Evolution of IP/Optical Integrated networks

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AGENDA

1. Introduction
2. Data Plane
3. Management Plane
4. Control Plane
5. Summary
IP-Optical Integration Market Drivers

**OPTIMIZE RESOURCES**
- IP routing and optical transport offer complementary strengths
  - IP/Optical integration optimizes multi-layer network synergies
  - Optimize network utilization to sustain profitable traffic growth
  - Traditional separate areas of the operator
  - Over provisioning links for resiliency up to 25%

**STREAMLINE OPERATIONS**
- IP routing and optical transport are functionally interdependent
  - IP/optical integration removes operational management barriers
  - Integrate and automate operations across IP routing and transport
  - Separate teams

**SDN/CLOUD PROGRAMMABILITY**
- Optical transport technologies have become far more agile and intelligent
  - IP/Optical integration enables dynamic, unified and programmable control
  - On-demand Cloud services and dynamic resource management
  - Demo in equipment room

Better resource utilization, streamlined operations, innovative and elastic services
Data Plane Integration
Integrating routing and transport technology to minimize interfacing and forwarding cost.

- Tunable router optics
- Integrated Packet Transport
- L2-L3 1830

Optical Extension Shelf

Control Plane Integration
Unified multi-layer control plane to efficiently coordinate operations across network layers.

- GMPLS control plane - integrated with IP MPLS
- SDN control interfaces (OF, PCE, Path Computation)
- Agile Optical Network (DWDM and OTN)
- Edge Router ROADM
- IP-Optical Integration

Management Plane Integration

Seamless network visibility, provisioning and troubleshooting across IP and optical domains single pane of glass.
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**IP Optical Data Plane Integration - R13**

Converged management and control for streamlined operations

- **IP**
  - 7x50 SR
  - IPoDWDM

- **IP with DWDM - transponders**
  - IP with OES
    - L2-L3 Packet blades - Optical Transport

- **Optical**
  - 1830 PSS

Best in class IP and optical technology

Use existing 7x50 CLI to config
10GE/100GE DWDM Pluggable IPoDWDM Solutions for 7x50

- **10GE SFP+ low-power**
  - Previously XFP form factor
  - Tunable across full C-band
  - MSA compliant DWDM pluggable
  - **Supported within all SFP+ based C-XMA/XMA’s**
    - High-density 10GE IPoDWDM solution
  - Reach up to ~80km

- **100GE CFP**
  - 100G Coherent Tunable DWDM CFP - pluggable
  - Supported in SR/XRS systems on CFP based cards
  - Built in OTU4 framer
  - Reach up to ~80km

Q1 2016

2H 2015
400G IPoDWDM for 7950 XRS, 7750 SR-12e
Industry 1st - clear channel with FP3

- 1 port 400G clear channel line card for 7950 XRS and 7750 SR-12e
- Integrated coherent DWDM optics for metro reach applications (60 km unamplified, ~600 km with ILA)
- Powered by Alcatel-Lucent’s proven 400G FP3 silicon. Deployable on existing hardware platforms
- Saves on optical transponders and DWDM transport. Integrated routing & transport OAM

4x link speed to efficiently transport video and big data traffic
Addressing Higher IPoDWDM Connectivity Needs

**ISSUES ADDRESSED**
- Tunable optics for routers are costly and have low port density
- Router optics typically trail transport optics in evolution
- CFP2-CFP4 example

OES connects using standard gray router optics (!)
- Low cost interface solution without impacting port density
- Transport OAM visibility via OES control port
- Configured with SR-OS

Leverages the 1830 PSS platform as OES
- Benefits from using state-of-the-art optics
- Scales by connecting multiple OES shelves
- Fully managed by router through OES control interface with CLI

Optical extension shelves offer better scalability in high density IPoDWDM scenarios than integrated transponders
Integrated Resource Management Under SROS Router and OES Operate as a Single Logical NE

Correlation of optical paths with router interfaces

- Propagate transport error information back to router
- “show port a” on the router displays information about a, p and p’ (with same consistent port state model)

Access OES configuration and status via SROS CLI

```
*A:bksim3107# show card
```

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<th>Slot</th>
<th>Provisioned Type</th>
<th>Admin Operational Type</th>
<th>Equipped Type (if different)</th>
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Router Port OES Port

- a Chassis X, port p
- b Chassis X, port r
- c Chassis X, port s
- d Chassis X, port q

1830 (OES)

Router to OES port mapping

SR OS Router

OES Control

transponder

transponder
**Initial OES Deployment Topologies**

**Point to Point link topology**
- Single 100G (130G) wavelength
  - Ultra Long Haul (up to 4000 km)
  - Amplifiers every ~80km (e.g. PSS-4)
  - **Uses existing 1830 cards**

