The bridge to possible

Routed Optical Networking Deployment Use Cases

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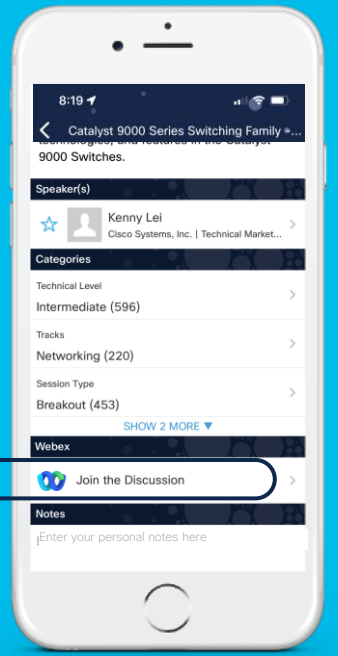
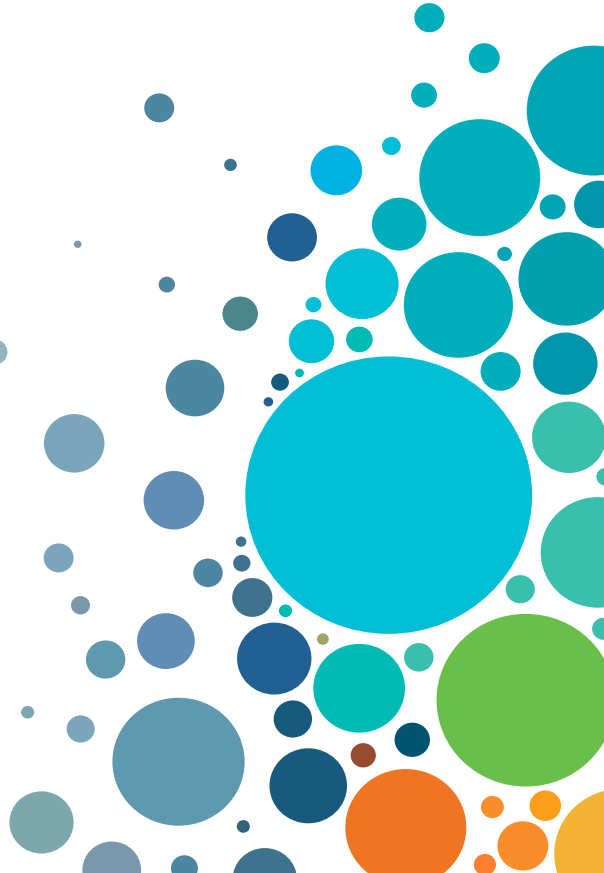


Agenda

- Introduction to the Routed Optical Networking
- Adoption of the Routed Optical Networking
- Deployment Journey Examples
- Conclusion

Introduction to the Routed Optical Networking



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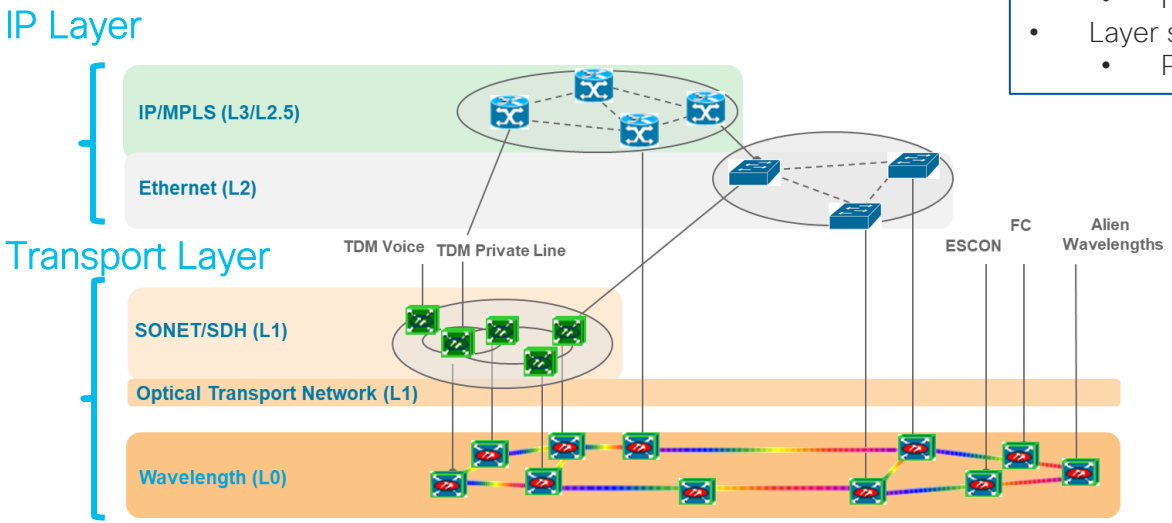
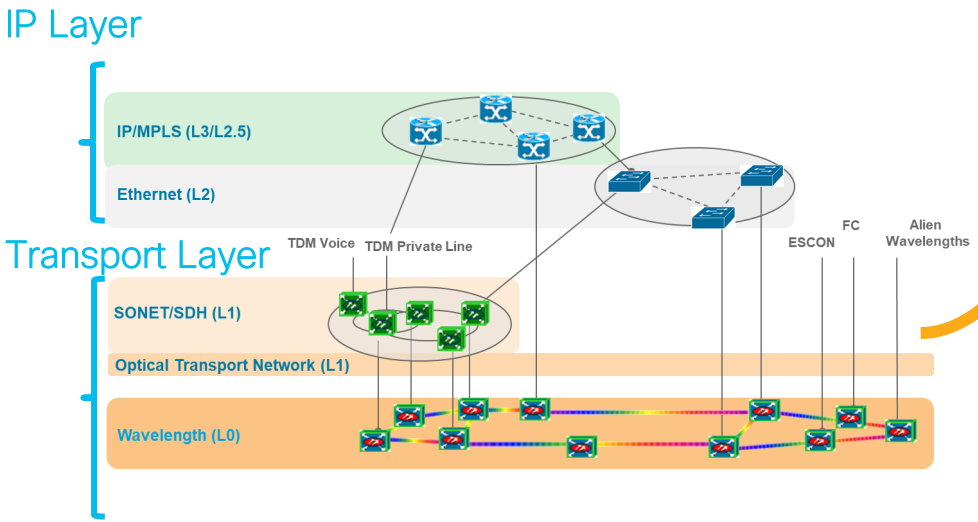
The State of the Multilayer Network

- Network Services:
  - Started with TDM, now IP services predominant
- Topology:
  - Ring based architecture, now more mesh based
- Traffic patterns:
  - Hub and spoke, now more any to any
- Layer silos
  - Purpose built layers, now less layers



From Traditional Multilayer to a Converged Routed Optical Network



4 End-to-end SDN driven automation

3 TDM becomes a service and not transport

Service Layer

Packet Transport Layer

2 Common packet transport layer with integrated transponders for simplified workflow, resource management, and automation

Optical Transport Layer

1 Fiber efficiency layer congruent with packet transport layer

Key Tenents of the Routed Optical Networking Solution

DWDM Optics in Routers

Digital Coherent Optics (DCO) in routers

Standard router line cards and ports without density trade off

Focus on Routers as the switching element with aggregation and statistical multiplexing

Converging Architecture

De-layer the network over simpler DWDM networks

Eliminate dedicated TDM infrastructure with Private Line Emulation

All services carried over a common IP/MPLS transport

Workflow Orchestration

Streamline operations across network lifecycle

Modernize management and automation framework through SDN controllers

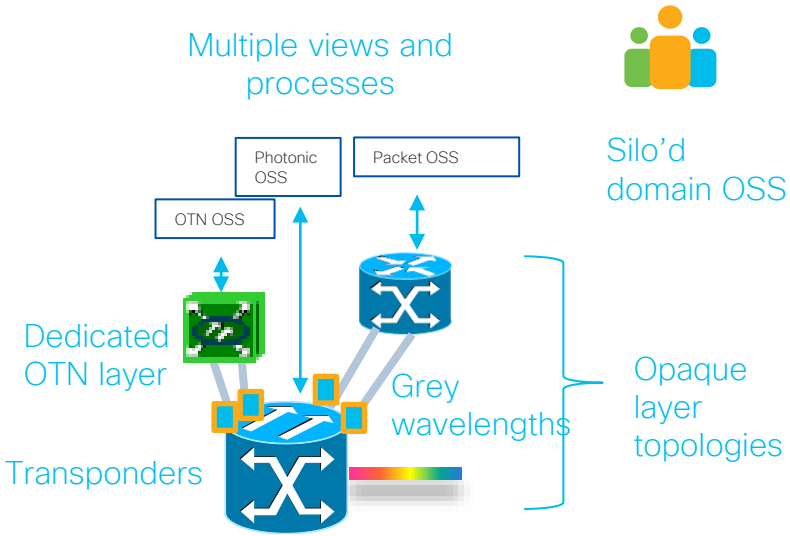
Multivendor and multidomain orchestration and automation

Types of Convergence

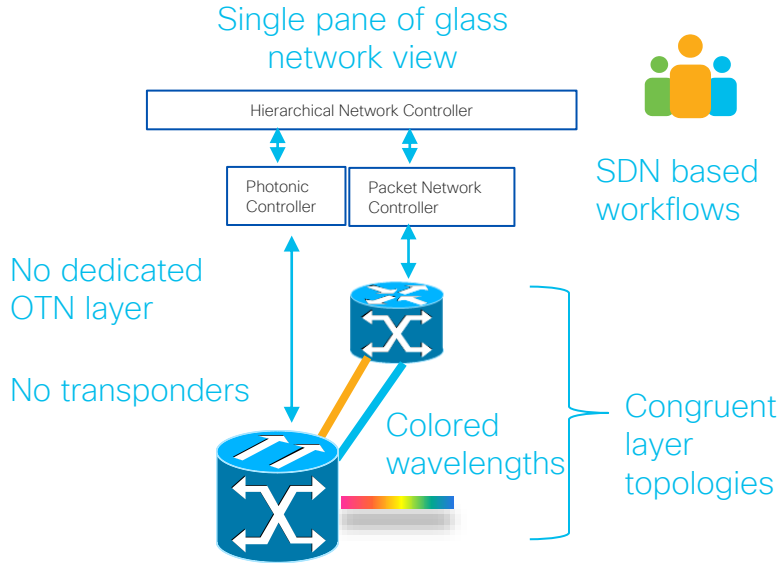
Layer Convergence	Converging layers through Digital Coherent Optics (DCO) in routers
Service Convergence	Converging services to a common packet transport by eliminating dedicated infrastructure
Topology Convergence	Converging network topologies with greater congruency in IP, Photonic, and Fiber layers
Orchestration Convergence	Converging network and service orchestration through hierarchical controllers
Operational Convergence	Converging business processes and organizations to achieve more optimal business results

