Unlocking Hyperscale Connectivity: The Rise of Managed Optical Fiber Networks (MOFN)

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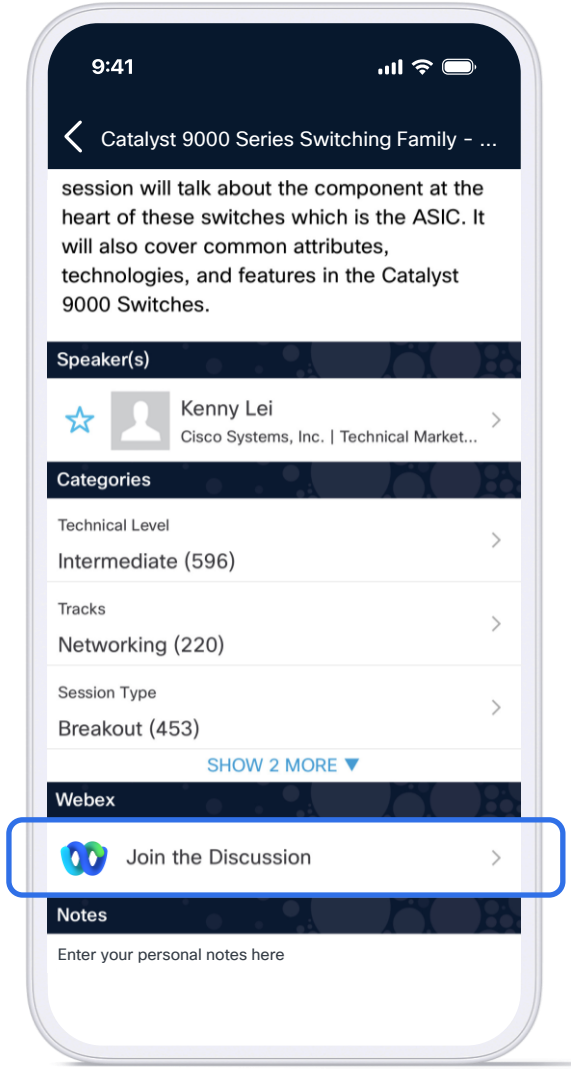

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Agenda

01 What is MOFN ?

02 Key Drivers for MOFN

03 Types of MOFN

04 Cisco MOFN Solutions

05 Cisco Coherent Optics

06 Cisco Optical Transport

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Demystifying MOFN

MOFN – What ChatGPT says?

A **Managed Optical Fiber Network (MOFN)** is a fiber-based connectivity service where the network provider delivers **high-capacity optical links** and **actively manages** the performance, configuration, and maintenance of the network for customers such as hyperscalers, enterprises, and carriers.

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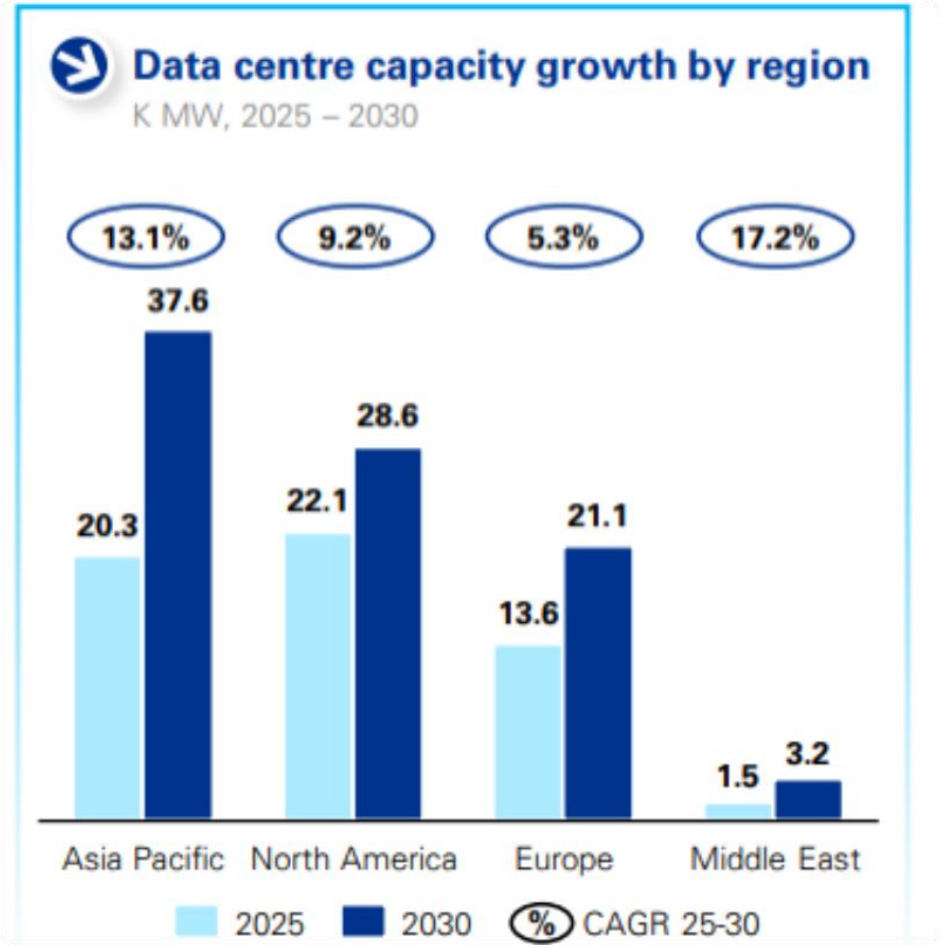
The need for connectivity ..

- AI training and inference workloads are driving increases in global data center capacity
  - $5.2T in data center CapEx expected through 2030[1]
  - 3.5x increase in data center capacity demand through 2030[1]
- Content and cloud providers now account for more than 70% of international bandwidth, driving the need to connect to data centers at major regional hubs/landing stations[2]
- Regional data center capacity growth is exploding
  - By 2030, Asia Pacific will have the highest data center capacity and growth: 13.1% increase in capacity to 37.6 gW[3]
- Critical need for data center interconnects which can be a few kilometers to thousands of kilometers apart.
  - From landing stations to inland data centers
  - Between regional training data centers and enterprise data sources



KPMG The Asia Data Centre Landscape:
https://assets.kpmg.com/content/dam/kpmg/cn/pdf/en/2025/03/the-asia-data-centre-landscape.pdf

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Capacity Service Options by Service Providers

Dark Fiber

- Fiber lease or IRU
- Fiber Route Diversity
- Colocation and/or Hut facilities
- End customer has full control to engineer network
- OTDR monitoring