**Single 200G (260G) wavelength**
- Metro reach (up to 1000 km)
- Single carrier multiplexes two 100GE

**Ring topology**
- ILAs for longer distances between sites
- Transponders managed by SR-OS Filters and amps separately

Trials in 2H2015

*Notes for the diagram:*
- 1x100GE
- OES
- RTR
- ILA
- Router
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ASON Domain/GMPLS L1 OTN Management

- Single pane of glass from 5620 SAM instead of PhM and SAM.
- GMPLS node management with CORBA (GMRE) Interface with R13
- GMRE Alarm synchronization/Reporting
- TE Link/DB link/SRG management
- SNC (O-GLSP) discovery, provisioning with BR, GR, PRC, SNCP restoration type
- Control Plane ODU Discovery upon creation of o-GLSP
- In demo area
Visual Insight: Multi layer service map

- Instant view of optical service layers end to end - OTN lambdas and physical path
- Rapidly identify root cause
- See working and protection paths
- Ready for integration with IP service layers
- R14 will include IP services visibility
IP-Optical Alarm Correlation

Link between alarm and root cause

Root cause across IP and Optical domain
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GMPLS UNI Architecture

- Control plane integration between 7x50SR/XRS and 1830PSS
- Standardized protocol set (RFC4208/RFC4204) with standard extensions
- Bind interface on 7x50 to gLSP’s tunnel group - can use any existing protocol on SR
  - R13 - 7x50
  - R8 - 1830

GMPLS over UNI

- LMP manages data bearers and TE links
- Out of Band (from data bearers)
- RSVP-TE
  - Control plane RSVP-TE used to setup gLSP’s across the optical network
- GMPLS Loopback
- NW IF
- B/W 10g-100g Abstracted into TE links
- Transport control with GMPLS
- Data bearer (Port)
- TE Link
- 7750 (UNI-C) client side
- 1830 (UNI-N) network side
Simplified Operation and Maintenance

Issues
- Different groups for IP and Optical
- Operator must inform the IP/MPLS layer of maintenance actions in the optical network
- Operators must manually coordinate connectivity setup across layers - spreadsheets
- Very time consuming and error prone!
- Maintenance coordination

Use cases

Network Maintenance and Monitoring
- Optical network can dynamically notify IP network of maintenance windows
- IP layer can take corrective actions without operator intervention based on local policy

Dynamic connection establishment
- Reduce per-connection transport provisioning
- Transport connection requests may include protection attributes and specific constraints - bandwidth delay, SRLG etc.

RFC 4208 with standardized extensions

Simplified provisioning and maintenance
End-to-end Protection and Redundancy

**ISSUE**
- Routers have no visibility on transport layer protection/redundancy
- What level of protection is being provided to IP layer?
- What are the resiliency requirements of the optical layer?
- Redundant and ineffective protection in routing and optical transport

**GMPLS UNI** reduces the need to provision duplicate optical resources for protection

**Multi-Layer Resiliency**
- Example could be FRR, ECMP in IP layer does not require 1+1 protection in optical layer
- Ensure path diversity in the optical layer using SRLG-aware signalling

**Improved Resiliency to Degradation**
- Optical layer notifies the IP layer when optical signal degrade conditions occur (e.g. FEC errors) instead of waiting on OAM
- Enable IP layer to take appropriate pro-active measures to prevent degraded routed services

**Visibility and configuration into IP and optical layers allow for efficient use of links to support protection and resiliency - each layer no longer needs independent protection**
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**Optical Segment Recovery**

**ISSUE**
- 1+1 self-healing protection is costly and only protects against a single failure

**OPERATION**
- Resources in the optical layer are visible to IP therefore you may not need additional IP protection, FRR, ECMP etc
- The IP layer requests SRLG-diverse optical segments with restoration capability, paths are diverse
- If an optical segment fails the transport layer will automatically recover it and notify the IP layer when optical degradation is not necessarily detected by OAM
- Only a fraction of resources must be reserved to backup working segments (1:N)

GMPLS has recovery schemes such as source based reroute which will reestablish gLSP using different path upon optical layer failure.

Optical segment protection with GMPLS dynamic restoration offers better resource utilization and multi-failure recovery.