Components of Convergence

Multilayer Architecture



Converged Architecture*



* This is one view of the Converged Architecture

Business Benefits

Reduced Components

Sustainability and circular economy

- Remove transponders from optical transport
- Remove OTN infrastructure and carry private line service over the converged infrastructure
- Remove proprietary storage protocols and carry storage connections over IP
- Simplify photonic transport

Simplified Operations

Simplified network lifecycle management

- Optimized operating models
- Consolidated network operations center
- Converged budgeting and planning cycle
- Consolidated operations tooling
- More efficient operations
- Teams focused more on delivering services than routine activities

Increased Service Agility

Faster time to value

- SDN driven automation workflow
- Faster device onboarding and service provisioning
- Automated service assurance
- Leveraging SRE principal and practices to increase service reliability
- Improved user experience and customer satisfaction

Lowered network cost and enhanced customer experience

Adoption of the Routed Optical Networking

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Key Points

- Traditional multilayer networks are evolving to a converged architecture
- New architecture adoption is a journey
- Not everybody will have the same journey

Adoption is Journey

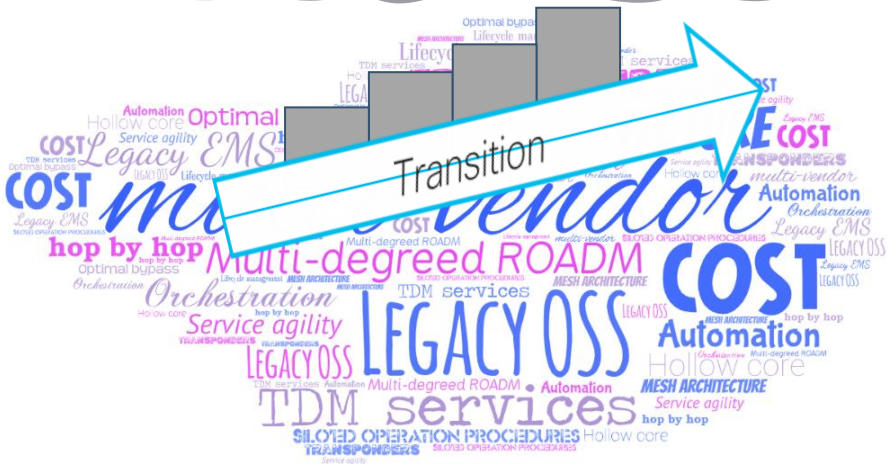
Entry Points

- Greenfield
- Optics
- Optical
- IP
- Automation
- IP + Optical
- IP + Optical + Automation
- IP + Optical + Optics

Challenges

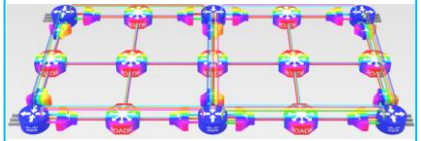
- Complex architectural transformation involving hardware, software, and orchestration components
- 3rd party and multivendor interop and integration
- Converging and simplification of operations and organizational structures

Need: A set of use cases and journey-based solutions to address these specific challenges to simplify and accelerate the adoption



Goal

Routed Optical Network Architecture



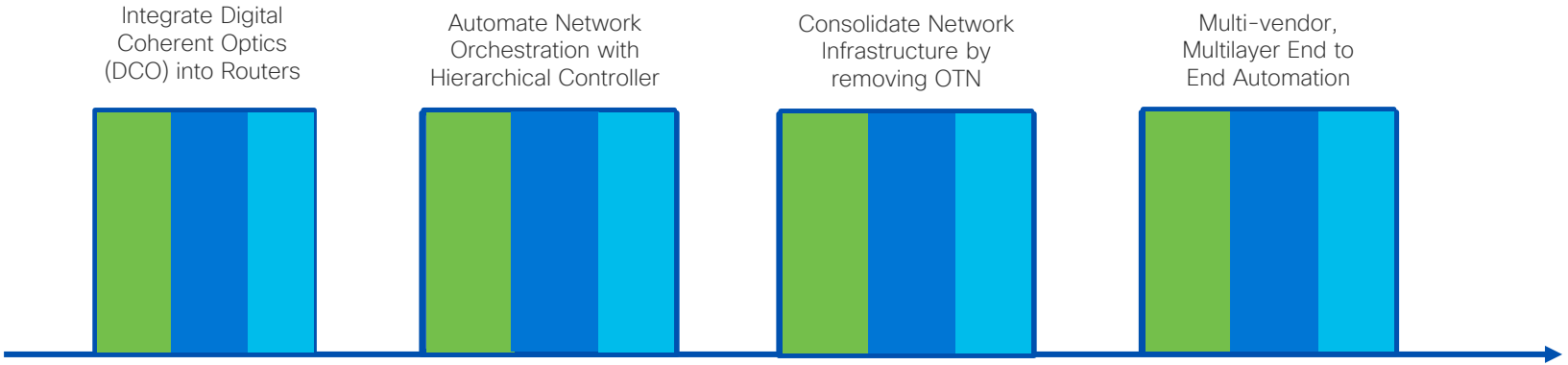
Automation

- Single layer network – single view into network, single control plane
- Optical operations team manage point-to-point networks
- Simplified model with converged Operations

Adoption Journey: Use Case View

- Adoption may come in waves due to business needs, risk control, or budget
- Each wave may come with its own adoption cycle
- Each wave may consist of different steps or partial components
- It is not necessarily a linear adoption journey

A hypothetical adoption example (for illustration purpose)

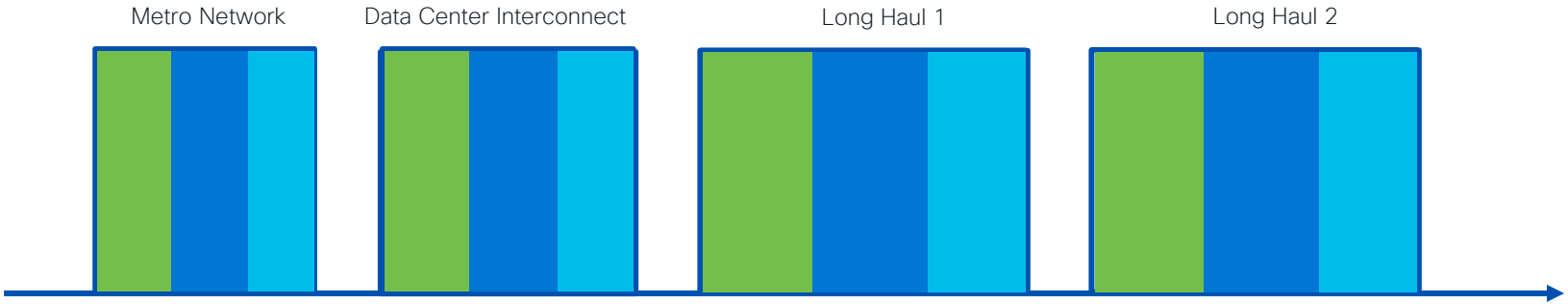


Adoption Journey: Deployment View

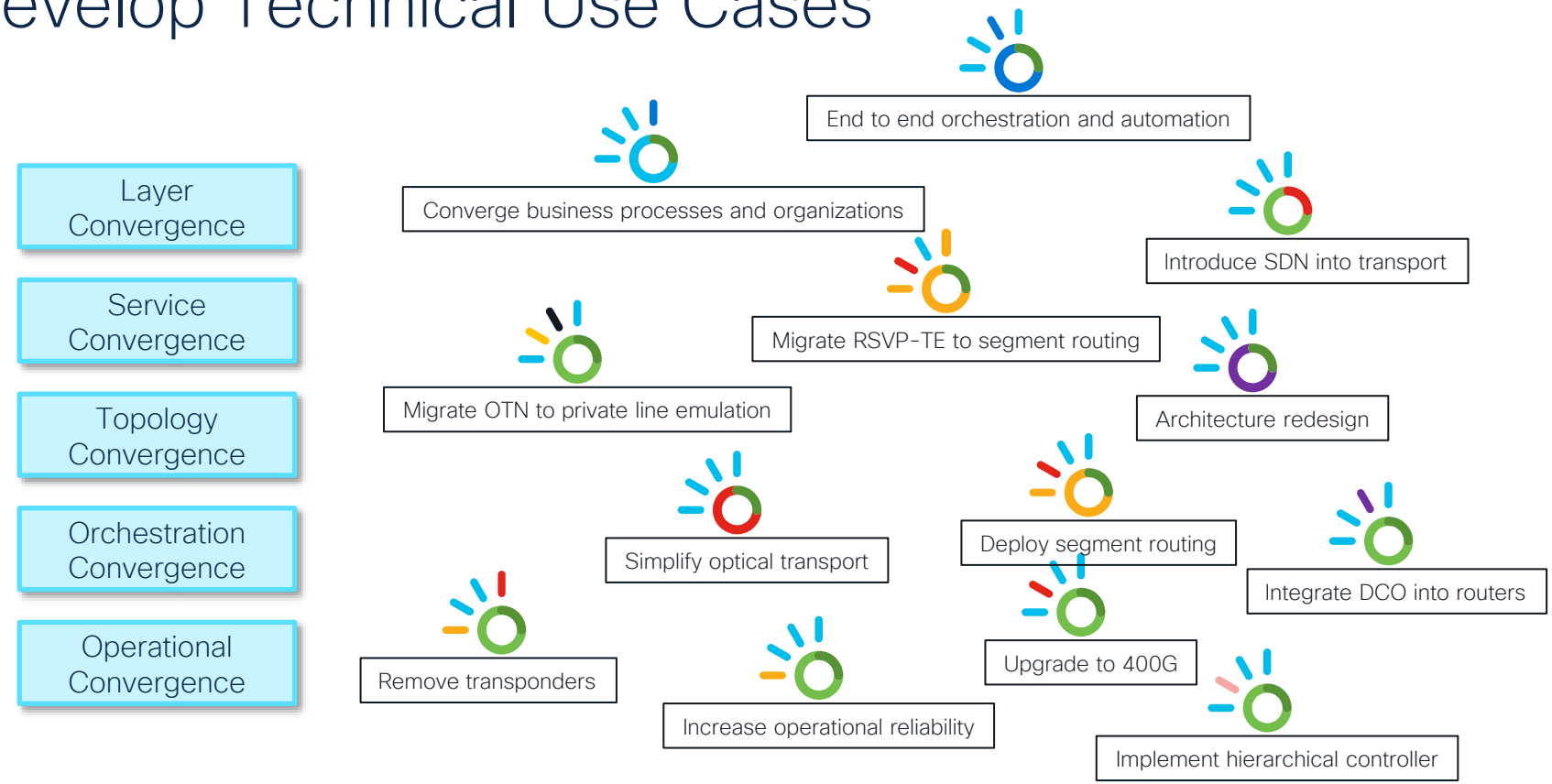
Proof of Concept | Pilot Deployment | Scaled Deployment

