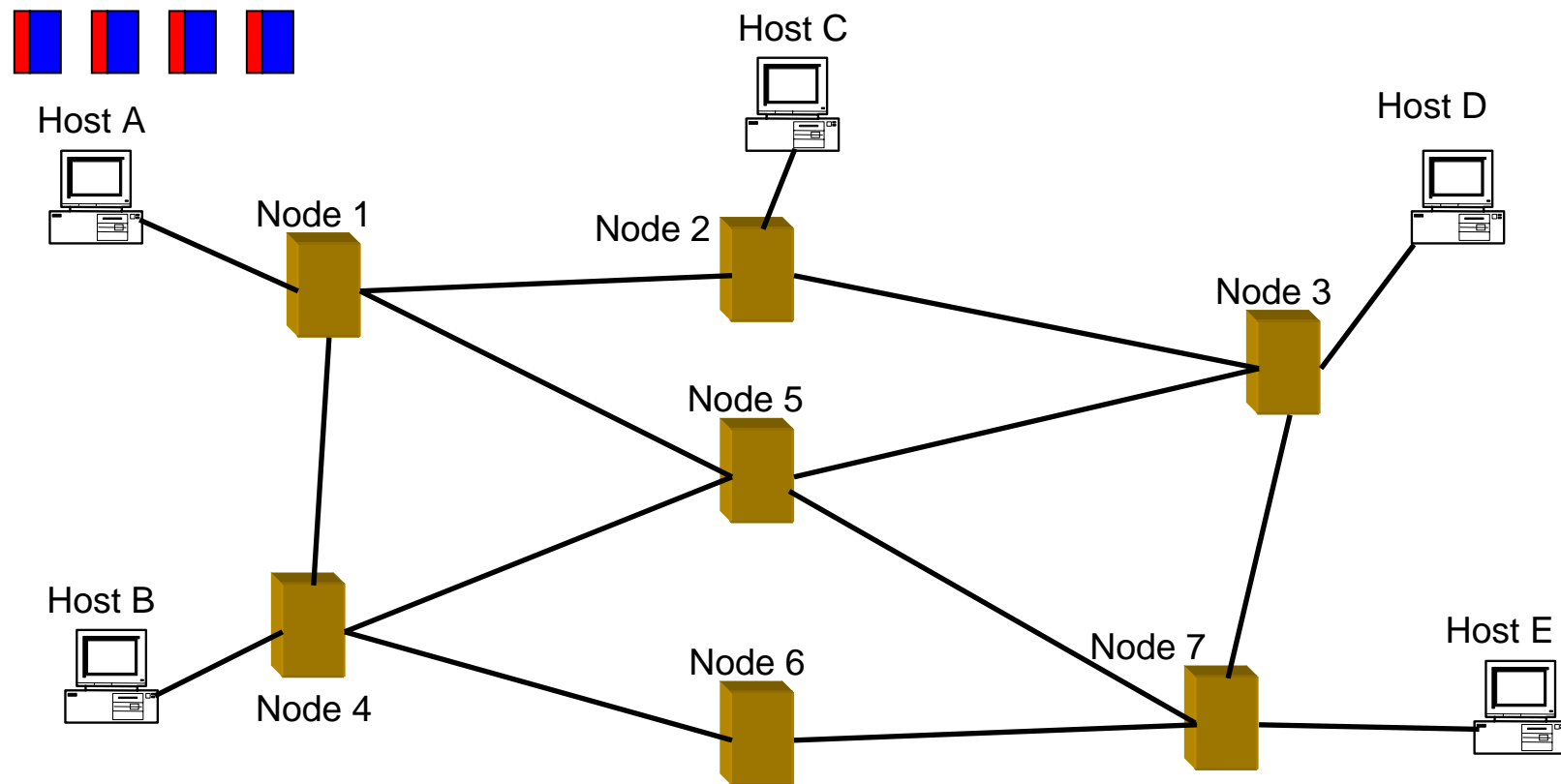- Want to transmit a file between host A and D
