How to Converge IP and Optical: a Deployment Example

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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

Traditional Architecture	Converged Architecture
• Silos	• Efficiency
• Complexity	• Simplified operations
• Limited service agility	• Faster service delivery

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

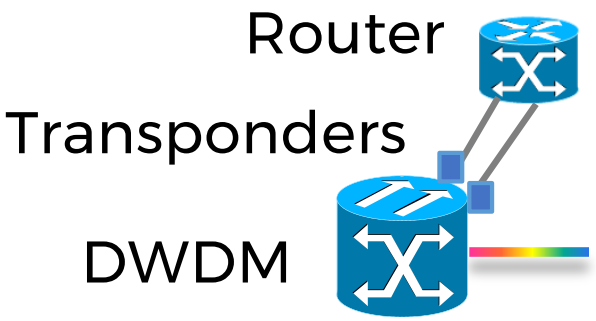
④ End-to-end SDN driven automation

Types of Convergences

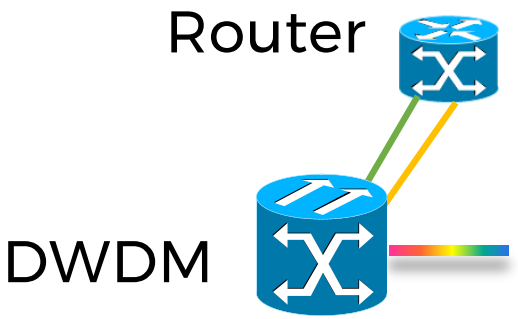
Layer Convergence	Converging layers through Digital Coherent Optics (DCO) in routers
Service Convergence	Converging services to a common packet transport by removing dedicated layers
Topology Convergence	Converging network topologies with greater congruency in IP, photonic, and fiber layers
Management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

Layer Convergence Example

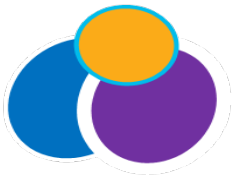
Present Mode of Operations



Future Mode of Operations



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

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Building a Convergence Journey

Align with business initiatives

Identify technology insertion points

Develop a set of use cases that fit the business needs

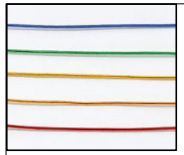
Construct a journey with continuous improvement

Operators Business Drivers

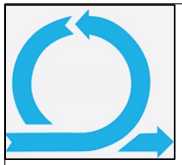
Bandwidth and capacity expansion

Network cost reduction

Network transformation



Architecture simplification



Agile service delivery

Sustainability and circular economy

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Insertion Points and Use Cases

Layer Convergence	Integrate DCO into routers	Architecture redesign
Service Convergence		
Topology Convergence	Migrate OTN to private line emulation	End to end orchestration and automation
Management Convergence		
Operational Convergence	Deploy segment routing	Increase operational efficiency

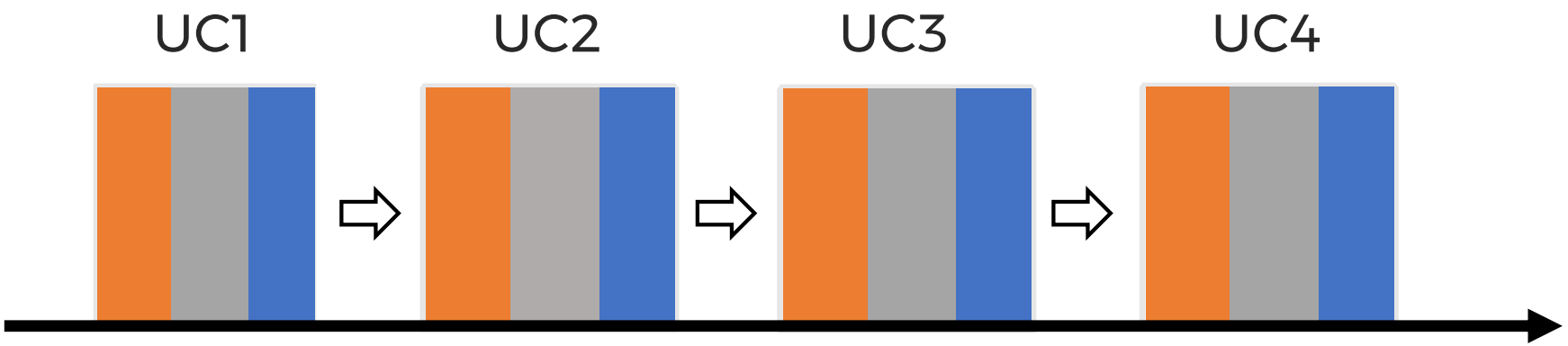
Use Case Based Journey

A hypothetical adoption example (for illustration purpose)

