Latest Advances in Optical Transport for Research and Education Networks

Jim Theodoras
100G Coherent & Metro
100G Standards Coverage

IEEE 802.3ba

Cabling

Access

Metro

LH

OIF

100GBASE-CR10 10m

100GBASE-SR10 100m

100GBASE-LR4 10km

100GBASE-ER4 40km

OIF 100G ULH DWDM Framework

Normalized

0

100

50

0

10

100

1000

10000

Distance (km)
Agile Core Express 100G+

- **100G+ optimized transport**
  - Coherent Intradyne Detection
  - Superior OSNR performance for increased flexibility and reach
  - No need for dispersion compensation up to 2,500 km
  - Hybrid Raman/EDFA amplification for maximizing OSNR performance
  - Up to 96 ITU-T 50GHz grid channels

Most advanced photonic layer for highest performance and flexibility
There is a gap in standards coverage. 100G Metro fills this gap.
Cost to Transport a 10G Signal

Spectral Efficiency (b/s/Hz)

- 10G: 0.2
- 40G: 0.8
- 100G Coherent: 2.0
- 100G Metro: 0.5 (1.0)

Better spectral efficiency at similar price per 10G
Packet Processing time

![Graph showing the relationship between data rate (Gbit/s) and time to transport packet (nS) for different packet sizes (64 byte, 128 byte, 256 byte, 512 byte, 1024 byte). The graph includes a bar chart for 128 byte packets at data rates of 1g, 10g, and 100g.]
Latencies of Client (?)FP included

- 1g SFP
- 10g XFP/SFP+
- 100g CFP

128 Byte
xFP delay
Lower Layer Encryption
This device changed everything: ExFo “passive non intrusive optical monitoring”

Cladding: 125 µm
Core: 9 µm

Get this device on eBay for $425.00
Fibre optics networks tapping possibilities

Where?
- to get access

Street cabinet
- Splice boxes / cassettes
  - (Outdoor / Inhouse)
- Y-Bridge for service activities

How?
- to get access

Data and protocol analysers
- Coupling device

There are multiple ways to access fiber
Multiple Protocols Transported - They all need security

- transparent to protocol with lowest latency,
- provides unlimited bandwidth and performance
- offers investment protection

› fully Encrypted payload

FULLY ENCRYPTED PAYLOAD AT THE PHYSICAL LAYER
End-to-End Data Transport
Secure End-to-End Data Transport

- Proper key management
- Multiple layers of security
- Intrusion detection
Multiple Layers of Security

Physical layer monitoring
- Power tracking
- Intrusion detection
- OTDR

Encryption
- AES-256
- Authentication
- Diffie-Hellman

Security-hardened software
- RADIUS
- Secure Shell
- SNMPv3

A complete and integrated solution leveraging advanced technology
Control Plane Convergence
How Should I Connect 2 Sites?

Site A

Site B
Packet Optical Networking
Routers and Transport

 › **Management plane integration**
   › Transport NM displays, monitors and manages native router DWDM ports and services
   › Transport NM can partition DWDM network bandwidth “reservation rules” per customer requirements

 › **Data plane integration**
   › OTN and non-OTN DWDM router ports connected directly to DWDM platform without the need for transponders
   › More than 1000km transmission distance demonstrated at 10Gb/s

 › **Control plane integration**
   › MPLS/GMPLS interop enables router user (via CLI) or automated script to create end to end loose paths across the transport network without needing to manually configure the DWDM equipment
Why “Packet Optical” Networking?

- **Service Velocity Leading to New Service Creation**
  - Introduction of new service features / pricing
  - Enabling customers to control their Bandwidth requirements

- **Service Flexibility Leading to CAPEX & OPEX savings**
  - Efficient use of network resources
  - Minimize equipment requirements
    - Transponder elimination and router bypass

- **Service Reliability Leading to Improved Customer Satisfaction**
  - Eliminating the human aspect of bandwidth provisioning
  - Improved multi-layer protection/restoration co-ordination
Dynamic Provisioning Example
Automated BW Provisioning

- Initial path set-up
- JUNOS CLI based connectivity request
- Additional traffic request leading to IP congestion
- Automated additional path setup, balancing traffic, reducing congestion

GMPLS O-LSP
Failed O-LSP
MPLS LSP
Protection and Restoration Example (1)

1st Cut

Data Center

Server

Core Router A

Core Router B

DWDM Switch S

DWDM Switch T

DWDM Switch U

DWDM Switch V

DWDM Switch W

Router Y

Router Z

POP

FRR

GMPLS O-LSP

Failed O-LSP

MPLS LSP
Protection and Restoration Example (2)
Inactive Back-Up Established
Protection and Restoration Example (3)

2\textsuperscript{nd} Cut

[Diagram showing network topology with various components like Data Center, Core Router A, Core Router B, Server, DWDM Switches, FRR, Router Y, Router Z, POP, GMPLS O-LSP, Failed O-LSP, MPLS LSP.]
Thank you

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