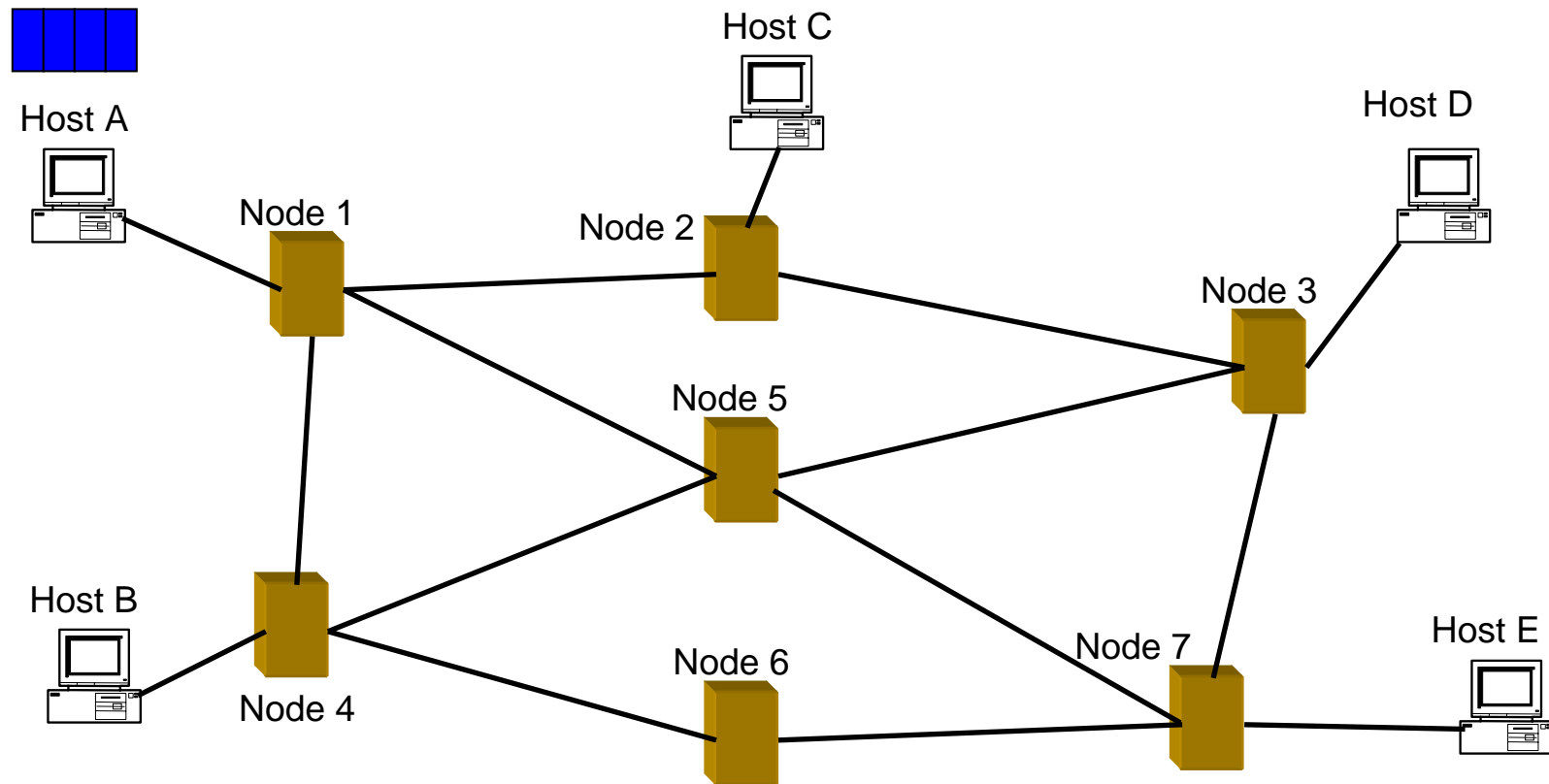
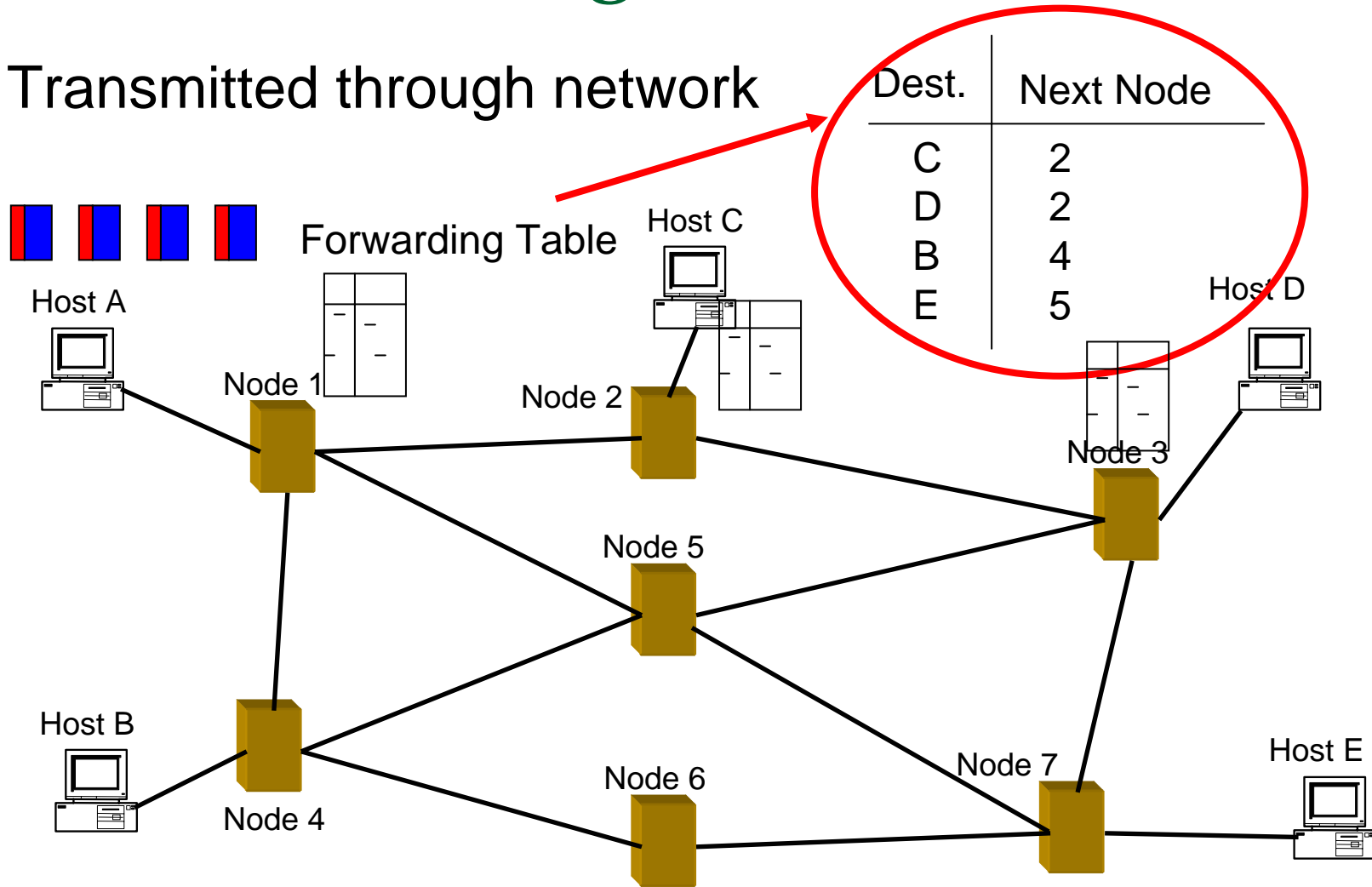# Packet Switching-Demo