Select

Deploy

Operate



Implement Convergence

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

3. Operate
Technology integration
Operational transformation
Workforce upskilling
Process optimization

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

A Practical Example

Mapping out a Convergence Journey

Goal of the Journey

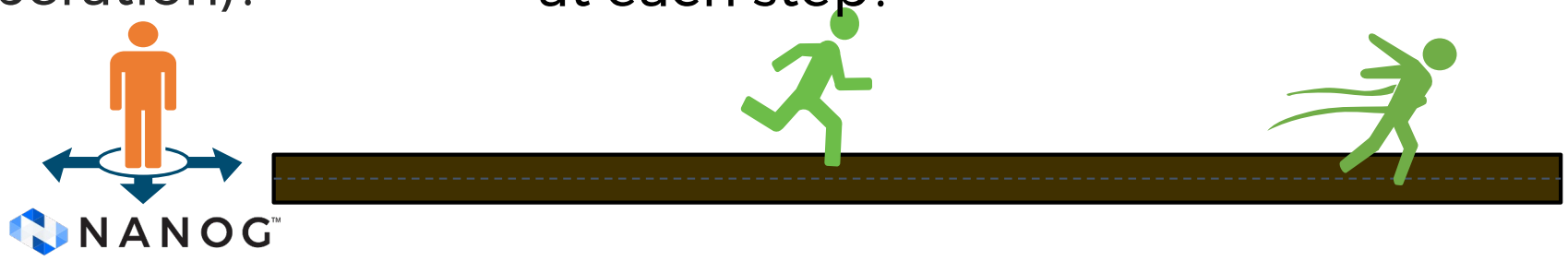
What business initiatives is the journey trying to address? What is the starting point (present mode of operation)?

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

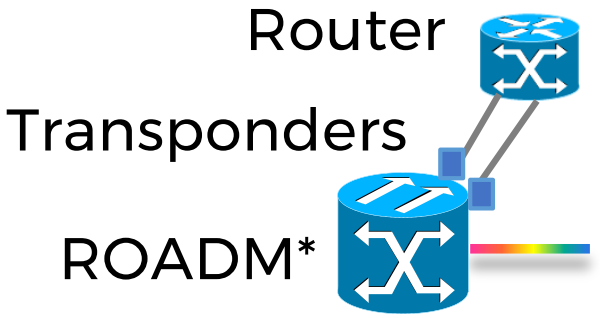
What is the future mode of operation? Does the target align with the goal of the journey