COLO/ILA-huts

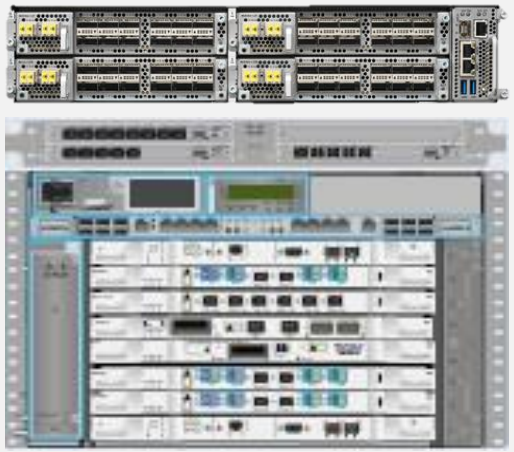
External Fiber Plant

Wavelengths

- 1G/10G/100G/400G/800G
- Protected, unprotected
- Latency SLAs
- Proactive monitoring and repair

CPE

Central Office



External Fiber Plant

Managed Spectrum

- N x 12.5GHz
- Faster turn-up, lower cost and opex compared to dark fiber
- Guard Band applied to protect other services
- Spectrum Power Monitoring

COLO/POP

External Fiber Plant

MOFN

- Managed Network including Fiber at SLA specified
- Product/Architecture can be specified by end customer
- Proactive monitoring and repair

COLO/DC

External Fiber Plant

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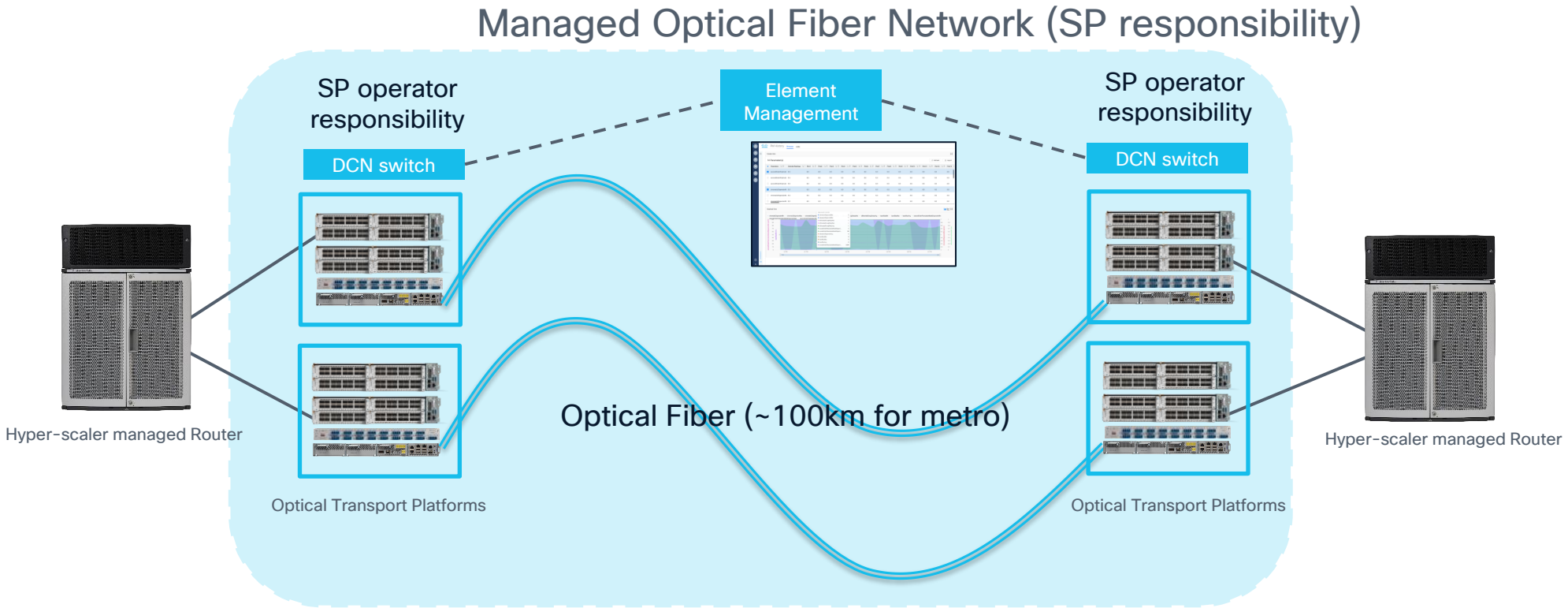
Managed Optical Fiber Networks (MOFNs)

- Key Drivers:
  - Web/Hyperscale operators cannot own/lease dark fiber without a telecom license in certain geographies
  - Faster TTM vs procuring fiber and managing network directly
- Local carriers to build and manage optical transport networks for end customer using technologies/products they prefer.



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Why MOFNs are Win-Win for Hyperscalers & Service Providers ?

Hyperscalers

Faster time to market

Scale

Customization

Service Providers

Incremental Revenue

Partnership

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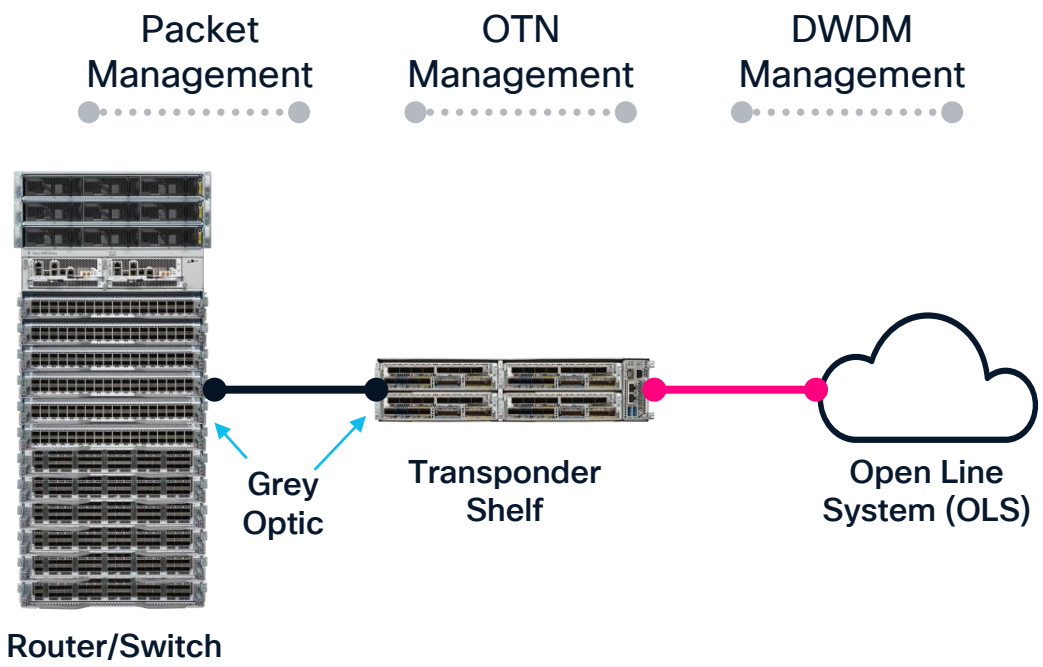
MOFN Solutions