- File is split into packets

Packet Switching-Demo

- Headers contain destination/order info is appended

Packet Switching-Demo

- Transmitted through network

Dest.	Next Node
C	2
D	2
B	4
E	5

Forwarding Table

Host A

Host B

Host C

Host D

Host E

Node 1

Node 2

Node 3

Node 4

Node 5

Node 6

Node 7

Why Packet Switching

- Dynamic bandwidth allocation
  - Links will be occupied on demand
  - Alternative routes when congestion occurred
- Packets from different sources can coexist on the same customer-to-network physical link without interference.
- Allows terminals operating at different bit rates to internet-work with each other
  - Routers will buffer the packets from a higher bit rate hosts
- Yet, Problems….

Network Topology
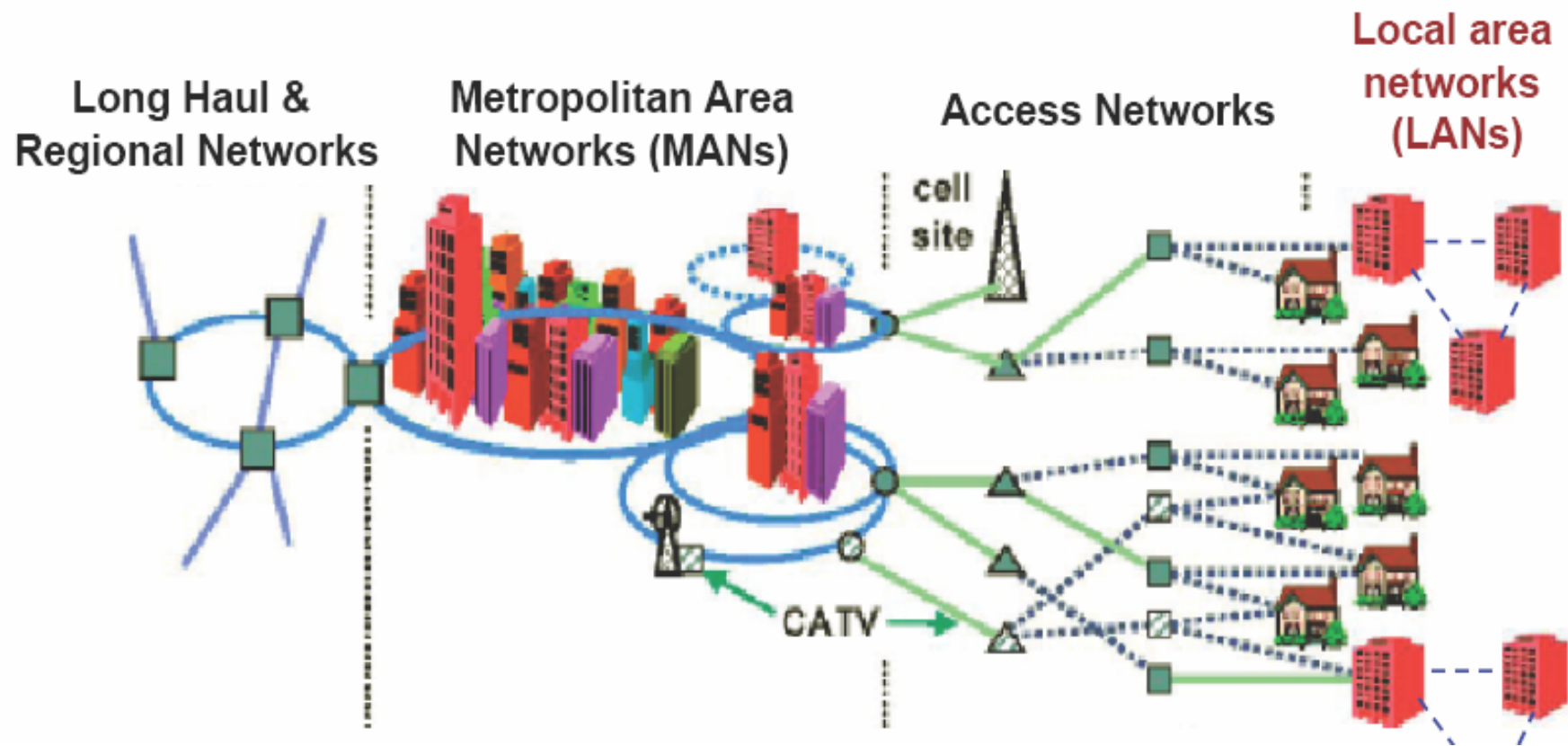
Optical Transmission Media

- In MAN, The link between nodes are optical fibers
- Packets are optical signals
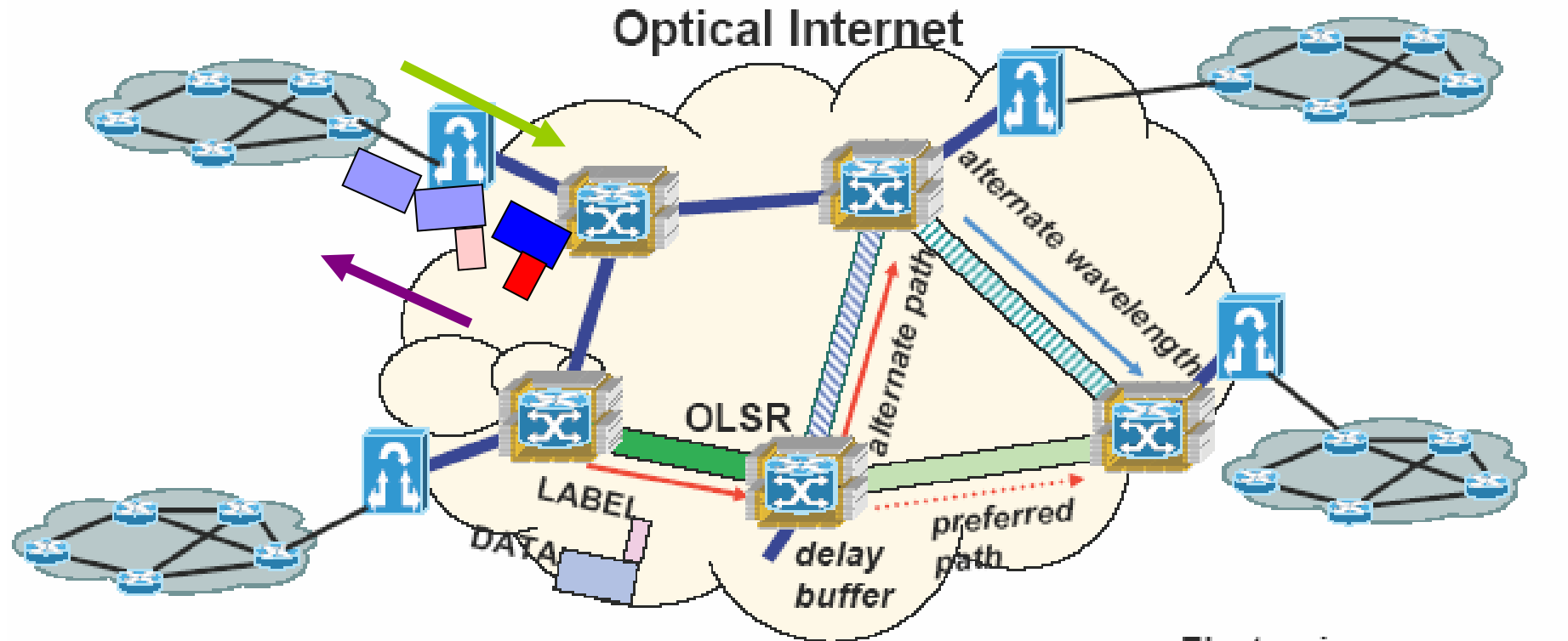- O-E-O conversion required at the interface
- Large Overhead
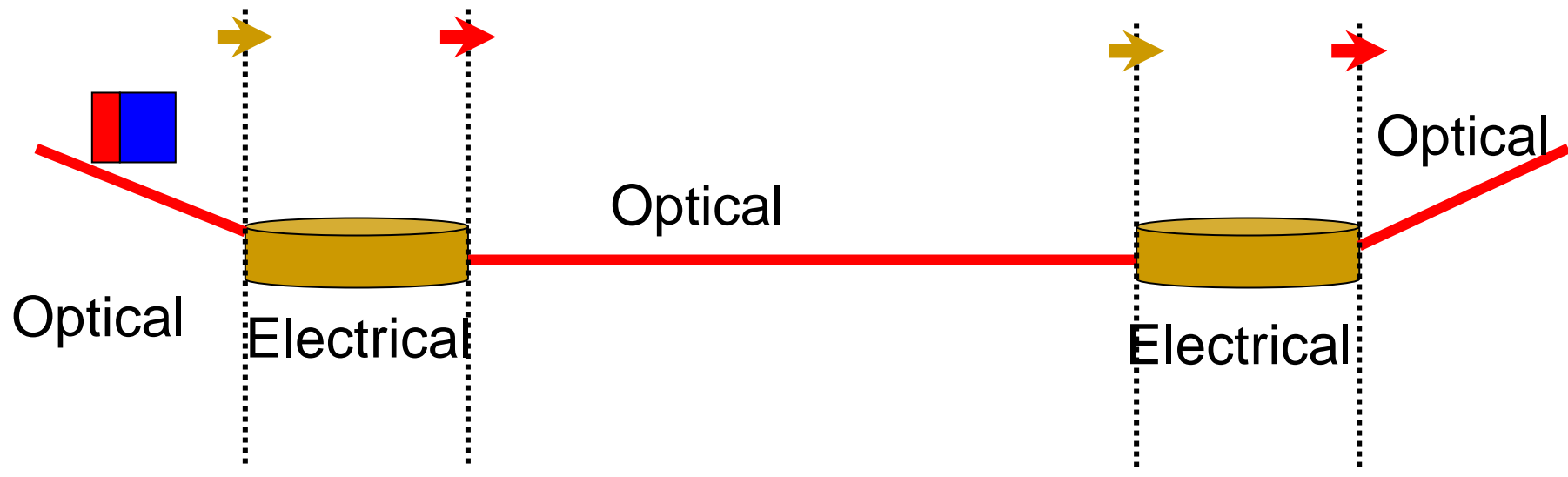
Solution: Optical label Switching