- Deployment may begin with different network segments
- Each segment may use one or more use cases

A sample adoption example (for illustration purpose only)



Develop Technical Use Cases



Sample Adoption Use Cases

Use Cases	Integrate DCO into routers	Implement segment routing	Simplify optical transport	Remove OTN infrastructure	Automate service delivery workflow	Operationalize convergence
Goals	Converge layers to reduce energy cost and space footprint	Provide simplified and multi-tiered service infrastructure	Simplify transport architecture for converged operating model over IP	Reduce or remove dedicated infrastructure such as OTN, SAN	Streamline service provisioning and assurance for faster service agility	Achieve operational efficiency through business process enhancement
Challenges	Optics interop with transport, power budget management, control and management with alien wavelength, architectural mind shift, IP and optical demarcation, multivendor integration	Assessment of the capability, design and deploy the solution network wide, circuit style traffic engineering requirements, skill gaps	Co-existing of CDC ROADM vs hop-by-hop, DWDM CP vs RON automation, L0 protection and restoration vs RON protection, expand network with L band, end to end circuit connectivity	Timing and latency, circuit protection, OSS/BSS update and integration, operating model and procedure update,	Integration of disparate management tooling, unified workflow, single provisioning workflow, context-aware FM and PM, service reliability, trouble ticket reporting,	Organizational convergence, workforce consolidation and upskilling, process consolidation, value stream mapping,
Benefits	Reduce power and space footprint	Simplify and scale packet transport	Simplify architecture	Reduce operating cost	Automation and agility	Operational efficiency and better experience

Deployment Journey Examples

Journey Examples

1

Brown Field

- Insertion of 400G DCO into routers
- Managing optics circuit as an alien wavelength on the 3rd party optical line systems

2

Hierarchical Controller

- Insertion of Cisco hierarchical controller to manage and converge multi-domain controllers
- Single pane of glass for network orchestration and assurance

3

Optical Line Systems

- Design Cisco optical line systems with NCS1010
- Deploy NCS1010 systems and controllers

Journey Examples

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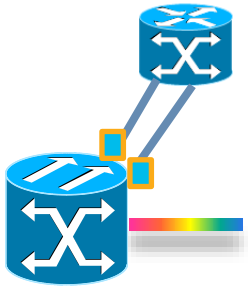
Journey Example 1: Setting Goals

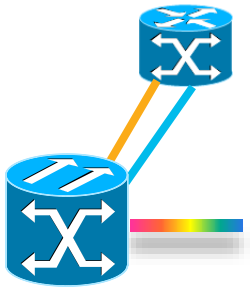
Present Mode of Operations

- State: Multidomain network with packet and optical transport. Transponders are part of the optical transport
- Goals: Simplify network, reduce cost, agile service



Future Mode of Operations

- Converge layers by adding 400G DCO directly in routers
- DCO signals carried over existing ROADM network as alien wavelengths



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

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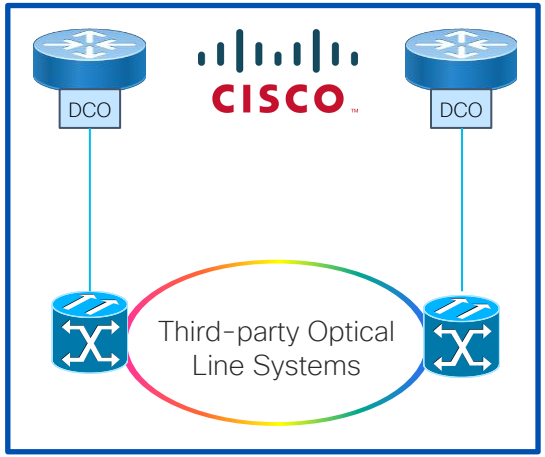
Summary of Key Challenges

1. Support and license on the 3rd party optical line systems for alien wavelength
2. Interoperability between DCO and optical line systems
3. Capability and capacity planning for new networks (eg 400G DCO)
4. OSS and orchestration systems
5. Organizational convergence and operating procedure updates



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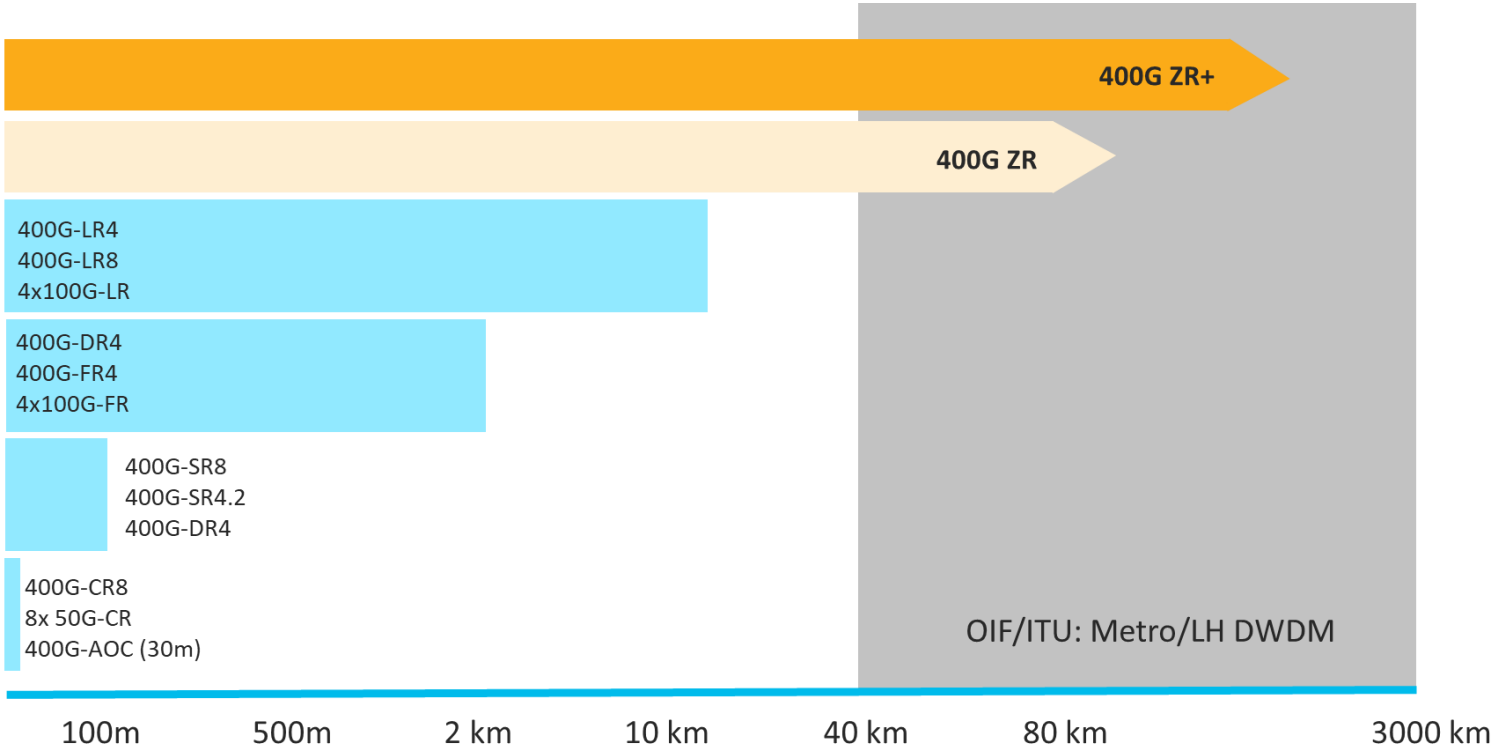
400G Ethernet PMD Comparison

- PMD: Physical Medium Dependent sublayer
- Focus of this presentation is on Routed Optical Networking use case with 400G ZR and ZR+



