400ZR/ZR+ management through automation

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Agenda

- Coherent Landscape
- Managing coherent optical
- Why automate IP/optical control?
- Typical use cases
The 400ZR Landscape
400G ZR/ZR+: The advent of pluggable coherent optics

- Industry standard OIF 400ZR with multiple vendors targeting introduce products in mid-2021
- Same form-factor as short-reach 400GE optics
- Integration in routers without compromising I/O density
- 7 nm silicon CMOS enabling low-power DSPs
- Allows for coherent 400G WDM in QSFP-DD/OSFP
- Reduces cost/space/power of WDM system elements
- Trade-off in terms of spectral efficiency and reach versus highest-performance, non-pluggable coherent optics

400G ZR/ZR+ will enable coherent WDM in standard router ports
400GE TCO modeling study
Metro-regional applications

Objectives
• Evaluate IP aggregation in access/metro networks
• Cost/benefit of using ROADMs and wave routing
• Evaluate different ring sizes and traffic volumes
• Quantify 400GE port count, router capacity and power consumption

Assumptions
• Hub-and-spoke IP aggregation with distributed access routers connecting to a centralized hub
• Ring size: From 3 to 8 access nodes per ring
• Traffic: From 50 to 800 Gb/s per access node
• Full traffic protection against a single fiber cut
• Optical line systems with or without ROADM
• ZR++ 0dBm pluggables
Scenarios and assumptions

**400ZR+ with ROADM**s

- **A3 West**
  - Transit traffic: A1 - A2, A4 - A8
  - Add/drop
- **A3 East**
  - FOADM + ILA

**400ZR without ROADM**s

- **A3**
  - Σ (A3 - A8) west
  - Σ (A1 - A3) east
  - FOADM + ILA

**L1/L2 ring topology with ROADM bypass**

**L3 ring topology (no ROADM)**

- Hop-by-hop IP aggregation
- All ports at 400G/16QAM

**Access node detail**
Scaling metro/regional aggregation rings with 400G DCOs

Scaling 400ZR ports with ring size
(800Gb/s ingress traffic per access node)

Scaling 400ZR ports with access traffic
(9 node ring: 8x access + 1 hub)

- 400G port count on hop-by-hop aggregation rings grows linearly with the amount of access nodes
- Hub-and-spoke traffic aggregation using ROADM offers 2 – 5x more capacity efficient than hop-by-hop

- 400G port count and router capacity on hop-by-hop rings grows in lockstep with aggregate access traffic
- Hub-and-spoke traffic aggregation using ROADM offers efficient and independent capacity scaling
Application-optimized IP-optical networks
Metro core use case

Routers with pluggable 400G DCOs + optimized bypass = efficient IP-optical
Power consumption of packet transport through routers versus ROADMIs.

Wavelength routing saves up to 100 Watt per router hop per 400Gb flow.

**IP routing:** >100 watts/400G

- IP Fabric: 0.15W/Gb
- Coherent optics (400ZR+): 20W/DCO
- Optical Line System: ~4W/lambda

**Wave routing:** 4 watts/400G

Using ROADMIs to optimize IP transport in ring topologies is up to 70% more power efficient.
Managing coherent optical
**400ZR: network management gradient**

Increased complexity = Increased need for automation

- **SR/LR grey optics:** Up to 10 km
- **ZR unamplified:** 40 km
- **ZR DWDM Amplified:** 120 km
- **ZR+ DWDM Amplified + OCM:** 400 km
- **ZR+ DWDM Amplified + Raman/DGE/OCM:** 1300 km
- **ZR+ DWDM Amplified + transponder and ROADM**

- Link up
- Channel plan
- Go/no go
- Power ramp
- Active power management
- Dynamic gain equalization
- PCE
Native line control

- **Alien Wavelength** is required on OLS, which is sub-optimal
- **Ok for simple OLS, but as ZR++ is introduced combined management is desirable**

400ZR+ pluggable
End-to-end IP/optical management, coordination and automation
Why automate IP/Optical?
Limitations with today’s IP and optical operations practice

“Lost in translation” syndrome

“Swivel chair” effect

Two separate teams using different tools

One person using different tools

Operational silos

× Slow processes
× Cost duplication
× Services interruption

Better coordination can improve operational efficiency and network availability
Cross domain control

**Issues**
- Lack of real-time IP-optical cross-layer insights can lead to severe operational issues, including unpredictable failure impacts and suboptimal performance
- Impact of optical layer operations (maintenance, restoration and protection) on IP layer

**Solution**
- Gain full control over the optical topology
- Use shared risk link group (SRLG) constraints and optical latency for network optimization

**Benefits**
- Improve network resiliency
- Enable latency-sensitive IP services
- Enhance troubleshooting through alarm correlation
IP/Optical use cases

- Topology discovery
- Cross-domain connection management
- Optical aware IP routing
- Cost-effective multilayer protection
- Diversity analysis
- Coordinated assurance and troubleshooting
- Elastic IP/optical bandwidth
- Coordinated operations control
400ZR Use cases
Various architectures, different solutions

Point-to-point

Hop-by-hop network wide

Management Automation SDN Control

Hybrid Models with IP/Optical Bypasses
Use cases and building blocks

1. **Router-to-Router**
   - Fiber z<40 km
   - IP Controller

2. **Access/Metro Network Operation**
   - Fiber <120 km
   - Amp
   - IP Controller mostly
   - Optical Controller (if needed)

3. **Regional / Long-haul Line system**
   - Fiber Direct <40 km
   - Amp
   - Multi-domain Controller
   - Optical Controller
   - Optical Network Planning

Note: IP/Optical controllers include management and operations functions such as network supervision, assurance, configuration, commissioning, etc.
Hybrid scenario with bypass tunnels

Intent = "Establish 400G connection/service between San Francisco & New York"
Issues to overcome
Challenges and solutions

• No one size fits all solution: depends on the network architecture selected and the level of integration required with existing deployments)

• The challenge of overcoming separate IP, Optical operational teams and who end up managing the ZR/+ plugs on the router (IP or Optical)

• Need to factor in MV both at IP level (router) and Optical network level but also at the supplier level of the 400ZR+ pluggables and ensure standard-based interoperability

• Cross-domain controllers can help manage the complexity through intent-based provisioning in hybrid and MV environments in addition to the multi-layer IP/Optical capabilities
References

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- https://openzrplus.org