- Place optical label at subcarrier frequency
- Routing information can be extracted by converting header only
- Conversion will leave payload untouched
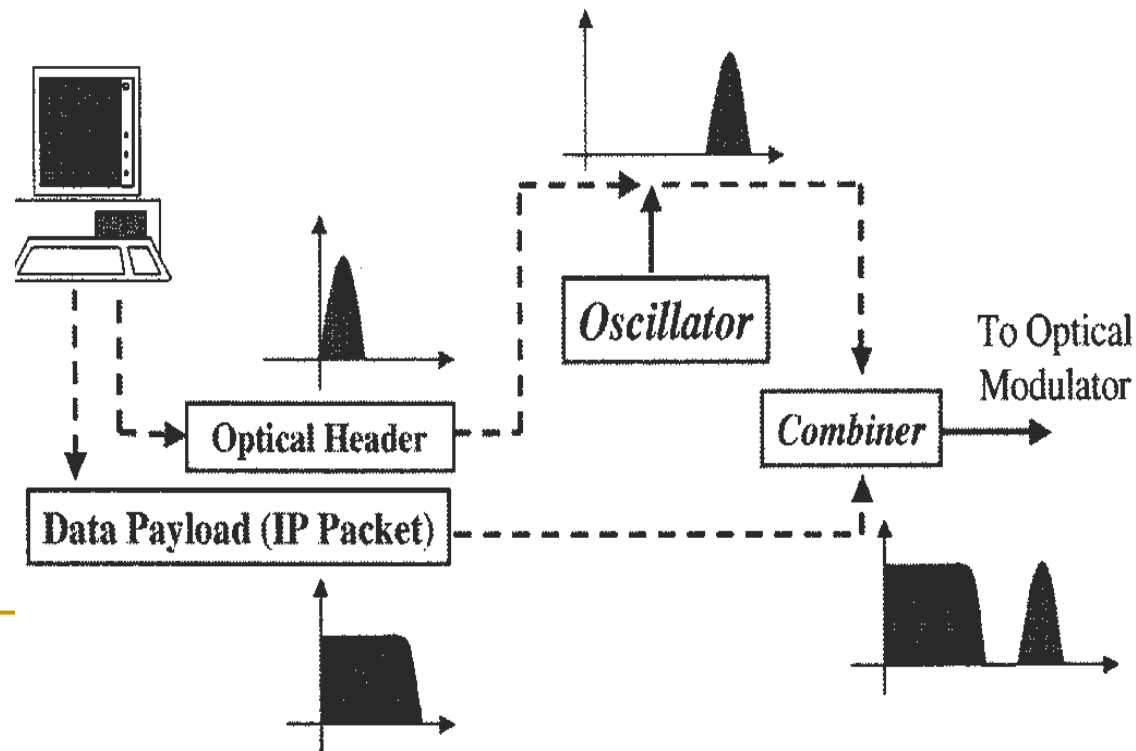
Architecture of OLS