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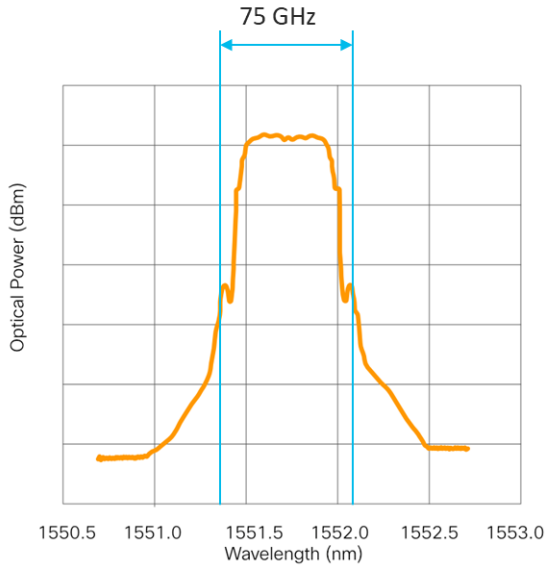
400G Network Requirements

50 GHz = 0.4 nm
75 GHz = 0.6 nm
100 GHz = 0.8 nm

- Symbol rate (spectral width): 59.84 GBaud (GHz) for 400G OIF ZR, 60.14 GBaud (GHz) for 400ZR+. The 50 GHz fixed grid filters do not work for 400G signals

- Support for 400G:
  - Spectral bandwidth
  - Additional amplifier needs
  - Mux/demux for 400G
  - Planning tool upgrade
  - OSS or optical controller upgrade
  - Accommodation for low launch powers for some DCOs
  - Higher ONSR need
  - Routing platform hardware and software
  - etc



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OIF 400G Channel Plan

OIF 64x75 GHz fix grid table based on wavelength (incrementing) but commonly shown with frequency in THz, reading left to right horizontally.

OIF Ch 1

196.100 1528.77	196.025	195.950	195.875	195.800	195.725	195.650	195.575
195.500	195.425	195.350	195.275	195.200	195.125	195.050	194.975
194.900	194.825	194.75	194.675	194.600	194.525	194.450	194.375
194.300	194.225	194.150	194.075	194.000	193.925	193.850	193.775
193.700	193.625	193.550	193.475	193.400	193.325	193.250	193.175
193.100	193.025	192.950	192.875	192.800	192.725	192.650	192.575
192.500	192.425	192.350	192.275	192.200	192.125	192.050	191.975
191.900	191.825	191.750	191.675	191.600	191.525	191.450	191.375 1566.52

OIF Ch 64

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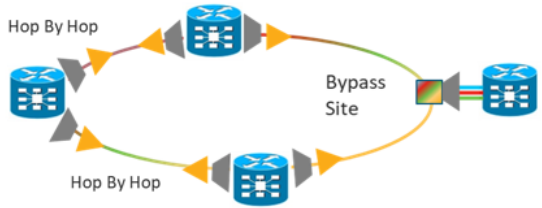
Multilayer Architecture Comparison

- Three common architecture models
- Use a multilayer planning tool to design and model

Router Bypass (Hollow Core)

Router Hop by Hop

Selective Bypass



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400G Re-Optimization

- Re-examine the current traffic matrix and utilization
- Re-analyze the capacity needs and growth projections based on the 400G network
- Identify any opportunities to further consolidate or optimize the traffic

Consider traffic re-optimization as a regular operational practice, particular before a major network upgrade

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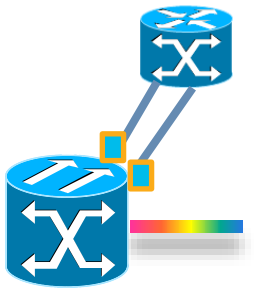
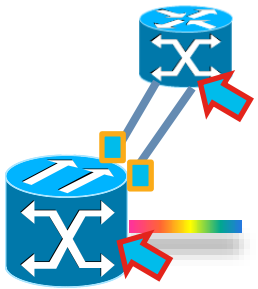
Journey Example 1: Creating Steps



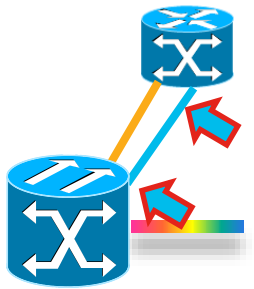
1 **400G readiness assessment**

Assessing the transport and routing hardware readiness for 400G



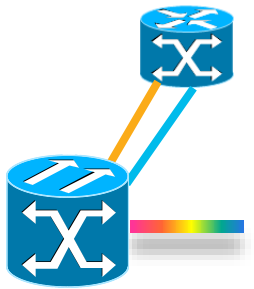
2 **400G upgrade**

Upgrading routers and redesigning transport as applicable to support 400G DCO



3 **Transponder to optics**

Migrating transponder circuits to DCO optics



4 **Operations update**

Performing decommissioning of transponders and operational update to support 400G DCO

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Journey Example 1: Activities and Outcomes

	1	2	3	4
Journey Steps	400G readiness assessment	400G upgrade	Transponder to optics	Operations update
Deployment Activities	• Network modeling and planning to support 400G DCO over a multivendor party transport • Transport readiness for 400G • Routing hardware and software readiness for 400G • Network management and SDN controllers for 400G • Alien wavelength support from transport network • Operational practices and procedures for converged infrastructure	• Network design updates for 400G support • Site readiness checks • Upgrade procedures • Upgrade routers to support 400G DCO • Upgrade transport for 400G DCO support • OSS and controllers upgrade	• Review solution designs and fiber routing • Proof of concept and lab validation • Create migration procedures • Pre-migration readiness checks • Update transport network as applicable • Circuit cutover from transponders to DCO optics	• Integrate optics into the transport network • Decom transponder equipment • Update operations procedure to support DCO in routers
Business Outcomes	• Understand the risk and readiness • Prepare budget and start schedule planning	• Network is ready for 400G	• Simplify architecture • Reduce network cost	• Reduce network cost • Reduce equipment footprint • Simplify operations

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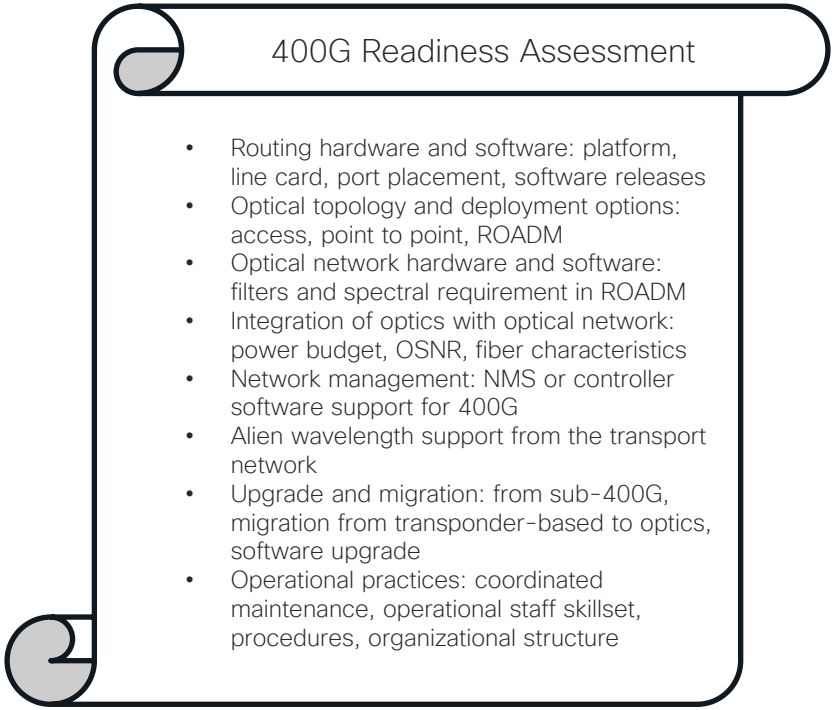
400G Readiness Assessment

- Identifying key use cases and validating these use cases through proof of concept testing
- Fully assessment the readiness and report on gaps and recommendations



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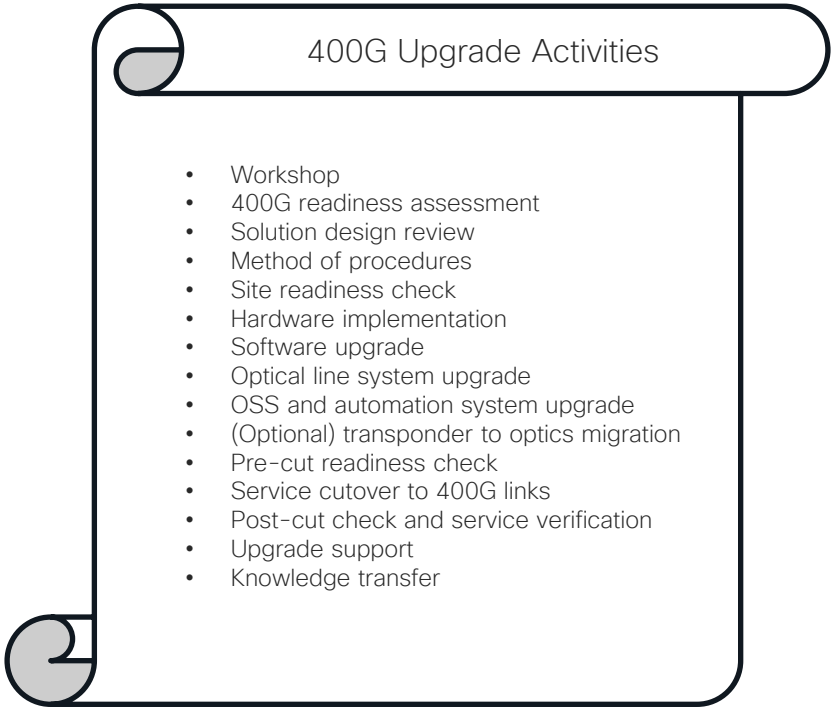
400G Upgrade

- Understand the scope of the service
- Asking a set of questions:
  - Is 400G readiness assessment needed?
  - Is transponder migration needed?
  - Is optical line system upgrade needed?
  - Is PoC testing needed?
- Creating or reviewing solution design
- Planning the upgrade procedures
- Performing the cutover and post-cut support