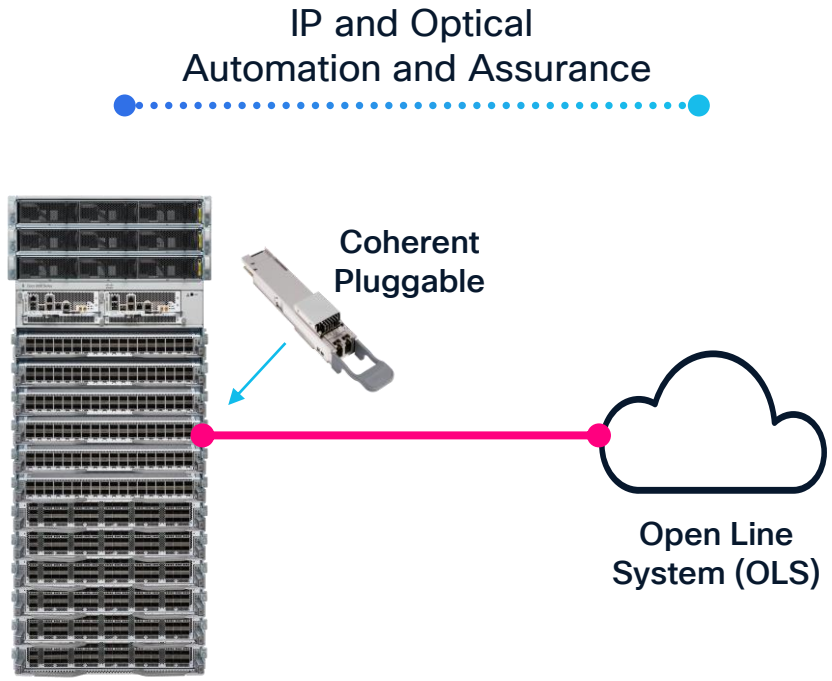
Architectures choices for MOFN

Traditional Architecture



Demarcation between IP and Optical

RON Architecture



Much Lower Total Cost of Ownership (TCO)

Significantly reduce capital and operating expenses **by 50% or more**

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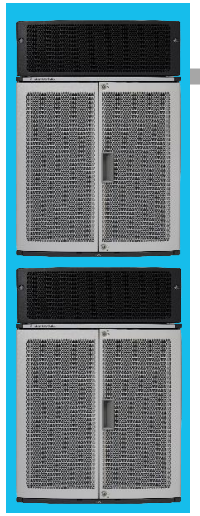
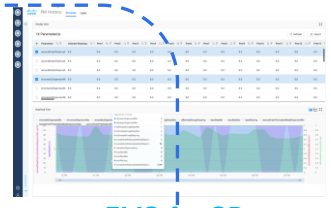
How to operate a MOFN network ?

Coherent Optics in a Transponder Shelf

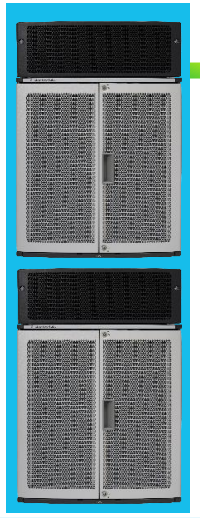


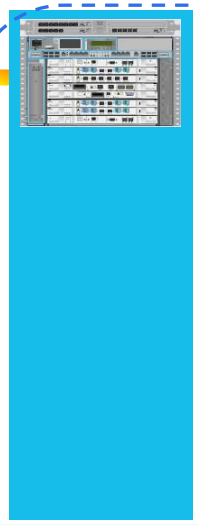


EMS for SP managed network

	Web/DC operator responsibility	SP operator responsibility
Config	• Router configuration to turn-on interface and ethernet config	• Transponder config for mode and trunk • Line system channel freq, BW config and other optical parameters
Acceptance Testing		• PRBS/traffic test each client.
SP SLAs		• Uptime of 100GE/400GE – CRC errors, flap counters etc.

Coherent Optics in Router





EMS for SP managed network

	Web/DC operator responsibility	SP operator responsibility
Config	Router configuration will include frequency and appsel code	• Line system channel freq, BW config and other optical parameters
Acceptance Testing	• PRBS/traffic test each coherent port	• Use Coherent Probe on OLS or stand-alone box with same coherent optic to test Q and GSNR for all waves
SP SLAs		• Drop PSD profile • SNR/Q-margin, UNC-WORDs, eth counters on probe

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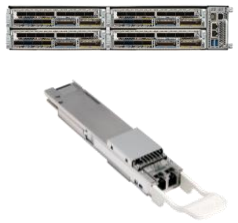
Cisco MOFN Solution Building blocks...

Cisco Routing Platforms: 8000, NCS, and ASR

Unparalleled performance, TCO, and operational simplicity

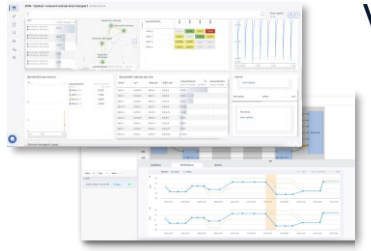
Cisco Coherent Pluggables & Optical Transport

Comprehensive lineup of coherent optics and optical transport platforms



MOFN Solution

IP & Optical Automation & Assurance



Vendor Agnostic Hierarchical Control

Visualization, Assurance and Provisioning of both IP and Optical domains

Cisco or 3rd Party Open Line Systems (OLS)

Full featured OLS with mesh ROADMs and in-line amplification

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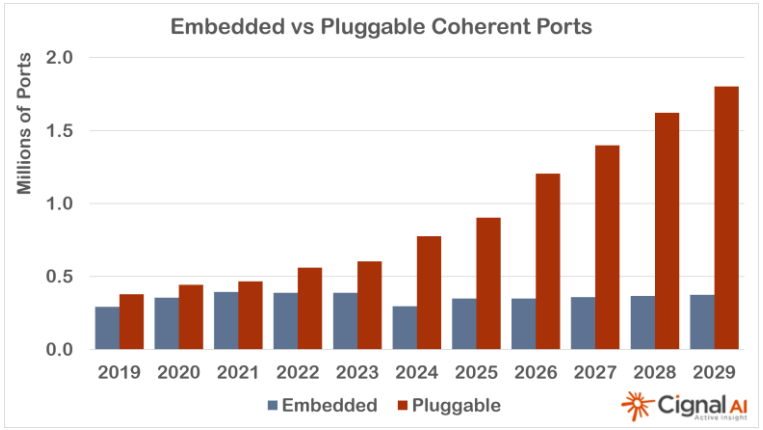
Cisco Optical Innovations & Coherent Pluggables