- *Interoperability*
- *Transparency to Data*
- *Flexible granularity*

Elements of OLS networks

- **Edge Router**
  - Transmitting Node:
    - Append optical label @ subcarrier frequency
    - Conversion to Optical Signal
  - Receiving Node
    - Remove optical Label
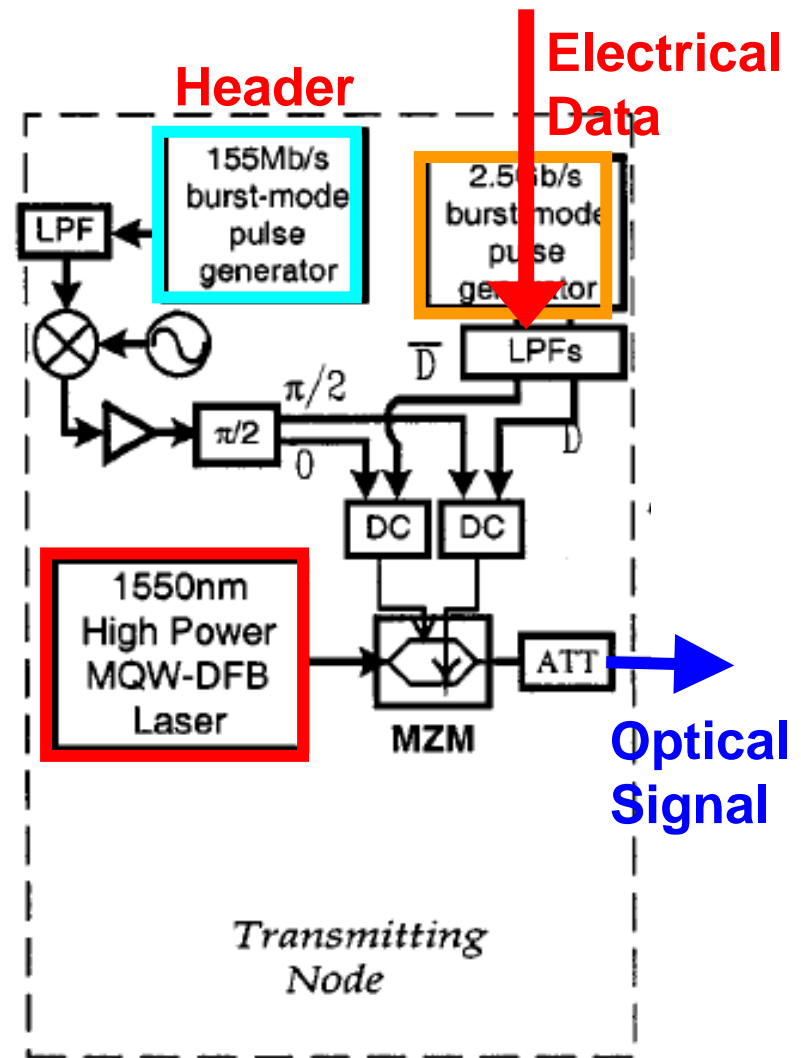   - Conversion back to Electrical Signal
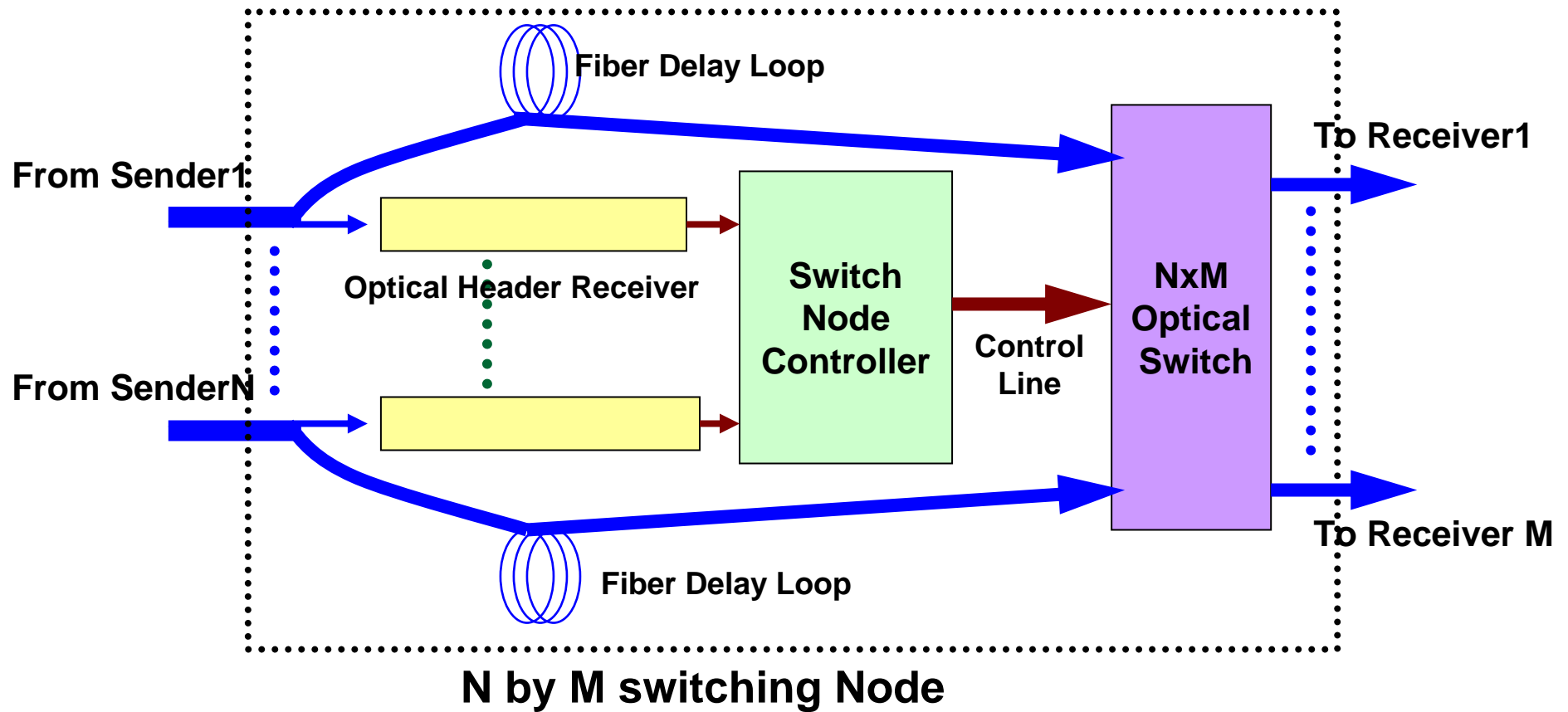- **Core Router**
  - Perform the Switching

Transmitting Node

- DFB Laser Source
- Modulation Signal
  - Data @higher Bit Rate
  - Header @lower Bit Rate
- Output
  - Modulated Optical Signal