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

Present Mode of Operations

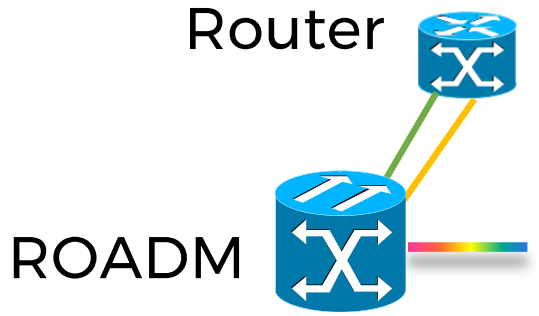


*Reconfigurable Optical Add/Drop Multiplexer

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

Future Mode of Operations



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

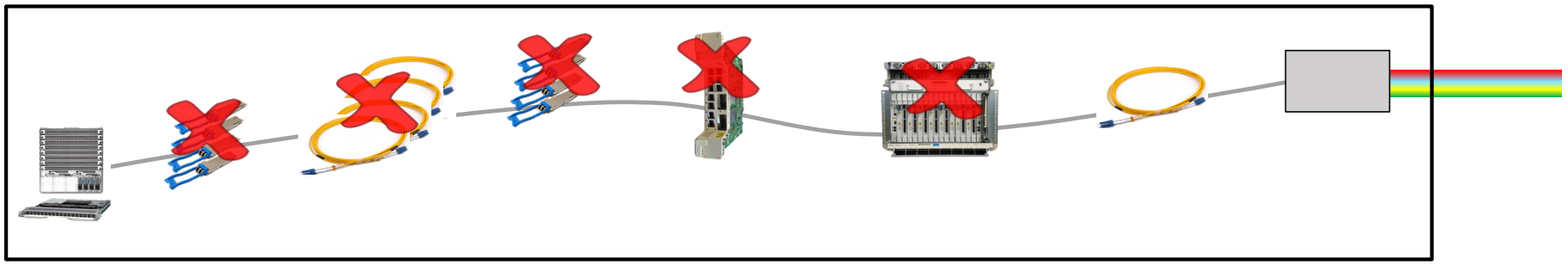
Journey Example: Starting Point

Grey Optics 4x100G

Grey Optics 4x100G

Transponder Chassis

ROADM



Router

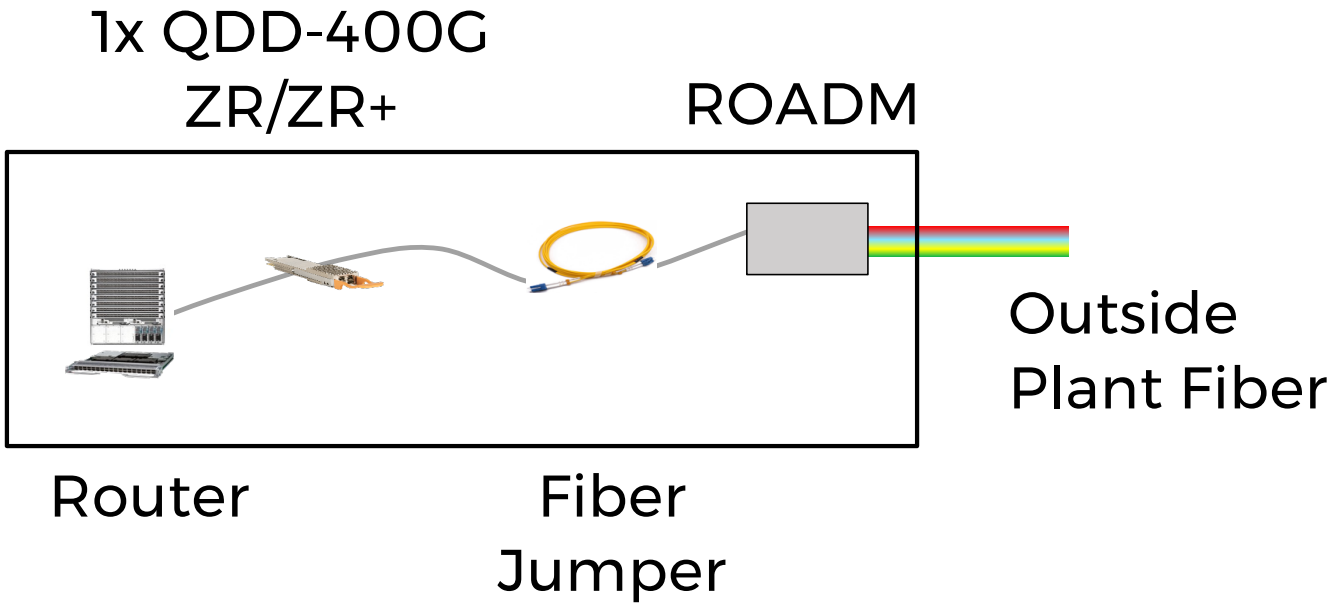
4x Fiber Jumpers

Transponder

Fiber Jumper

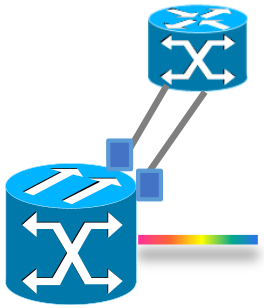
Outside Plant Fiber

Journey Example: End Point



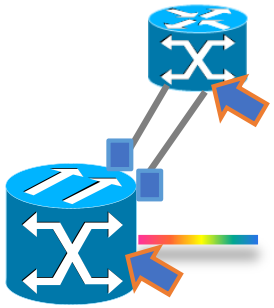
Journey Example: Identifying Steps

1. Select | **2. Deploy** | **3. Operate**



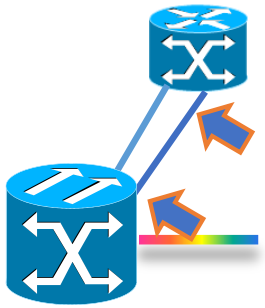
400G readiness assessment

1



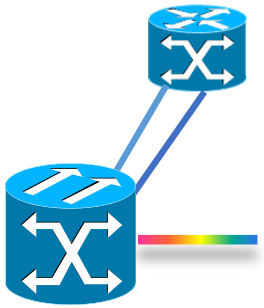
400G upgrade

2



Transponder to optics

3



Operational update

4

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

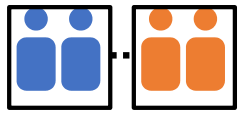
- Clarify organizational ownership for the DCO and align network management tooling and processes with the ownership
- Define the interface and handoff between the routing and optical teams
- Cross training: train IP team on DCO and optical team on alien wavelength support