Transponder to Optics

1. Workshop with key stakeholders to understand migration requirements and scope. New hardware may be needed
2. Network discovery to collect required data for migration preparation (see details)
3. Solution integration and service assurance testing
4. Assessment and site readiness check: from discovery, ensure network, sites, and customers are ready for migration
5. Migration design review: review existing designs for pre- and post-migration architecture changes
6. Migration planning and MOP development. Document any prep steps, for example, software and hardware upgrade that need to take place before cutting over transponders to optics
7. Migration execution: pre-check, cutover, post-check. Additional prep work may be scoped here
8. Migration support and post-migration support

Network Discovery for Migration

- If migrating a sub-400G transponders to 400G DCO, need 400G readiness assessment.
- Whether same fiber is to be used for the optics, fiber characteristics
- Document transponder information: type, modulation, FEC, OSNR, power levels, wavelength, add/drop unit
- Document optics information: type, modulation, FEC, wavelength
- Document existing services
- Software and hardware platform support for optics
- Optical network design file for transponders and optics, including additional amplifiers, change of filters, ROADMs, and cabling
- Router configuration changes
- Proof of concept and lab testing report

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Integrating DCO: Operational Considerations

- Clarify organizational ownership for the DCO
- Update network management tooling, demarcation, and procedure to align with the ownership
- Define the interface between the routing team and optical transport team
- Train routing teams on DCO and optical team on alien wavelength support (if applicable)

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Integrating DCO: Optics Ownerships

- Ownership responsibility: planning, budget, procurement, onboarding, maintenance, optimization, tooling
- Organizational demarcations: clearly defined responsibility boundary
- Change control procedures: track and approve changes

Optics Ownership Models

Routing Team

- A logical model as optics are hosted on routers
- Consider exposing optics parameters to the transport team to assist maintenance

Transport Team

- End to end transport ownership from optics to optics
- Routing team has read access to optics data
- Need to clearly define the demarc

Joint Ownership

- More suited for where both teams are under the same management
- Helpful for building a converged team
- Need clear change control procedures

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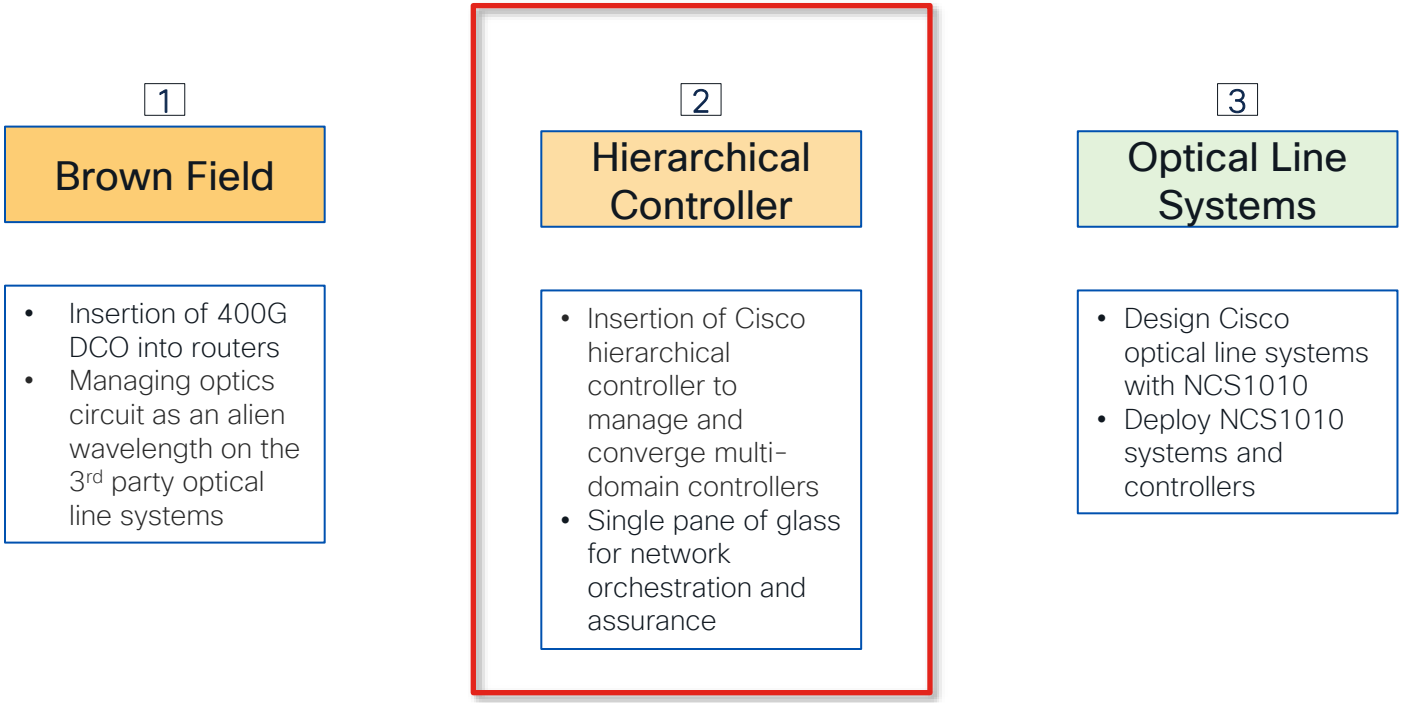
Integrating DCO: Optics Lifecycle Management

- Develop and deploy an optics lifecycle management platform to bring ongoing operational visibility
- Essential features
  - Live optics inventory
  - Multiple dashboards based on user stories: engineering, planning, operations, executive
  - Deployment assistance: optical power reporting, error reporting, line quality testing (such as PRBS), loopbacks
  - Performance monitoring

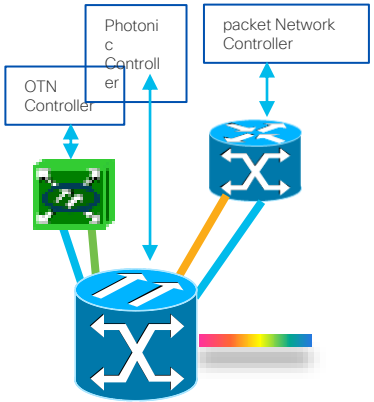
Journey Examples



Journey Example 2: Setting Goals

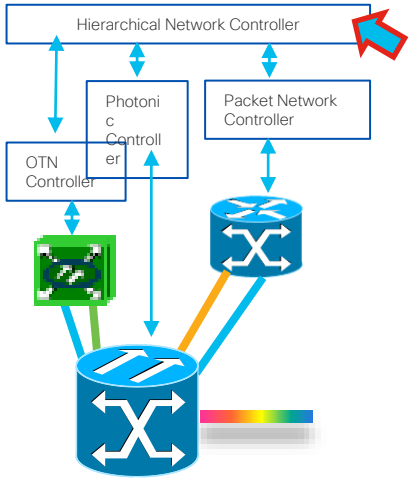
Present Mode of Operations

- State: Multidomain network with packet and 3rd party optical transport (DWDM and OTN)
- Goals: Simplify network, reduce cost, agile service