Market/Technology Trends – Coherent Pluggables

Coherent Pluggables % Continue Increasing

- Today coherent ports are dominated by pluggables
- IP-over-DWDM gaining widespread adoption



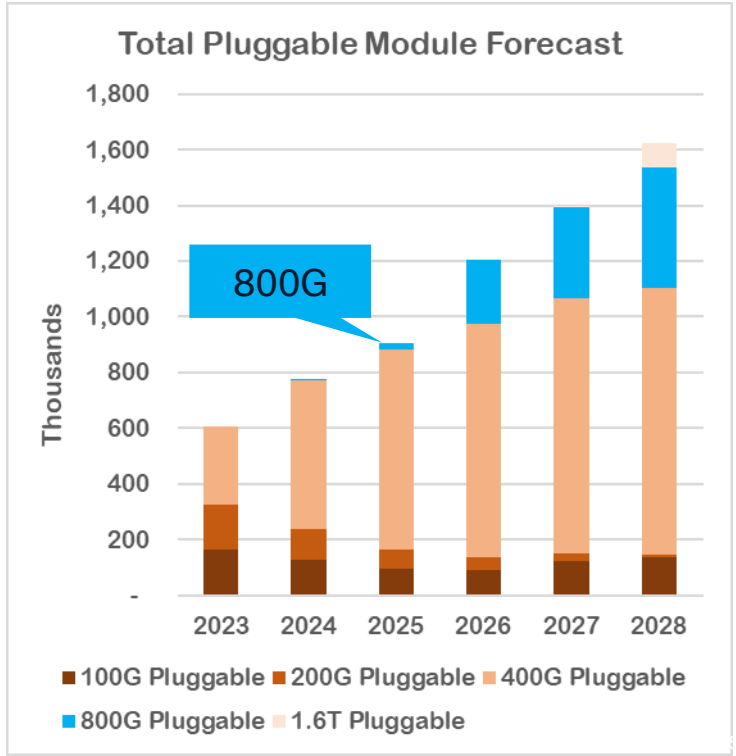
Coherent Pluggables Expanding Applications

Farther: 400G ULH

Wider: L-Band

Shorter: Coherent Lite

800G Coherent Market Takes Shape



Acacia/Cisco continues to be the pioneer in coherent pluggables: 800G ZR+ (interop PCS), 400G ULH

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Coherent Pluggable Brings Some Important Levers

01

Network costs and efficiencies

CapEx cost breakdown, $/100G, PAYG models, etc.

02

Power, thermal, and space

Compact devices, Watt/100G, DC power and rack space optimization

03

Network architectures

Disaggregation, optimize topologies, spectrum efficiency

04

Drives interoperability

MSAs/standards, best in breed adoption

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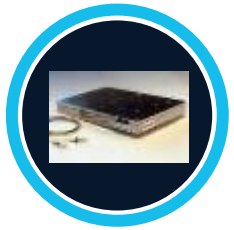
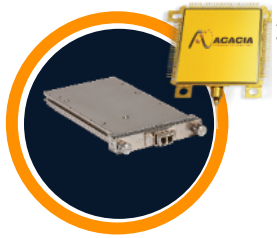
Acacia Coherent Technology Innovation

2011
Everest DSP (40nm)
(AC100)
100G QPSK LH, UHL

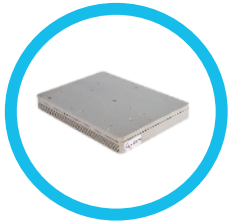
2012
K2 DSP (40nm)
(AC040)
40G BPSK Subsea



2013
Mauna Kea DSP(40nm)
(AC100S)
100G RZ-QPSK Subsea



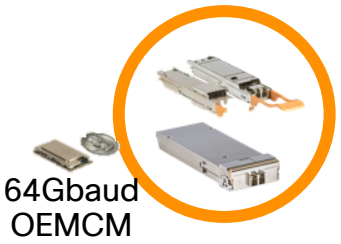
2014
Sky DSP(28 nm)
(CFP-DCO)
100G QPSK, Metro, LH



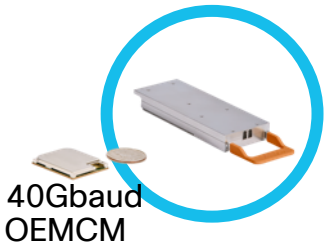
2015
Denali DSP (28nm)
(AC400)
2λ, Multi-haul

2016
Meru DSP (16nm)
(CFP2-DCO)
100/200G Metro, LH

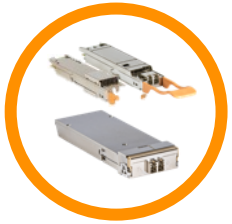
2018
Pico DSP (16nm)
(AC1200)
2λ, Multi-haul