DCO Asset Ownership Models

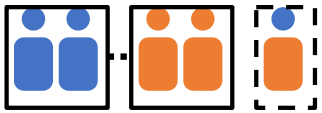
Optical Team	IP Team	Converged Team
More suited to existing silo'd models	More suited to an IP centric model	More suited for where both teams are under the same management

The ownership model may evolve over time

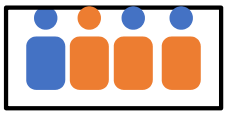
An Example of Operational Model Evolution



1. Coordinated Operations



2. Accelerated Operations



3. Converged Operations

Considerations for Next Steps

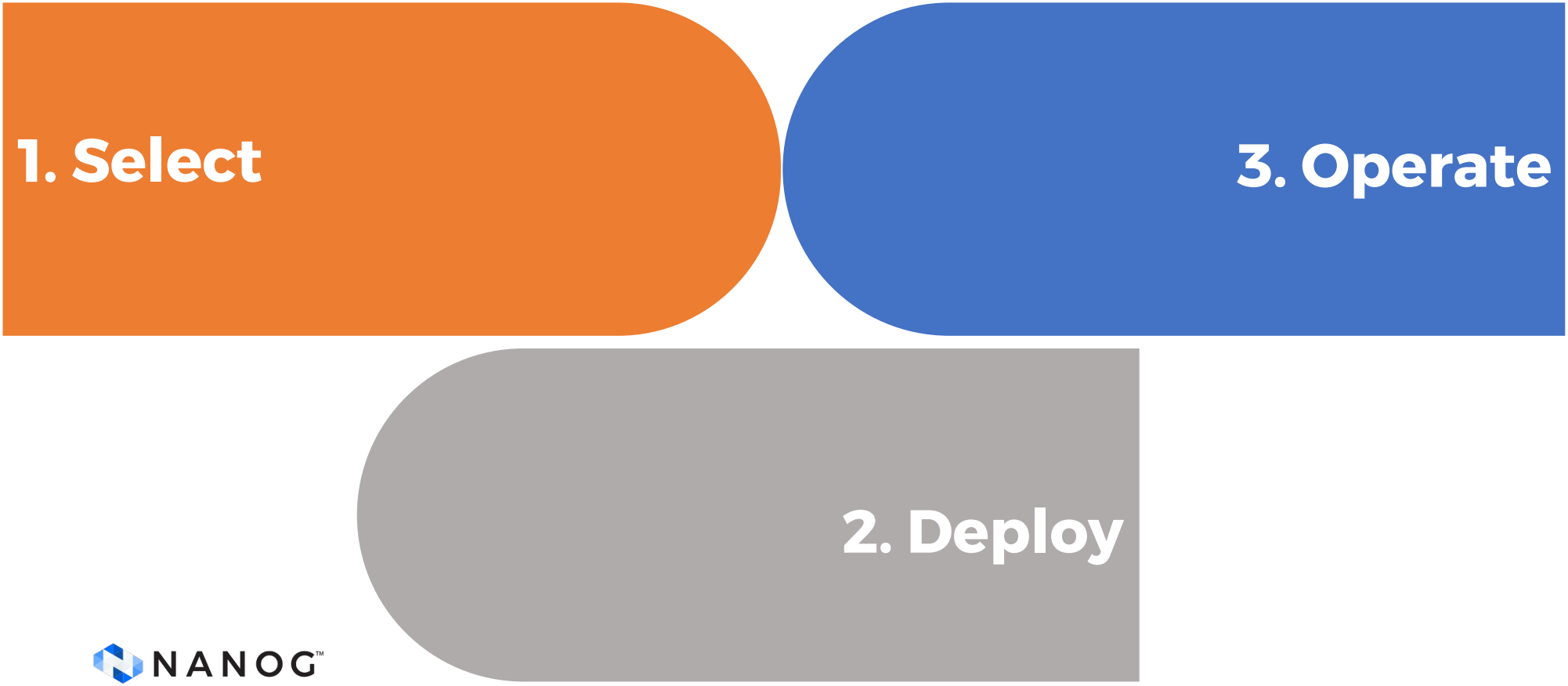
1. Does this journey achieve the original business and technology goals?
2. Is the operational team trained to support the solution?
3. Identify any business needs to continue to drive the convergence journey
4. … …

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



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Thank you

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