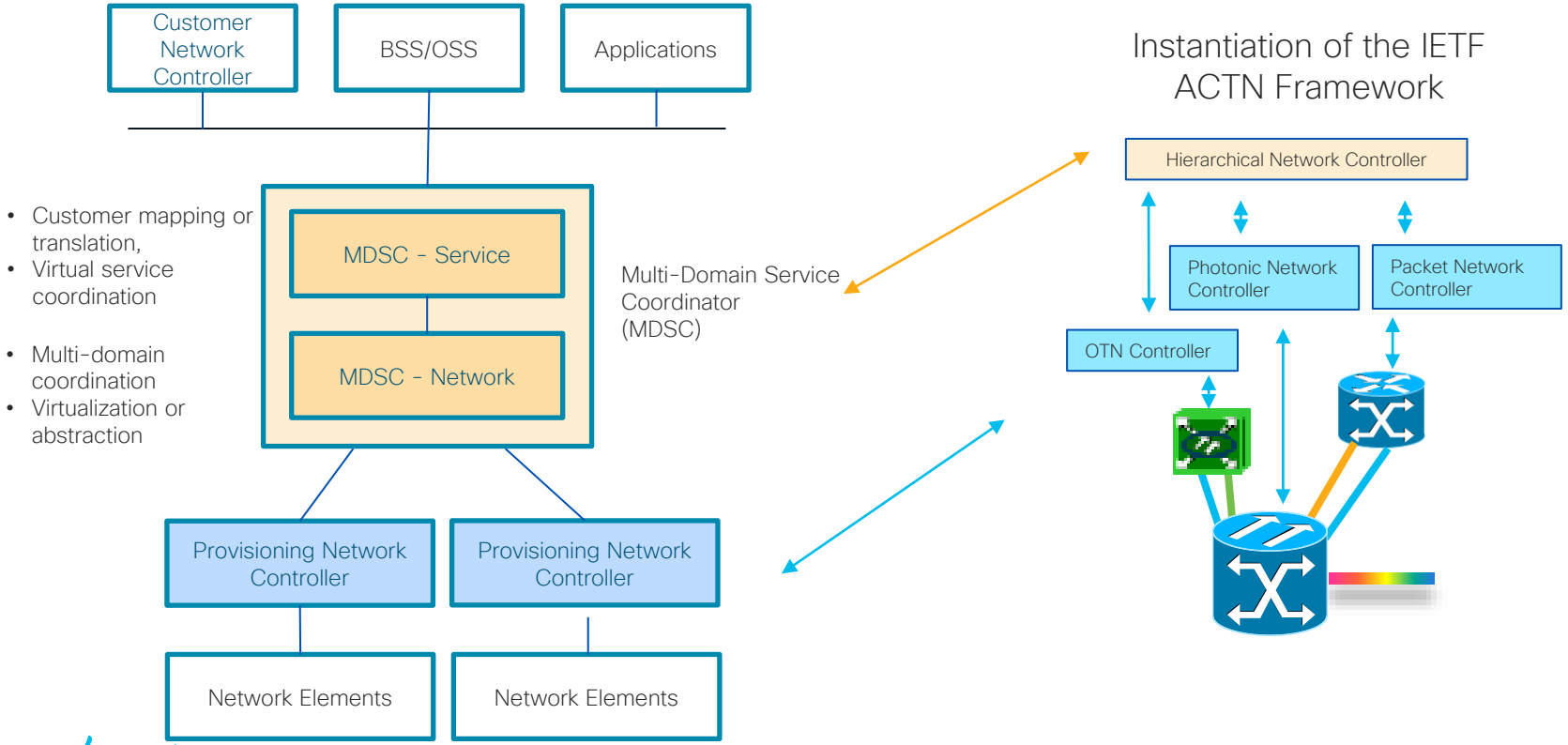


Future Mode of Operations

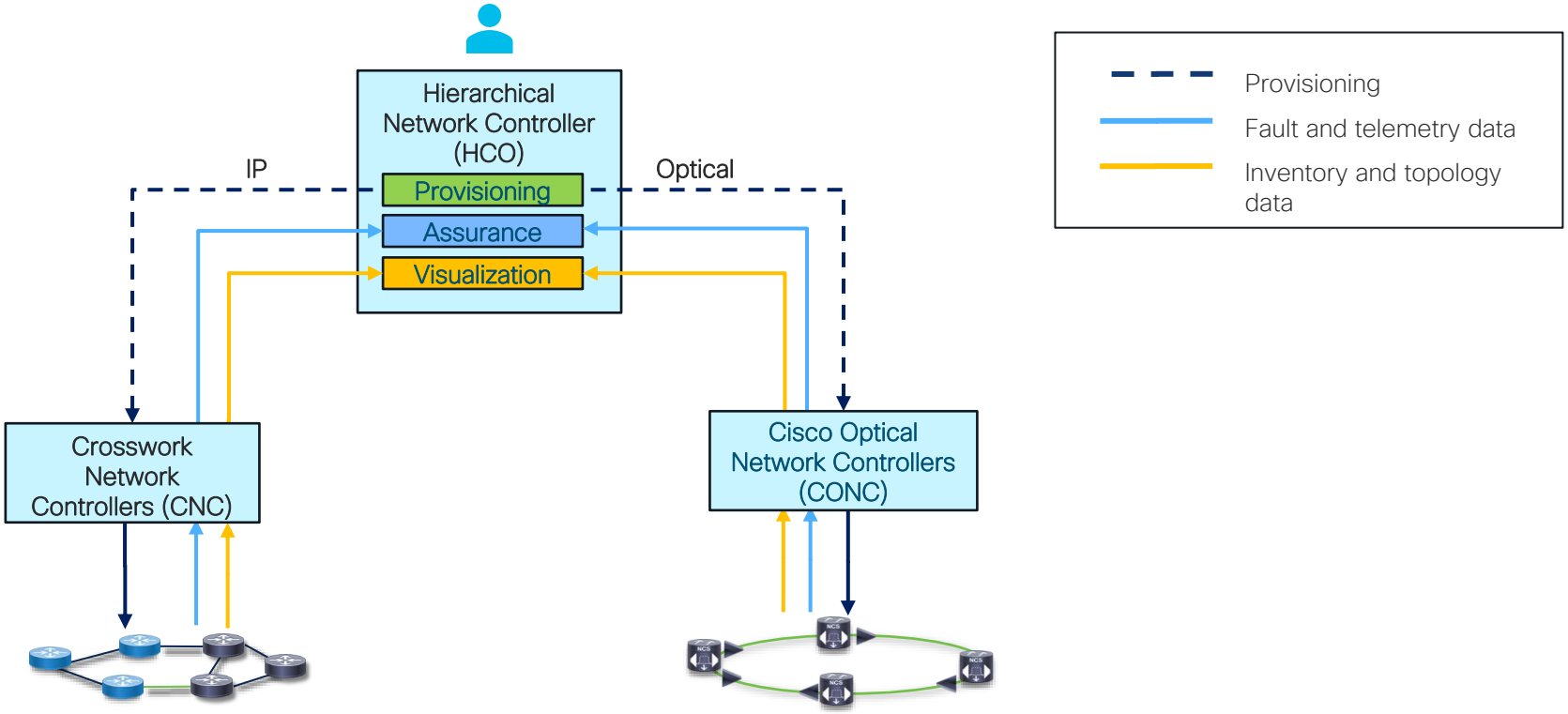
- Converged workflow with multiple domain controllers for a multivendor network
- Single pane of glass for network management and automation



Framework for Abstraction and Control of TE Networks



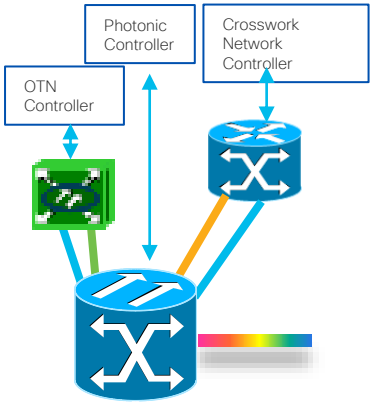
Automation for a Converged Network



Deployment Considerations for Hierarchical Controllers

- Define a set of use cases that will feed into the design and test plans
- Collect and document requirements:
  - What are the specific domain controllers and specifications to be integrated?
  - Is there a need to integrate the Hierarchical Controller into the overall workflow?
  - Is there high availability (HA) needs? In case of HA, is there geographical requirements and what is the latency requirement?
  - Is there need for lab and production instances?
  - Is there need for north bound API access
  - Does the Hierarchical Controller support south bound API adaptors (to domain controllers)?

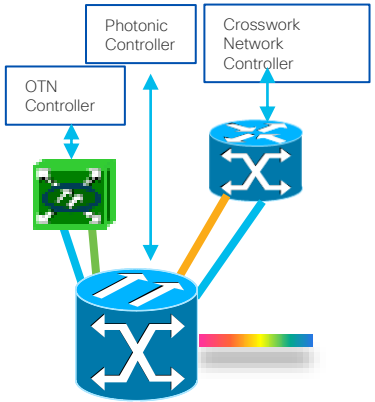
Journey Example 2: Journey Steps



Assessment

1

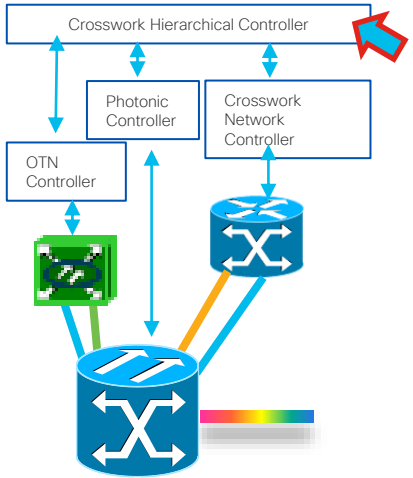
Assessing the implementation requirements and readiness for Hierarchical Controller



Platform staging

2

Hardware and VM staging for implementing Hierarchical Controller



Implementation

3

Design and implement Hierarchical Controller

Journey Example 2: Activities and Outcomes

	1	2	3
Journey Steps	Assess Requirements and Readiness	Perform Platform Staging	Implement Hierarchical Controller
Deployment Activities	• Conduct workshops to understand requirements • Assess the readiness for Hierarchical Controller • Document orchestration stack and needs to adapters, APIs • Make recommendations for hardware platform and software packages • Create use cases • Solution requirements development	• Install and configure the hardware platform as applicable • Perform software update as applicable • Create VM according to specification	• Create solution design • Develop and integrate API adaptors • Implementation (lab and production) • Test plan development and test execution (lab and production) • Post implementation support • Network discovery • Demo circuit provisioning • Knowledge transfer
Business Outcomes	• Customer requirements are satisfied • Hardware and software resources are ready for Hierarchical Controller	• Hardware and software platforms are ready for Hierarchical Controller	• Increase service agility by automation • Simplify network management by consolidating management platforms

Journey Examples

1

Brown Field

- Insertion of 400G DCO into routers
- Managing optics circuit as an alien wavelength on the 3rd party optical line systems

2

Hierarchical Controller

- Insertion of Cisco hierarchical controller to manage and converge multi-domain controllers
- Single pane of glass for network orchestration and assurance

3

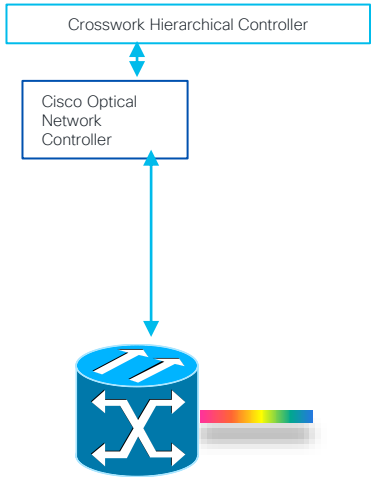
Optical Line Systems

- Design Cisco optical line systems with NCS1010
- Deploy NCS1010 systems and controllers

Journey Example 3: Journey Goals

Future Mode of Operations

- Simplified optical transport with NCS 1010
- SDN based management with CONC and HCO
- End to end workflow and automation



NCS1010: a Disaggregated Optical Line System

C+L-Band Support	ASE Loading	Gain Equalization	Visibility & Manageability	Support for ZR/ZR+
Support for both C and L bands; hitless upgrade from C to C+L	Embedded channelized ASE (Amplified spontaneous emission) for consistency in performance from day 1 to full capacity growth	DGE (dynamic gain equalizer) for equalization and better control of Raman Gain ripple	Optical Channel Monitor (OCM), Optical Time Domain Reflectometry (OTDR), Optical Supervisory Channel (OSC), Connectivity Verification (CV)	Ingress amplifier supports coherent sources with low launch powers (400G ZR and ZR+ at -10 dBm)