2020
Greylock DSP (7nm)
(400G DCO)
100-400G, Metro, LH



2022
Jannu DSP (5nm)
(CIM 8)
Multi-haul



2024
Delphi DSP (4nm)
(400G ULH, 800G
ZR?ZR+)
DC, Metro, LH

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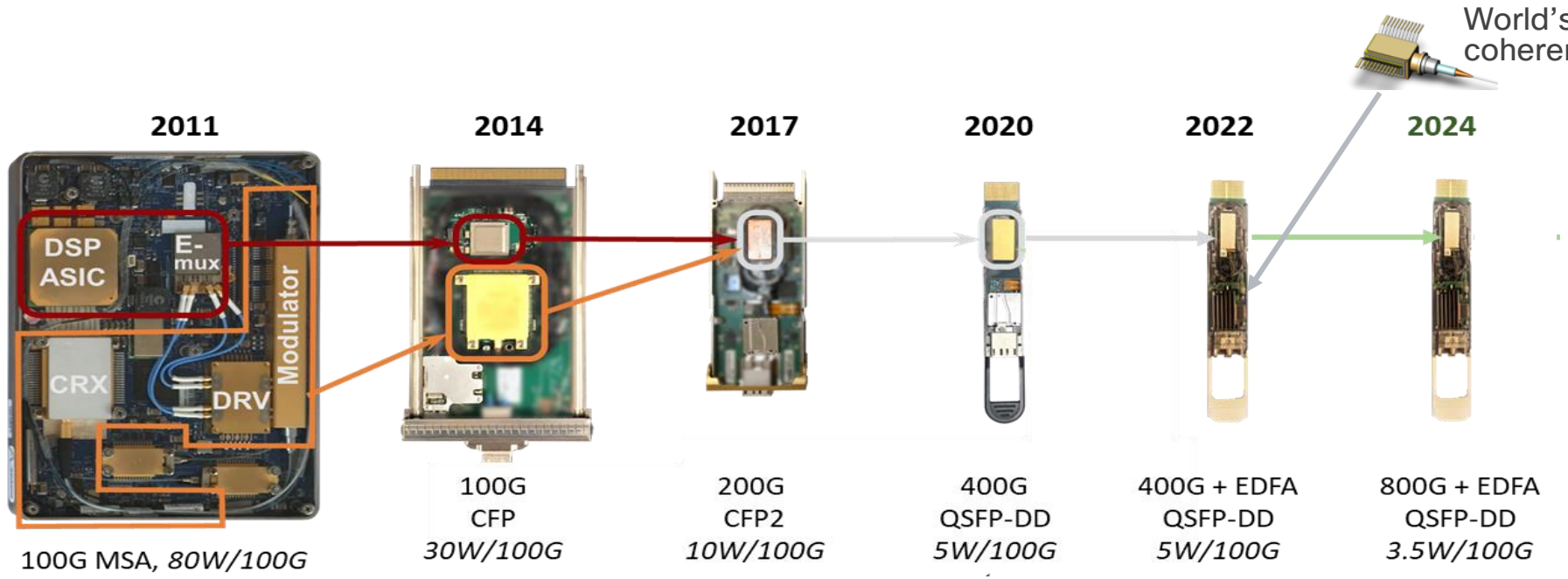
Vertical Integration is Key to Lowest Cost and Best Performance



In-House:	DSP	+ SiPh Optics	+ OE-MCM	+ ASIC	+ Laser 100% Vertical
QAM:	QPSK	QPSK	16QAM	16QAM	PCS
CMOS:	40nm	28nm	16nm	7nm	4/3nm
Optics:	Discrete, InP, LiNbO3	SiPh	SiPh	SiPh	SiPh

Cisco is the only company that is 100% Vertically Integrated today

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Approaches of Coherent Implementation

2014 2016 2020 2024

MSA Pluggable (aka DCO)

Industry's first pluggable coherent module (100G CFP)

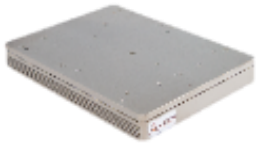
100G/200G CFP2-DCO

400G pluggable portfolio in QSFP-DD, OSFP and CFP2

800ZR/ZR+ and 400G ULH pluggables – QSFP-DD & OSFP

Deployed in router/switches and transport platforms (e.g., 8K, ASR9K, NCS, Nexus 9K etc.)

Performance Optimized



400G multi-haul module (AC400)

1.2T Coherent Module (AC1200)

Industry's first 1.2T coherent multi-haul pluggable (CIM8)

Deployed in transport platforms (e.g., NCS 1004, 1014 etc.)

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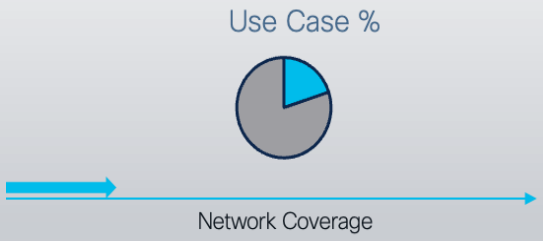
400G QSFP-DD Digital Coherent Optics Portfolio

ER1

Point to Point
Intra-data center, campus interconnect, core-to-edge router

Lowest Cost
Based on fixed laser with simple point-to-point connectivity

Short Reach
Up to 45KM for unamplified at 13dB

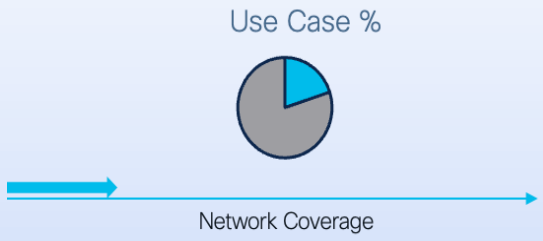


ZR

Point to Point
Web, Data Center Interconnect, Non-SP/SP router interconnect

Low Cost
Lowest cost 400G DCO option for very simple designs

Short Reach
Up to 120KM for P2P amplified links

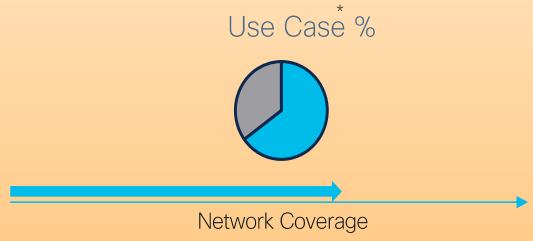


Bright ZR+

Transport Centric
WebService Providers, Routed Optical Networking

High TX Power
+1dbm for difficult spans; interop with brownfield transponder & legacy line systems

Advanced Features
TOF, OTN and L1 Encryption features; integrated optical amplifier