Core Router

- Switching node Architecture
- Senders/Receivers can be on different wavelength

Fiber Delay Loop

From Sender1

Optical Header Receiver

From SenderN

Switch Node Controller

Control Line

NxM Optical Switch

To Receiver1

To Receiver M

Fiber Delay Loop

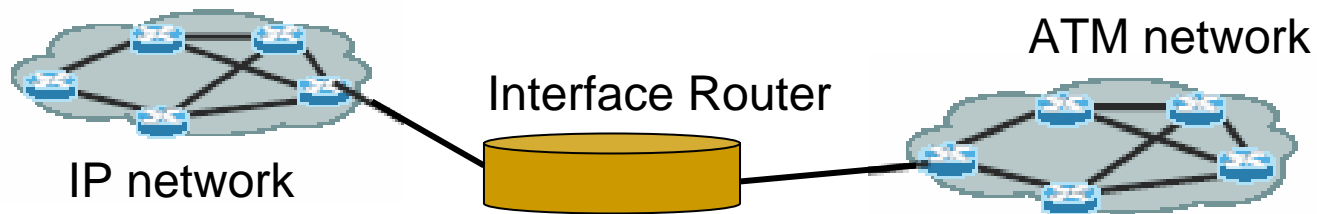**N by M switching Node**

Switch Node Controller

- **Network Control Units**
  - Communicate with other nodes / update Forwarding Table
- **Forwarding units**
  - Header Buffer: One per wavelength
  - Forwarding table Interface: Obtain Address Info
 - Priority Control and Decision
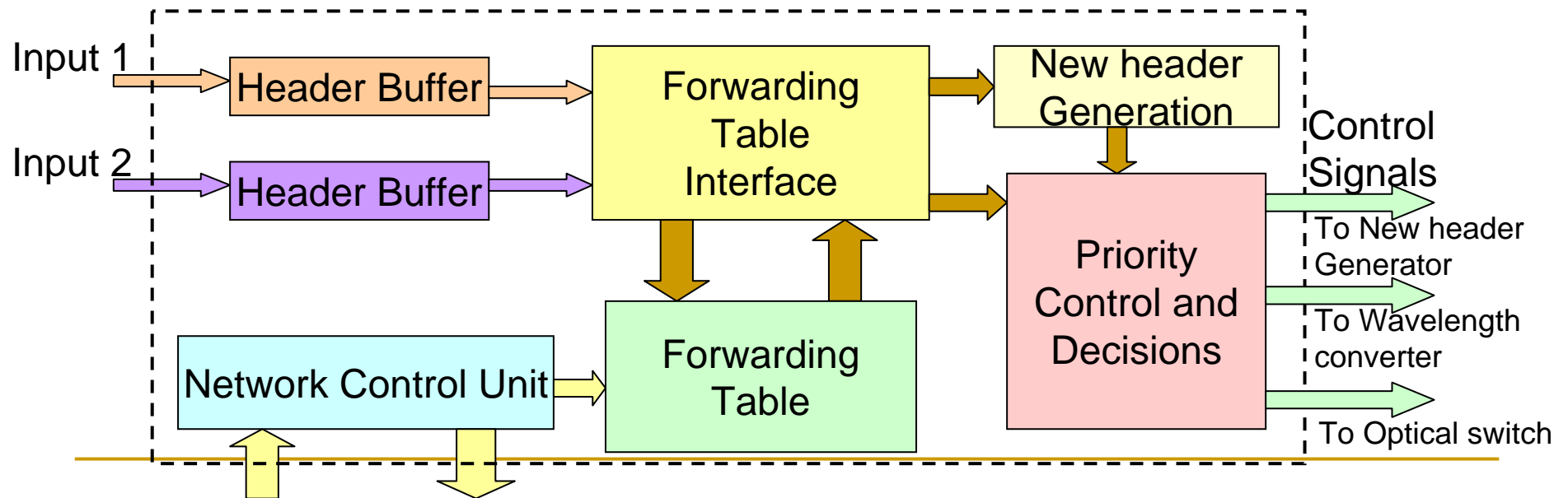
Label Swapping

- In Electrical Packet switching, headers may be modified as passing a switch
  - The TTL (time to live) bits in the IP header to prevent a packet looping in the network forever
  - Interfacing between one type of network to another

ATM network

Interface Router

IP network

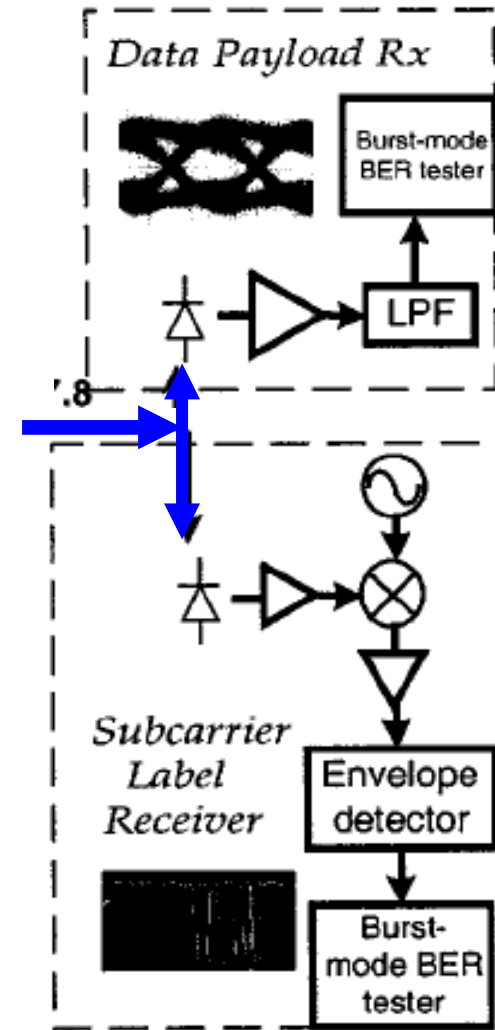- Require the optical label to be writable/rewritable
  - Modify the switching node
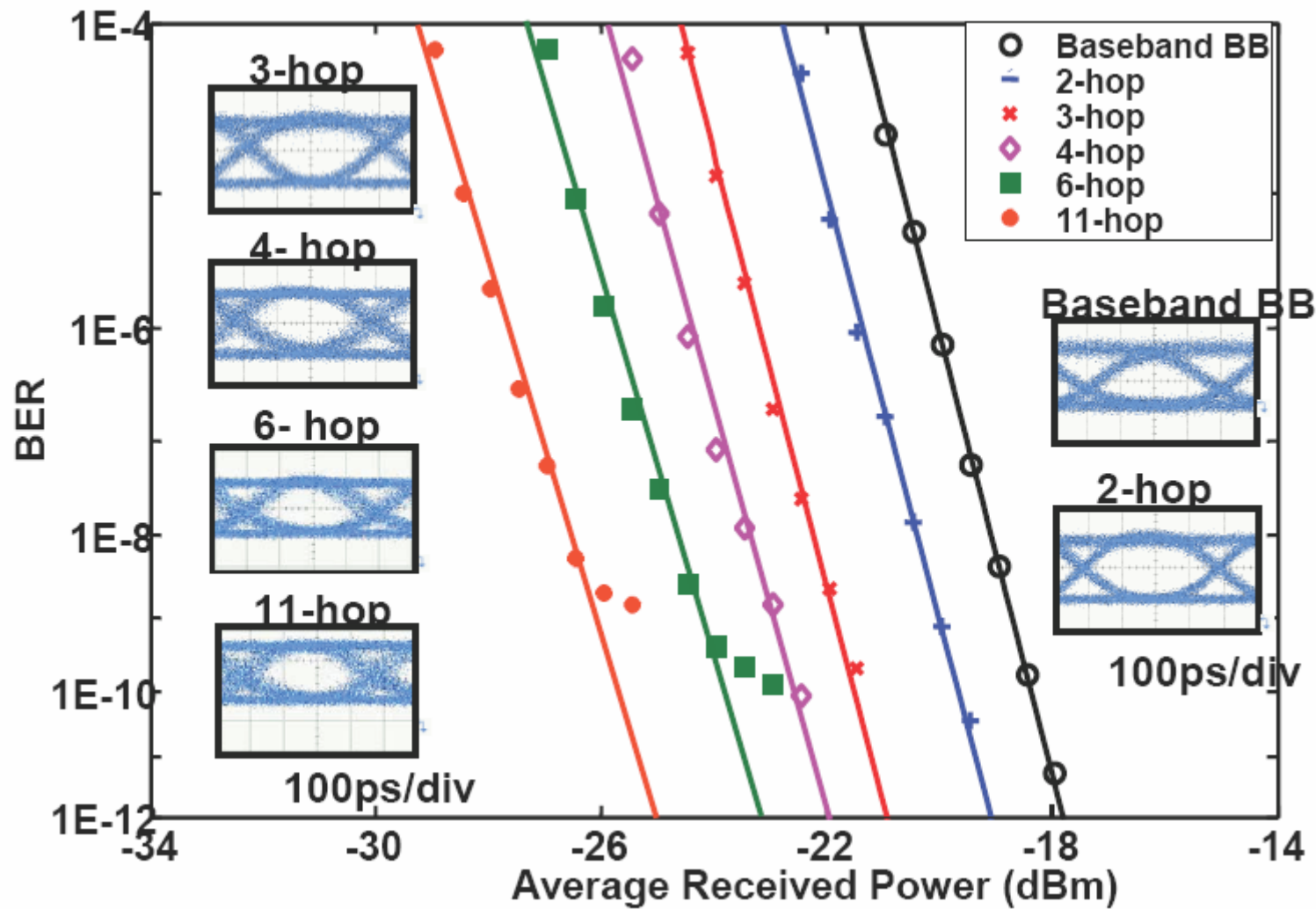 - Add a label writer