NCS1010 Topology Options and Device Types

- Point to point terminal or line amplifier
- Colored or colorless add/drop
- Multi-degree ROADM

Optical Line Terminal (OLT)

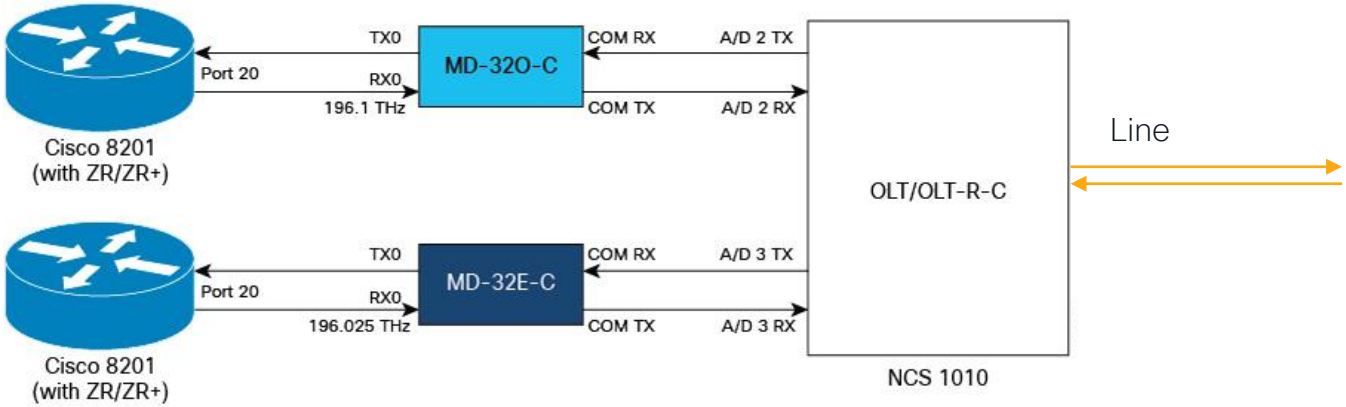
- OLT C-Band
- OLT L-Band
- Optional: Raman module

Inline Amplifier (ILA)

- ILA C-Band
- ILA C-Band with 1x Raman amp
- ILA C-Band with 2x Raman amps
- ILA L-Band

Sample Setup for Colored Add/Drops

- OLT-R-C is the version of NCS1010 with RAMAN amplifier
- MD-32O-C and MD-32E-C are two C band 32-channel Odd or Even multiplexer/demultiplexer

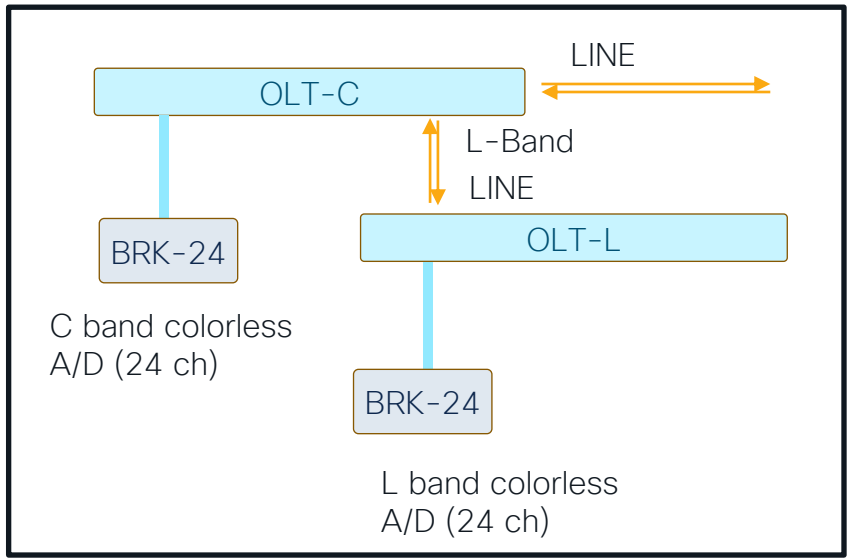


* Showing one terminal site

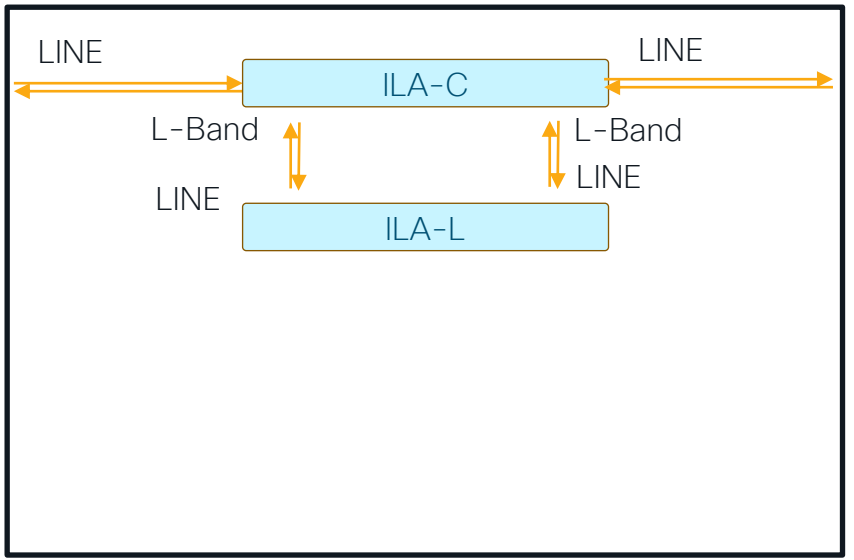
Sample Setup for C+L Bands

- OLT-C and OLT-L are C and L band versions of NCS1010 terminals
- ILA-C and ILA-L are C and L band versions of NCS1010 line amplifiers
- BRK-24 is a 24-chanel colorless add/drop structure

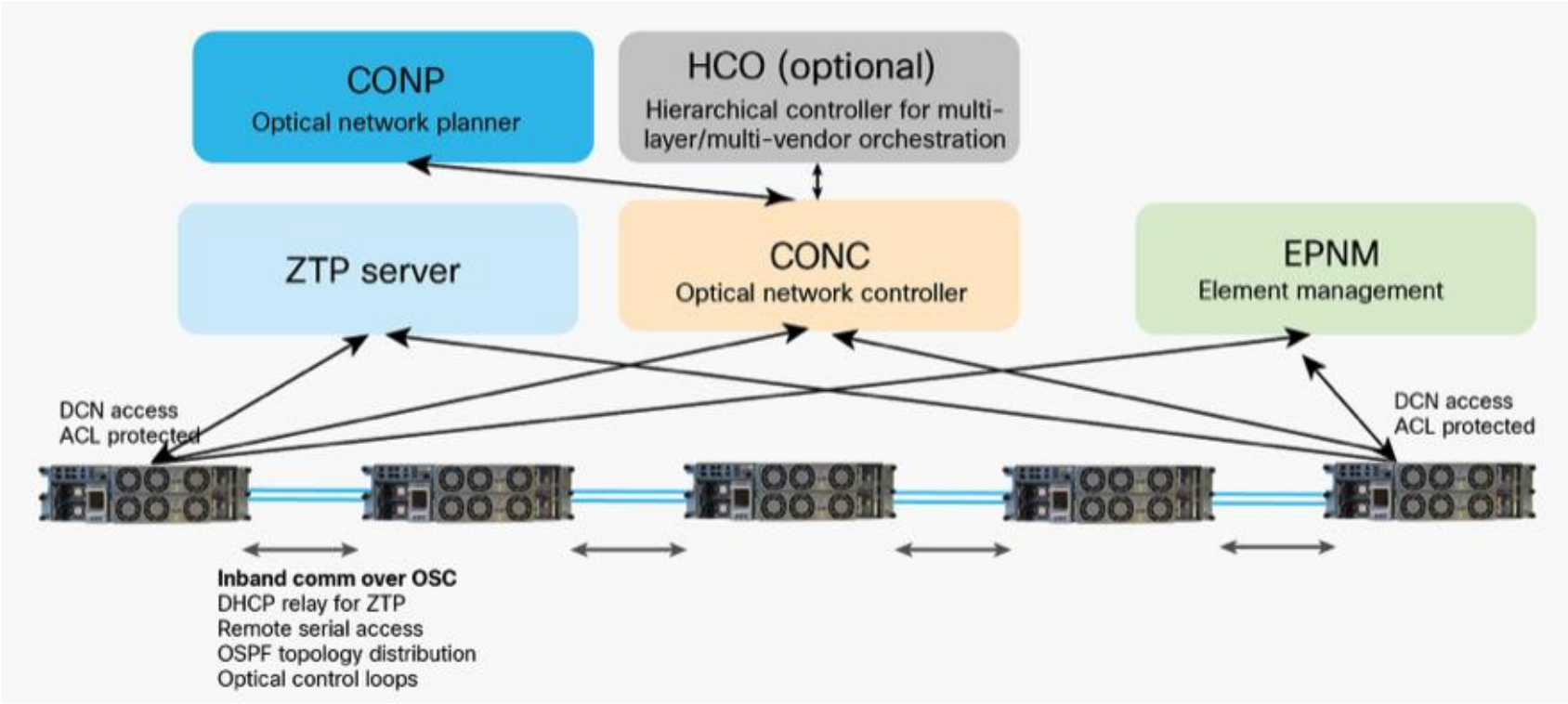
Terminal Site



Line Site



Management and Automation Architecture



Deployment Models

CLI

- Node bringing up with IOS-XR CLI only
- Applicable for simple network setup
- Device by device configuration and verfications

