How to Converge IP and Optical: a Deployment Example

Randy Zhang, Principal Architect, Cisco Systems
Agenda

- Introduction
- Journey to IP and Optical Convergence
- A Practical Example
- Conclusion
Introduction
# The Evolution of the Multilayer Network

- **Network Services**: Started with TDM, now IP services predominant
- **Topology**: Ring was a common architecture, now more mesh based
- **Traffic Patterns**: Hub and spoke, now more any to any
- **Network Layers**: Purpose built layers, each with its own lifecycle, now layers are converging
### Economic Value Drives Architectural Change

<table>
<thead>
<tr>
<th>Traditional Architecture</th>
<th>Converged Architecture</th>
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<tbody>
<tr>
<td>• Silos</td>
<td>• Efficiency</td>
</tr>
<tr>
<td>• Complexity</td>
<td>• Simplified operations</td>
</tr>
<tr>
<td>• Limited service agility</td>
<td>• Faster service delivery</td>
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NANOG™
A Converged IP and Optical Network

1. A simplified optical transport with more efficient fiber utilization
2. A common packet transport layer with integrated transponders
3. Private line services delivered over a packet transport
4. End-to-end SDN driven automation
**Types of Convergences**

<table>
<thead>
<tr>
<th>Layer Convergence</th>
<th>Converging layers through Digital Coherent Optics (DCO) in routers</th>
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<tbody>
<tr>
<td>Service Convergence</td>
<td>Converging services to a common packet transport by removing dedicated layers</td>
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<tr>
<td>Topology Convergence</td>
<td>Converging network topologies with greater congruency in IP, photonic, and fiber layers</td>
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<tr>
<td>Management Convergence</td>
<td>Converging network and service orchestration and assurance into a unified view</td>
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<tr>
<td>Operational Convergence</td>
<td>Converging processes to achieve more optimal business results</td>
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</table>
Layer Convergence Example

Present Mode of Operations

Router
Transponders
DWDM

Future Mode of Operations

Router
DWDM
Convergence Benefits

- **Simplified Network Architecture**
  - Lower Cost and Higher Sustainability

- **Optimized Network Lifecycle Management**
  - More Efficient Operations

- **Increased Operational Agility**
  - Faster Time to Value
Journey to IP and Optical Convergence
Building a Convergence Journey

1. Align with business initiatives
2. Identify technology insertion points
3. Develop a set of use cases that fit the business needs
4. Construct a journey with continuous improvement

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Operators Business Drivers

- Bandwidth and capacity expansion
- Network cost reduction
- Network transformation
- Architecture simplification
- Agile service delivery
- Sustainability and circular economy

NANOG
Insertion Points and Use Cases

- **Layer Convergence**
  - Integrate DCO into routers

- **Service Convergence**
  - Migrate OTN to private line emulation

- **Topology Convergence**
  - Deploy segment routing

- **Management Convergence**
  - Architecture redesign

- **Operational Convergence**
  - End to end orchestration and automation
  - Increase operational efficiency
Use Case Based Journey

A hypothetical adoption example (for illustration purpose)
Implement Convergence

1. Select
   Business case and modeling
   Architecture selection
   Use case definition
   PoC testing and assessment

2. Deploy
   Design and implement
   Architecture migration
   Solution validation
   Automation & orchestration

3. Operate
   Technology integration
   Operational transformation
   Workforce upskilling
   Process optimization
A Practical Example
Mapping out a Convergence Journey

Goal of the Journey
What business initiatives is the journey trying to address? What is the starting point (present mode of operation)?

How to Get There
What are the steps to get there? How to align products and services together? What specific business outcomes are achieved at each step?

Target of the Journey
What is the future mode of operation? Does the target align with the goal of the journey?
Journey Example: Starting Point

- **State:** Multidomain network with packet and optical transport at 100G. Transponders are part of the optical transport.
- **Goals:** Simplify network, reduce cost, deliver higher capacity.