Label Rewriter Details
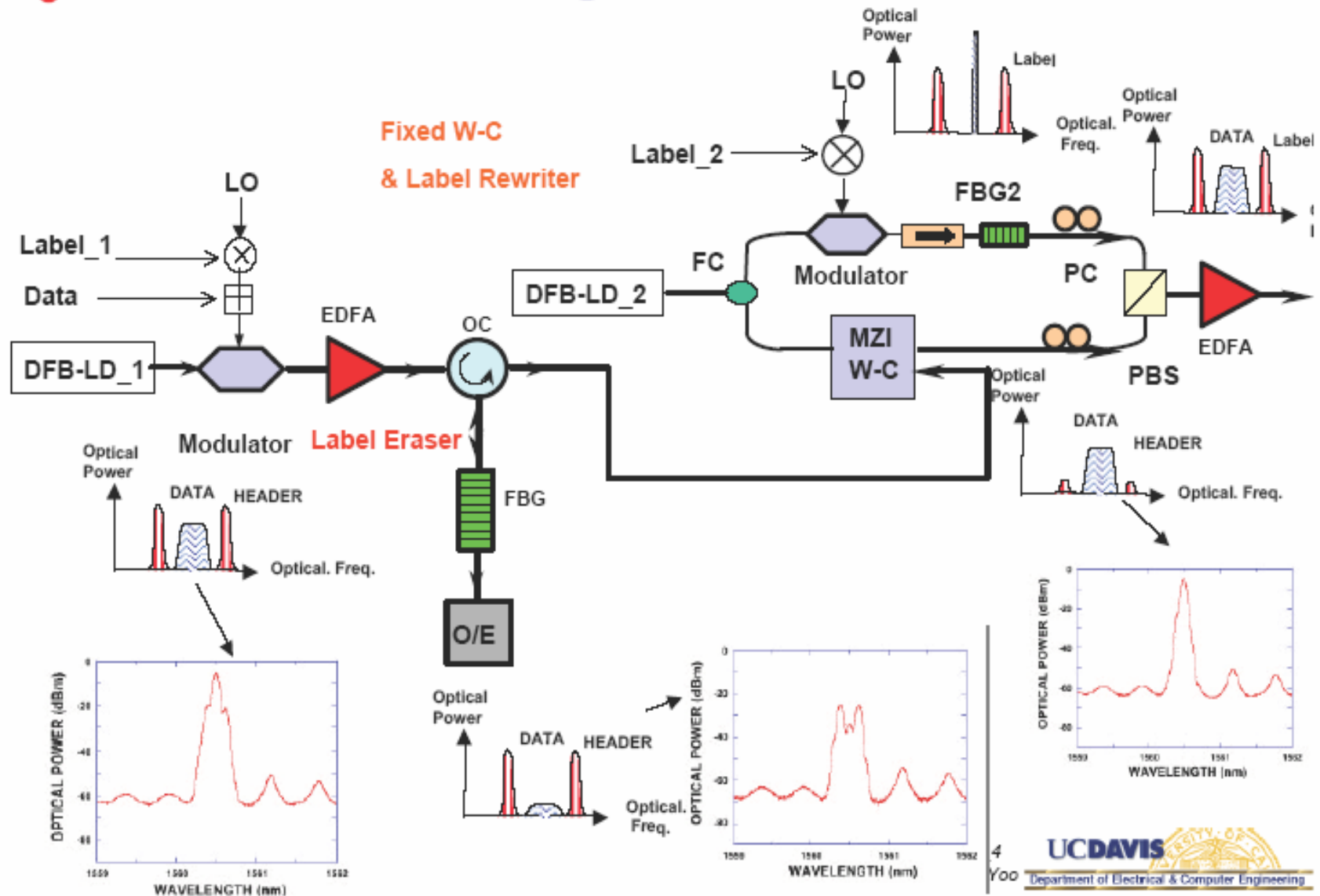
Receiving Node

- ## Data payload Receiver
  - Photo detector
  - Amplifier & LPF

- ## Subcarrier/header Receiver
  - Homodyne Detection

BER test of cascaded OLS Router

Network Features of OLS

- **All-optical** between end stations
  - Once a packet leaves a host computer, it sees one long fiber
- Header is **decoupled** from the data payload
  - They can be in **different bit rate**
  - Payload may not be digitally encoded
- Packet on a given path experiences the **same delay**
- When a packet is **blocked** at a given node, it can be routed at **a different path** or **dropped**
  - Timing consideration
- **Contention control** by **wavelength deflection**
  - When packets from **multiple users** arrive at **a switch node** at the **same time**, **contention** happens
  - Can route a packet to a different, less loaded wavelength