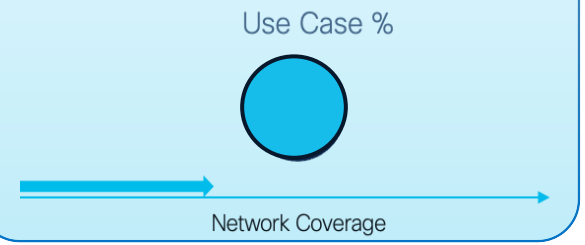


400G ULH

Transport Centric
Service Providers, Routed Optical Networking

Long Haul Optimized
400G with **RON Anywhere** up to 3000km, high Tx power

Power Optimized
Designed to fit in all routers support 400G Bright ZR+ today



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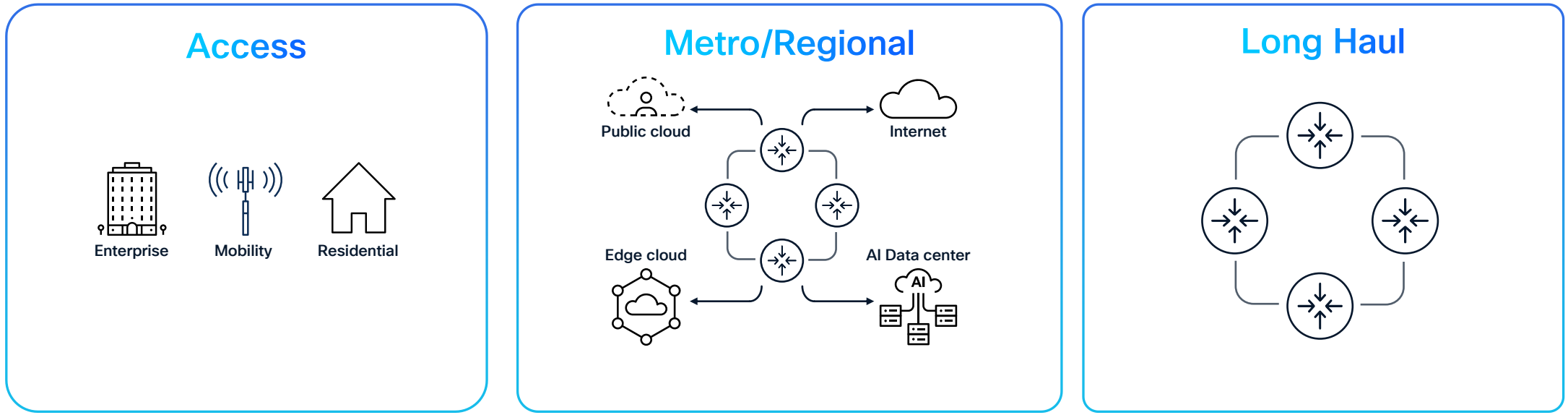
Expanding Pluggables to Access & Long-Haul networks ..



100ZR QSFP28: interop with Bright

400ULH – interop with Bright

Shipped 600K+ 400G pluggable ports (400ZR/ZR+/Bright)

800ZR/ZR+: Improved W/G, $/G

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Cisco 400G Ultra Long-Haul (ULH) Module

GA

400G High Performance module suitable for regional, long haul and subsea use cases

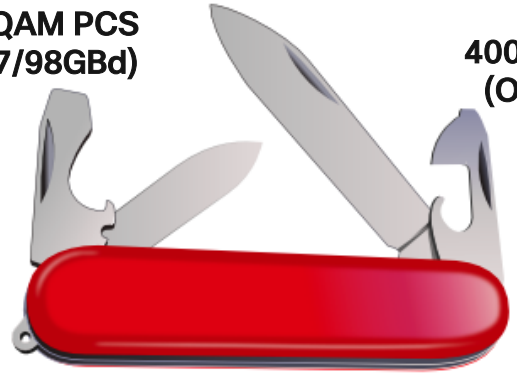
Cisco 400G QSFP-DD ULH (DP04QSDD-ULH-A1)

Designed for existing host platforms with same electrical interface (8x56G SerDes) and power <24W

400G QPSK (OpenROADM)

400G 16QAM PCS (66/75/87/98GBd)

400G 16QAM (OpenZR+)



Feature rich – integrated amplifier & TOF (Tx power +1dBm), C & L band variants, CMIS 5.3 compliant

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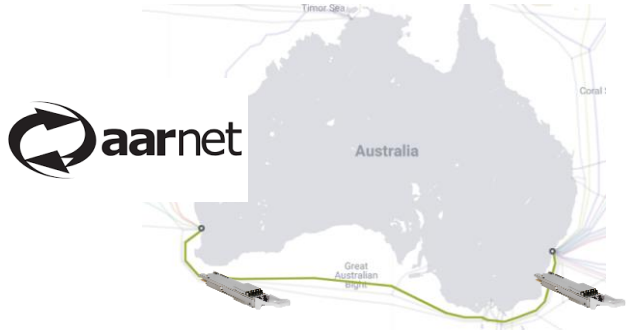
400ULH: Successful Field Trials*

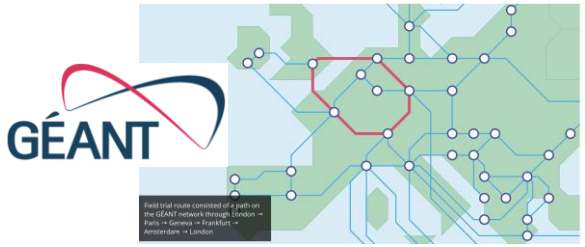
AARNet: 4,600km Link

- Sydney-Perth Indigo Central subsea cable
- 75Gbaud transmission



GÉANT: 3403km Link

- London → Paris → Geneva → Frankfurt → Amsterdam → London
- Multiple spans, 7 ROADMs, 42 amplifier sites, 3rd party OLS
- 118GBaud,150GHz spacing



Internet2: 3000km Link

- Albany-Indianapolis
- Multiple spans, multiple ROADMs, 3rd party OLS
- 118GBaud,137.5GHz spacing

Arelion: 2250km Link

- Denver-Chicago
- Mix of G.652 and G.655, multiple ROADMs, 3rd party OLS
- 98Gbaud, 112.5GHz spacing

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800G Coherent Pluggables

GA

Industry's first DSP compliant to OIF and OpenROADM

MSA

Feature Rich

QSDD & OSFP form factors
C/L Band Variants,
Built in EDFA & TOF

Low Power

Applications

4nm CMOS,
SiPh architecture
<28W (800ZR), <30W (800ZR+)

Metro DCI,
Metro/Regional DWDM
P2P router interconnect

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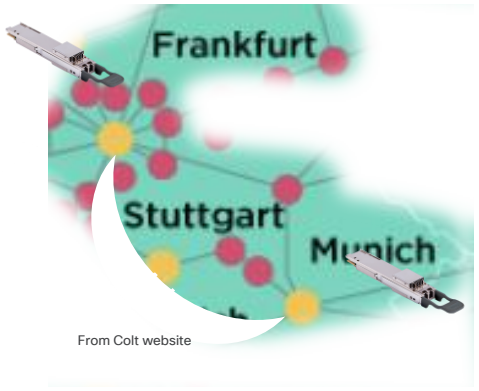
800G ZR+ Successful Field Trials

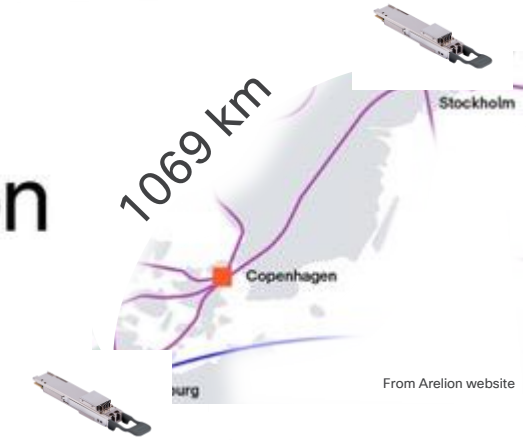
Colt: First Ever 800G ZR+ Field Trial

- Frankfurt-Munich, 634km w/ margin
- Mix of G.652 and G.655 w/ multiple >100km spans, multiple ROADMs