*Reconfigurable Optical Add/Drop Multiplexer*
Journey Example: Setting Target

- Converging layers by adding 400G DCO directly into routers
- DCO signals carried over existing transport network as alien wavelengths
- DCO management integrated into the operations

Note: Though 400G is used in this example but the basic principles apply to others
Journey Example: Starting Point

Grey Optics 4x100G

Grey Optics 4x100G

Transponder Chassis

ROADM

Router

4x Fiber Jumpers

Transponder

Fiber Jumper

Outside Plant Fiber

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Journey Example: End Point

Router

1x QDD-400G ZR/ZR+

ROADM

Fiber Jumper

Outside Plant Fiber
Journey Example: Identifying Steps

1. Select
   - 400G readiness assessment

2. Deploy
   - 400G upgrade
   - Transponder to optics

3. Operate
   - Operational update
400G Readiness Assessment

High Level Check List:
1. Understand 400G DCO signal type, spectral width, network requirements
2. Create DCO insertion strategy and channel plan
3. Create a readiness assessment document: routing hardware and software, optics types, optical transport including alien wavelength support, operational environment, tooling and procedures
400G DCO Signals

- 400G ZR with 16 QAM at 59.84 GBaud
- Designed for metro applications

- 400G ZR+ with 16 QAM at 60.14 GBaud
- Also supports 300G, 200G, and 100G on the line side
- Optimized for long reach applications
400G DCO Signal Performance Monitoring Metrics

- Transmit and receive power levels
- Optical signal to noise ratio
- Bit error rate (pre-FEC and post-FEC)
- Q factor
- Q margin
400G DCO Insertion Considerations

• 75 GHz spectral width. The 50 GHz fixed grid filters do not work for 400G signals.

• Ensure interoperability and alien wavelength support from the transport equipment

• Newer generations of DCO have higher launch powers and can be directly integrated along with the existing transponder-based transport
# 400G DCO Insertion Options

## Access Network
- For low cost network with limited space and number of channels
- Typically linear (open ring) or ring

## Point to Point
- Fixed and colored connections
- One or more spans, unamplified or amplified

## Meshed
- Add/drop units can be colored or colorless
- Traffic routing may be directional or directionless
Hybrid Network with Transponders and DCO

- **Mixed**: Both transponders and DCO signals are mixed in the same Add/Drop structure; optical powers already balanced before being inserted into the Add/Drop structure.

- **Separate**: Different Add/Drop structures are used; optical powers are balanced before injected into the wavelength switch.
400G Readiness Assessment Report

- Power, space, and cabling requirements
- Routing hardware and software
- Optical topology
- Optical hardware and software
- Integration needs
- Network management
- Alien wavelength support
- Upgrade and migration
- Operational practices
400G Upgrade Plan

- Define the scope of the upgrade (hardware, software)
- Ask a set of questions:
  - Is 400G readiness assessment done or needed?
  - Is optical line system update needed?
  - Is PoC testing needed?
- Create or review the solution design
- Create the upgrade procedures
Transponder to Optics Migration Plan

1. Network discovery to collect required data for migration preparation and document transponder information
2. Prepare the optical line systems and routers for DCO insertion
3. Ensure readiness of the migration procedure and sites
Operational Considerations

- Clarify organizational ownership for the DCO and align network management tooling and processes with the ownership
- Define the interface and handoff between the routing and optical teams
- Cross training: train IP team on DCO and optical team on alien wavelength support
# DCO Asset Ownership Models

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<tr>
<th>Optical Team</th>
<th>IP Team</th>
<th>Converged Team</th>
</tr>
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<tr>
<td>More suited to existing silo’d models</td>
<td>More suited to an IP centric model</td>
<td>More suited for where both teams are under the same management</td>
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The ownership model may evolve over time.
An Example of Operational Model Evolution

1. Coordinated Operations
2. Accelerated Operations
3. Converged Operations
Considerations for Next Steps

1. Does this journey achieve the original business and technology goals?
2. Is the operational team trained to support the solution?
3. Identify any business needs to continue to drive the convergence journey
4. ... ...
Conclusion
Key Points

• Convergence of IP and Optical brings real business benefits to network operators

• Journey to convergence may take different forms or phases

• Use-case driven deployment brings flexibility
Steps to Implement Convergence

1. Select
2. Deploy
3. Operate
Thank you