Social/Economic Impacts of OLS

- Bridging the Gap between the IP protocol and WDM at the edge of the network

- Replace the existing ring topology in MAN with optical switching

- Foundation for next-generation service provider
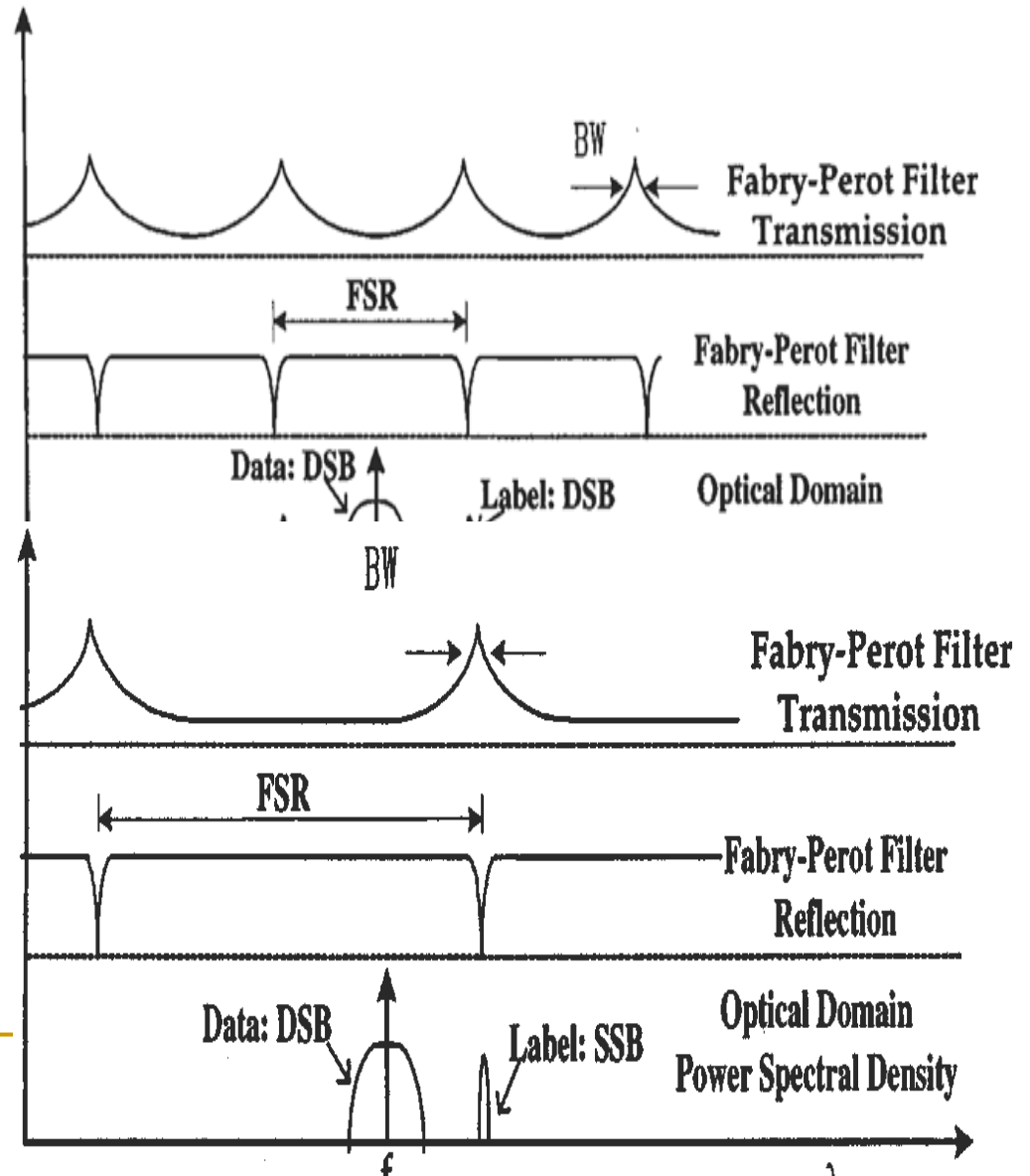 - All optical network
  - Fast
  - Simple to manage

Summary

- **Electrical packet switching is not compatible with optical transmission**
- **Optical label packet switching**
  - Avoid OEO conversion
  - Compatible with various network layer protocols
    - Optical label swapping
  - Compatible with WDM
  - Multi-dimensional contention solution
  - Increased complexity

Optical single side band (OSSB)

- **Double Side band labels**
  - Harder to Erase by Fiber Fabry-Perot Filter
  - Requires matching FSR AND
  - Requires the notch filter to have a sharp and narrow notch

- **Single Side band Labels**

BW

Fabry-Perot Filter Transmission

FSR

Fabry-Perot Filter Reflection

Data: DSB   Label: DSB   Optical Domain

BW

Fabry-Perot Filter Transmission

FSR

Fabry-Perot Filter Reflection

Data: DSB   Label: SSB   Optical Domain Power Spectral Density

Spectra in optical label swapping

- Spectra (a) before and (b) after the OSSB subcarrier label is suppressed.
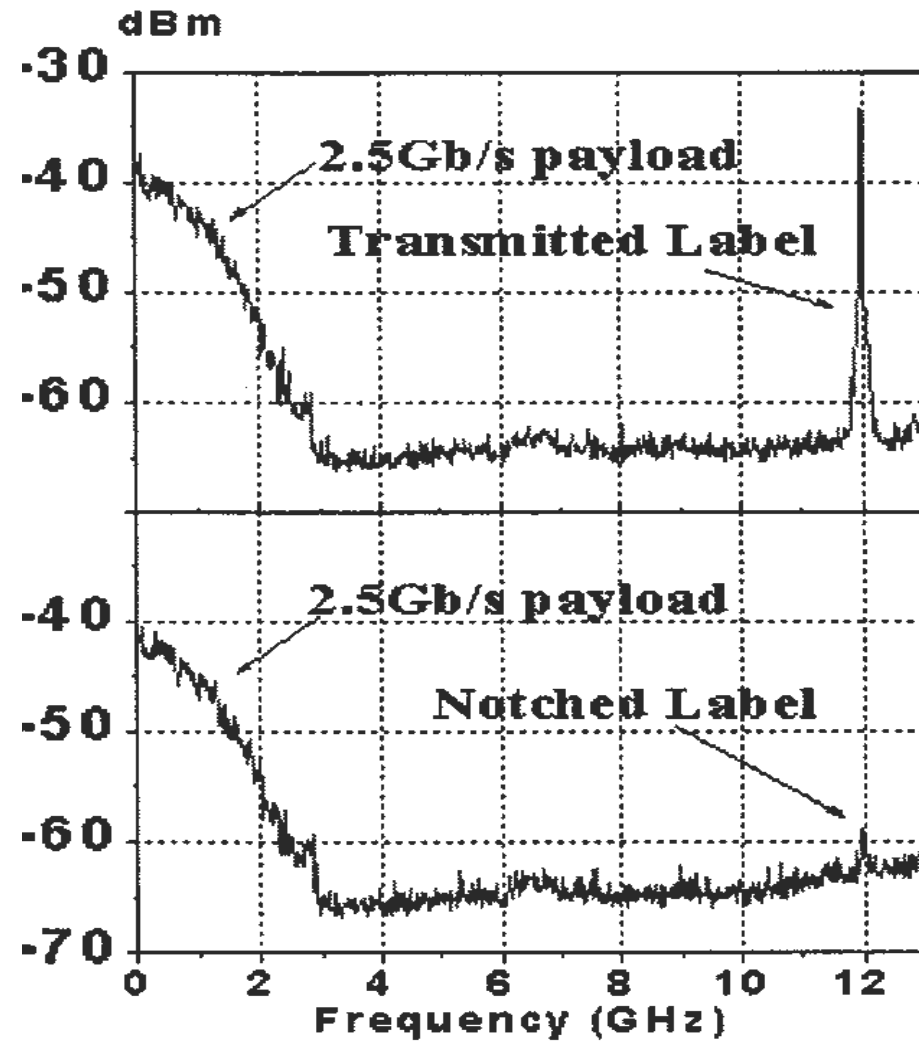
Extension to Multi wavelength/protocol