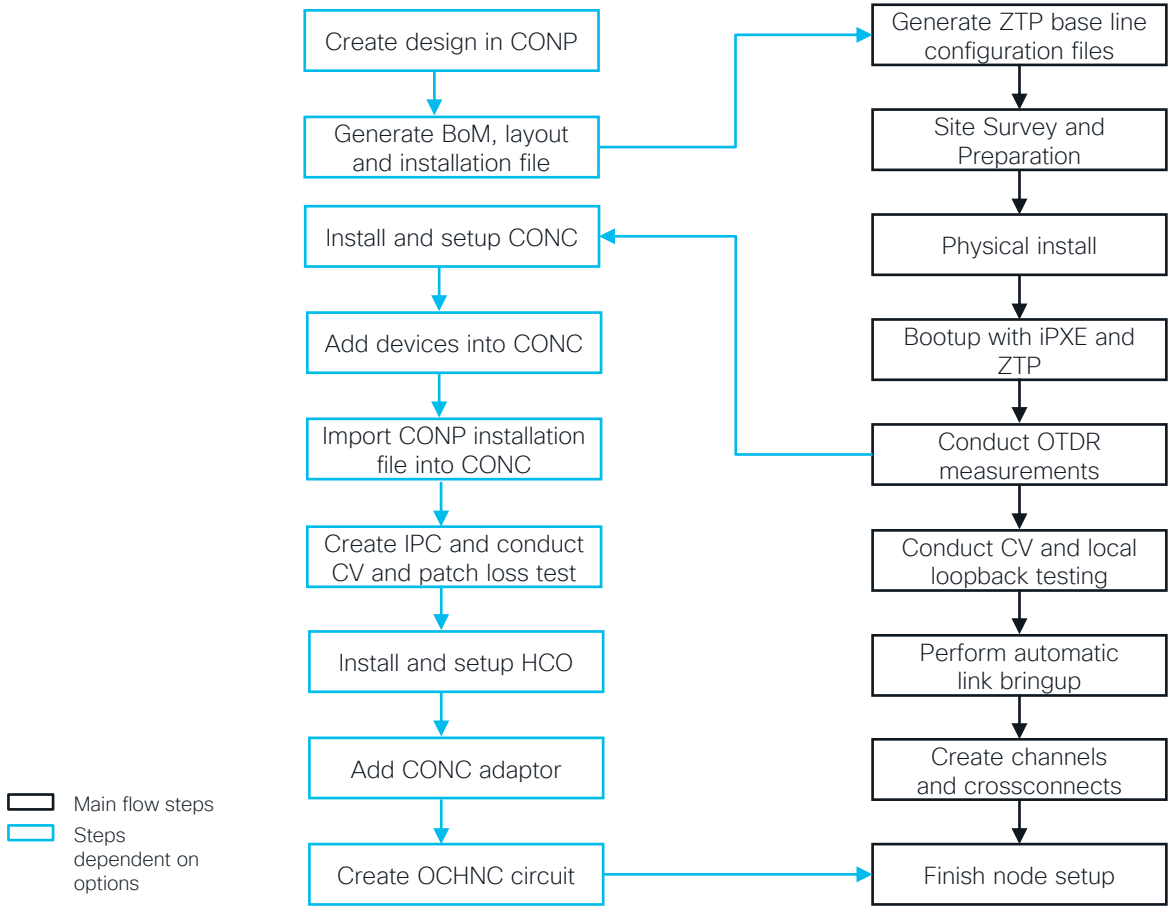
CONC

- CONP for design, layout, and installation file
- Single point of management through CONC
- Preferred for multi-degree sites
- Circuit provisioning may be via API

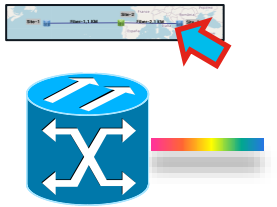
CONC+HCO

- Complete workflow with Cisco automation packages
- Applicable if customers purchase HCO
- GUI-driven provisioning, visualization and assurance

A Sample NCS1010 Turn Up Workflow

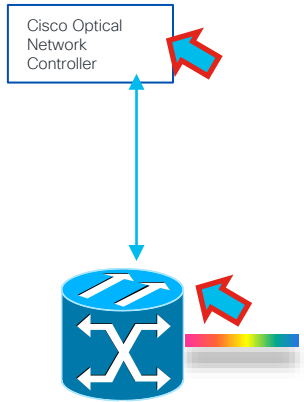


Journey Example 3: Journey Steps



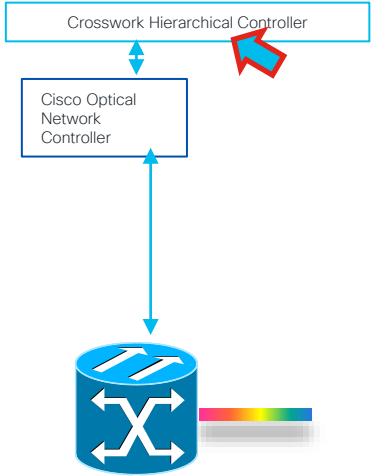
Optical Design

1 Creating network design for NCS1010



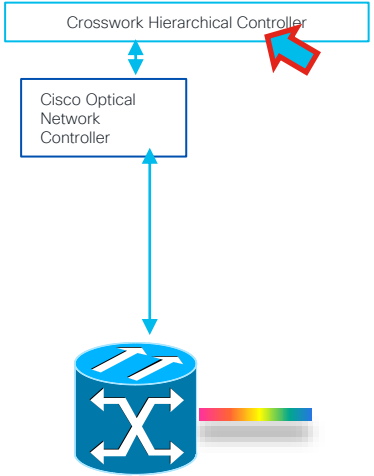
NCS1010 Setup

2 Setting up NCS1010 nodes and SDN controllers



Automation

3 Adding HCO as the single pane of glass of Routed Optical Networking automation



Integration

4 Integrate end to end orchestration using HCO

Journey Example 3: Activities and Outcomes

	1	2	3	4
Journey Steps	Optical Design	NCS1010 Setup	Automation	Integration
Products and Tools	• Cisco Optical Network Planner (CONP)	• NCS 1010 optical line system • Cisco Optical Network Controller (CONC)	• Crosswork Hierarchical Controller	• OthCrosswork Hierarchical Controller • er domain controllers
Deployment Activities	• Install CONP • Collect network requirements • Create a network design for NCS1010 line systems • Analyze the design and export installation parameter files	• Implement NCS 1010 network elements • Boot up with iPXE and ZTP • Implement CONC • Bring up NCS1010 with CONP design file • Discovery and management of NCS 1010 via CONC	• Design and implement HCO • Adding CONC adapter • Discovery of all NCS1010 network elements and topology • Demo OCHNC circuit creation	• Adding additional adapters for other domain controllers • Adding inter-layer management links • Perform connectivity check • Demo end to end IP link provisioning via HCO
Business Outcomes	• Consistent workflow from design to implementation • Design version tracking	• Reduce network cost • Simplify architecture	• Reduce network cost • Simplify architecture	• Streamline business processes • Remove inefficiencies • Increase productivity

Conclusion

Use Cases and Journey

- Journey to Routed Optical Networking is an architectural transformation
- There could be many different types of journeys
- Use case based adoption provides flexibility
- Construct your journey based on your business requirements

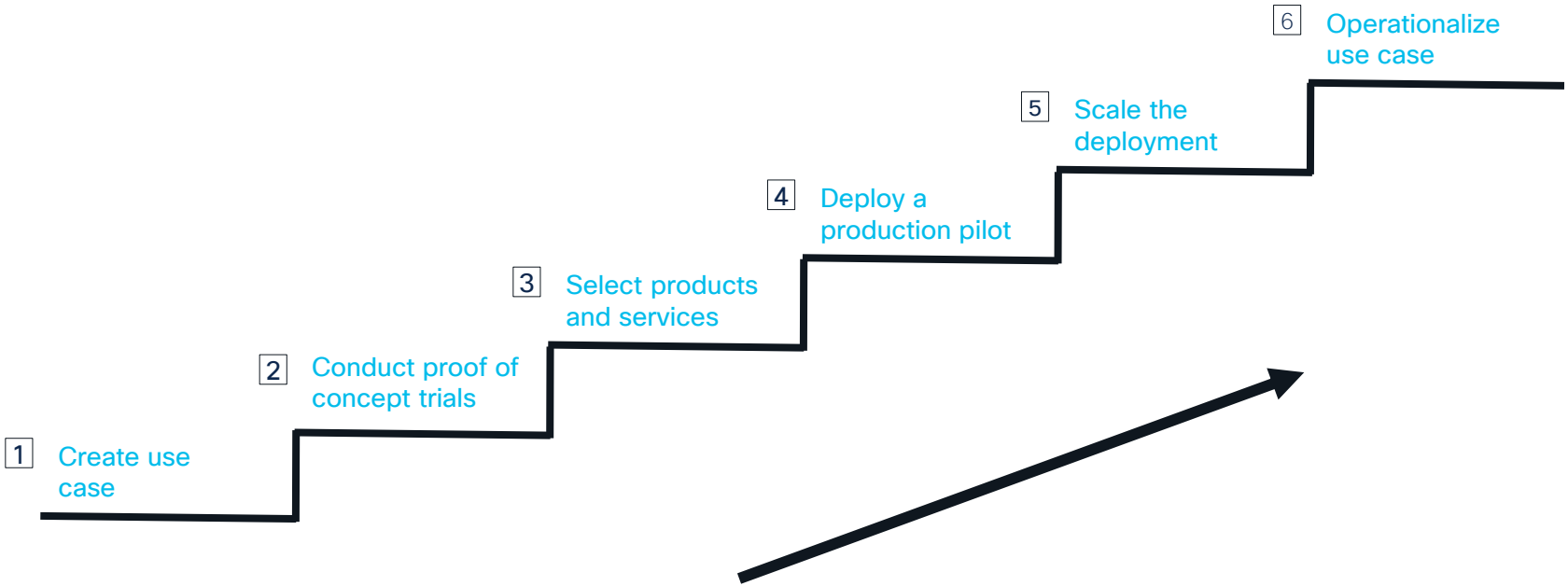
Journey Examples

Brown Field

Hierarchical Controller

Optical Line Systems

Embarking on a Journey



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