Arelion: First >1000km 800G ZR+ Field Trial

- Stockholm-Hamburg, 1069km w/ margin
- Multiple >100km spans, multiple ROADMs



- Trials used Acacia/Cisco 800G ZR+ QSFP-DD coherent pluggable modules (DCOs)
- Leverages industry standard enhanced performance OpenROADM interoperable PCS mode

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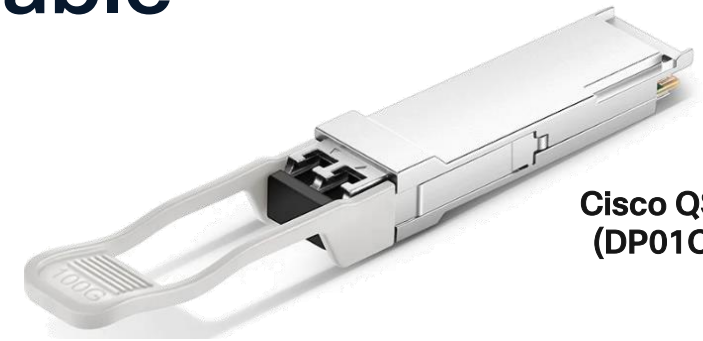
100ZR QSFP28 Coherent Pluggable

Designed for Access, Aggregation, Metro, X-haul, and Campus Interconnect



Cisco QSFP28 100G ZR
(DP01QS28-E20/E25)

GA

Gen 1

- P2P unamplified reach: 80KM
- Amplified reach: 300KM
- Tx power: -8dBm
- Max power <5.5W

Gen 2

- P2P unamplified reach: 140KM
- Amplified reach: 500KM
- Tx power: 0dBm
- Max power <6W

iTemp variant available for deployment in outdoor plants and environment

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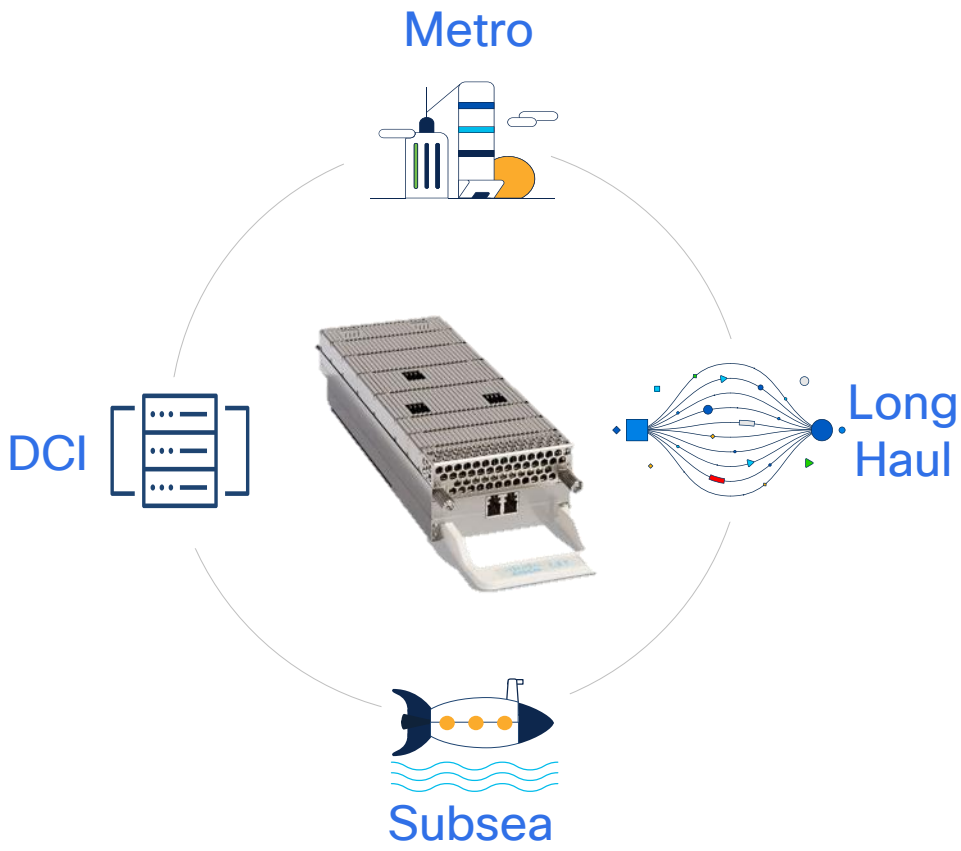
First Pluggable to Break into the Terabit Era

Coherent Interconnect Module 8 (CIM 8) powered by Jannu DSP

20%+ performance with 3D shaping – 800G covers 90% of network

65% lower power than competition

3D Siliconization packaging



2.4Tbps Transponder

NCS 1014 Next-Gen compact modular shelf

Single carrier 140Gbd 1.2T faceplate pluggable

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Top Networks Are Adopting Our Technology

NCS 1014 Industry Leading Performance

verizon

Commercial fiber network with 1Tbps across 14x spans

windstream wholesale

1 Tbps wavelength over a 1,100 km link across Windstream's Intelligent Converged Optical Network

Microsoft

800Gbps on the Amitié transatlantic communications cable

aarnet

Longest distance 400 Gbps transmission trial on the Indigo subsea cable system; 18,400 km from Sydney to Singapore

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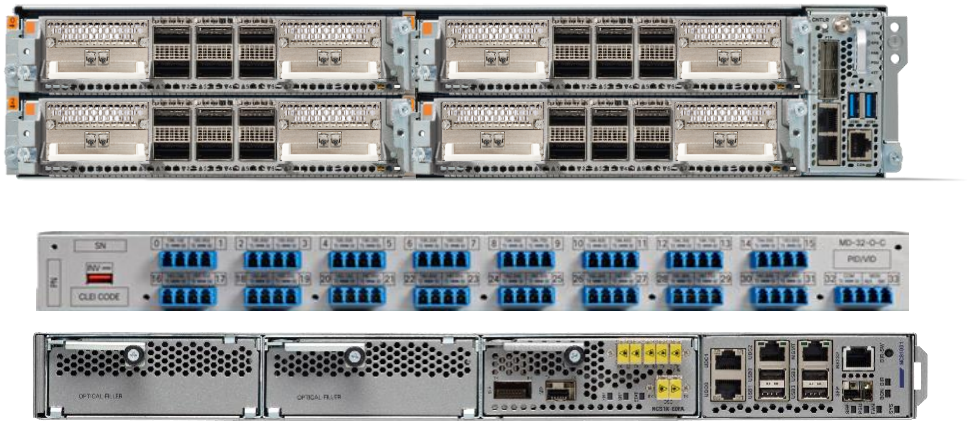
Cisco Optical Transport