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draft-ietf-teas-rsvp-te-srlg-collect-00  RFC4873
End-to-End gLSP Restoration - between routers

ISSUE
- 1+1 self-healing protection is costly and only protects against a single failure
- Over provisioning of resources between IP and Optical networks

OPERATION
- The routers are requesting end to end protection across transport - source based reroute SBR
- After notification the router tears down the gLSP, reroutes the path (no guaranteed backup)
- The IP layer requests SRLG-diverse paths using unprotected optical segments
- However, the Optical layer keeps additional segments in reserve (1:N)
- If a segment fails, the IP layer is notified and restores gLSP which is routed via an unused segment

GMPLS UNI signalling
- Protection Type, SRLG
- Constraints (BW/Latency)

Efficient use of optical resources with restoration by the routers

draft-ietf-teas-rsvp-te-srlg-collect-00  RFC4872
End-to-End 1:N protection - provides guaranteed backup

**ISSUE**
- 1+1 link protection is not effective with LAG/ECMP

**OPERATION**
- Committed backup resources waiting to be used by a group of protected gLSPs
- A single backup gLSP protects N gLSPs with N IP interfaces between 2 routers
  - If a gLSP fails, its IP interfaces are moved to the backup gLSP
  - If the failed gLSP is restored, the IP interfaces are reverted back

In case of gLSP failure, the interface is moved to pre-provisioned gLSP.

Efficient protection for N x gLSPs without lighting up a new lambda for a backup gLSP or disturbing the IP/MPLS layer

RFC 4872

draft-ietf-teas-rsvp-te-srlg-collect-00
End-to-End N+1 Load Sharing Protection

**ISSUE**
- 1+1 link protection is not effective with LAG/ECMP

**OPERATION**
- A single IP interface is load shared across N gLSPs
- GMPLS can emulate a LAG
- Operates in similar manner to static LAG, gLSP failure results in load pickup by other members of tunnel group
- Customers can grow bandwidth incrementally without disturbing the IP layer or adding IP layer resources (e.g. more interfaces)

Efficient protection for N x gLSP tunnel group without IP-layer re-
draft-ietf-teas-rsvp-te-srlg-collect-00
Router Port Protection to Optical Cross Connect with GMPLS UNI Floating Backup

**ISSUE**
- Router ports require back-up port for each destination
- Rapidly consumes ports in larger meshed networks

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<tr>
<th>Dest</th>
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Floating Backup port protection
- 1:N port sparing between router and transport
- gLSP segment in standby for backup
- IP interface is moved to spare port - used for any destination
- RSVP controlled link protection across GMPLS UNI
- Efficient protection eliminates 1:1 port sparing

Efficient 1:N port protection across multiple far end routers, rather than just between a given pair of routers.
Quantifying Benefits of Multi-Layer Resiliency
Bell Labs Study - CAPEX

Present Mode of Operation
- Routing layer protection
- MPLS recovery schemes
- 99.999% availability

Future Mode of Operation 1
- Photonic layer protection
- GMPLS recovery schemes
- 99.999% availability

Future Mode of Operation 2
- Multi-layer protection
- MPLS + GMPLS with UNI
- 99.999% availability

Five optical cross connects and six routers using 100g links
Bell Labs study - Savings with IP-Optical Integration

Present Mode of Operation
- Routing layer protection
- MPLS recovery schemes
- 99.999% availability

Future Mode of Operation 1
- Photonic layer protection
- Basic GMPLS recovery schemes
- Break-even in 6 months
- Up to 40% savings over 5Y
- 99.999% availability

Future Mode of Operation 2
- Multi-layer protection
- MPLS + GMPLS with UNI
- 35% immediate cost savings
- Over 40% savings over 5Y
- 99.999% availability

Source: Bell Labs
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GMPLS UNI on Alcatel-Lucent Products

7750 SR7/12/12e, 7950 XRS
ROUTING (UNI-C)
GMPLS CLIENT SIDE
R13

1830 PSS-16/32 DWDM, PSS-36/64 OCS
OPTICAL TRANSPORT (UNI-N)
GMPLS ROUTING ENGINE AND GMPLS
UNI (OTN AND DWDM)
R8
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Summary

Control plane integration between IP and Optical networks helps to break down barriers, enabling more efficient, streamlined operations.

Multi-layer resiliency enabled by a GMPLS UNI can have a significant impact on CAPEX.

GMPLS UNI available from Release 13.0R1 of 7x50 and Release 8.0 of 1830

Please come and see the GMPLS UNI running live in the demo area!
Alcatel-Lucent’s IP-Optical Integration Strategy

- Comprehensive IP/optical integration approach
  - Cross-domain management plane (5620 SAM)
  - Unified multilayer control plane (GMPLS/UNI, SDN/PCE)
  - Converged IP/optical data plane (IPT, IPoDWDM, OES)
- Levering best-in-class IP and optics platforms
  - #2 in IP routing with 650+ deployments
  - #2 in optical transport with 500+ deployments
- Enabling Telco's, MSOs and web scale operators to
  - Control cost per bit to sustain profitable growth
  - Streamline operations to improve service velocity
  - Embrace emerging SDN and Cloud opportunities

A programmable IP Network Fabric with optical cost synergies
Every success has its network