MOFN Optical Transport Solution Offerings

Solution #1: 1.2T CIM8 Module

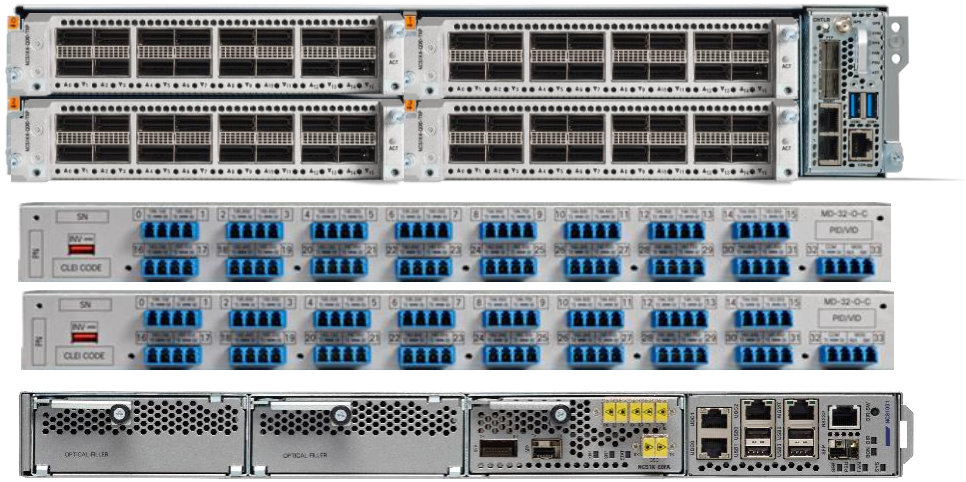
NCS 1014 2.4T Transponders with NCS 1001 Line Systems
Managed by Cisco Optical Network Controller



- 9.6T in 2RU
- 32x1.2T, 38.4T/fiber pair best capacity (C band)
- 4 x NCS1014 per fiber pair

Solution #2: 400ZR/ZR+ Coherent Pluggables

NCS 1014 3.2T Transponders with 400ZR optics and Cisco or 3rd party OLS
Managed by Cisco Optical Network Controller



- 12.8T in 2RU
- 64x400G, 25.6T/FP (C band), 2 x NCS1014 per FP
- Highest density
- Low power consumption

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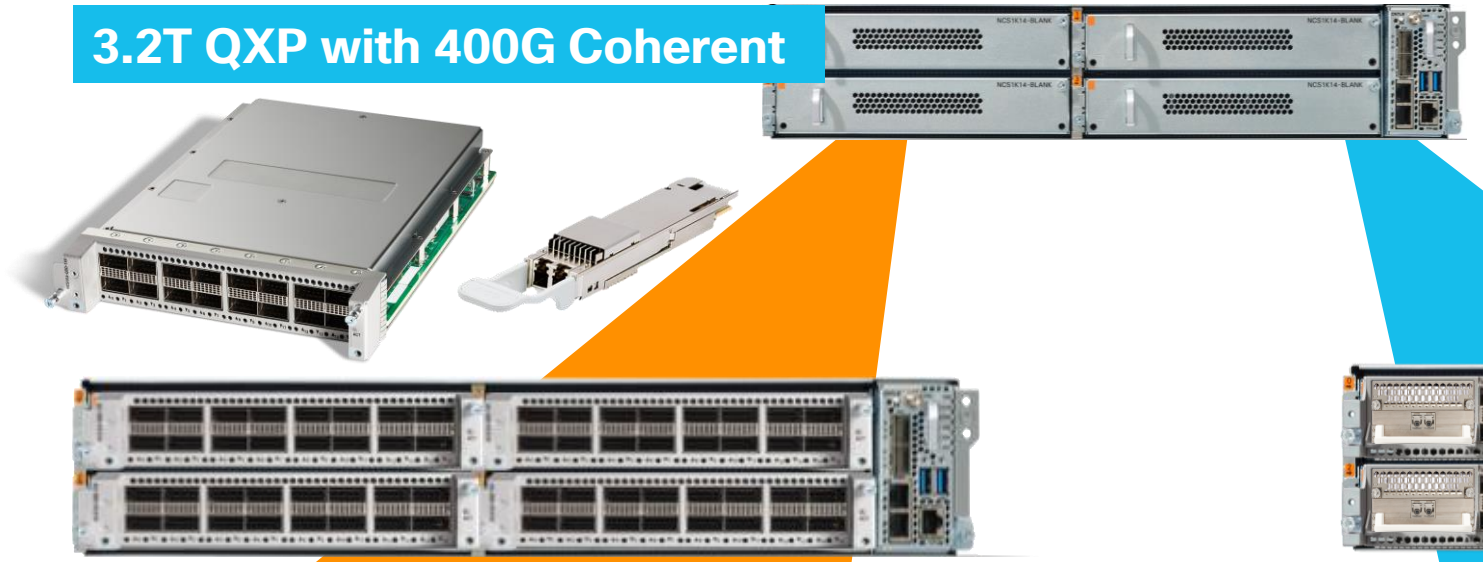
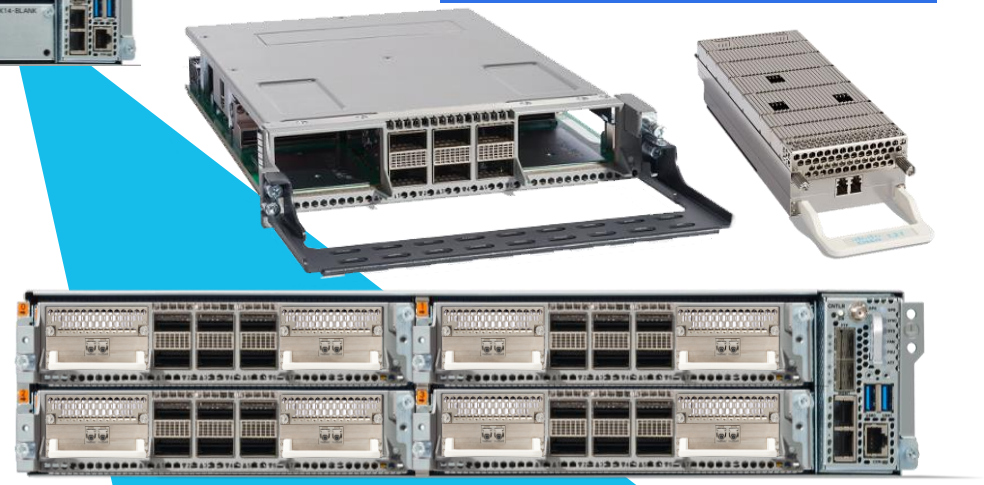
NCS 1014 Optical Transport Solution

3.2T QXP with 400G Coherent



- 400ZR, 400ZRP, 400G-ULH*
- 100GE, 400GE
- Wire-speed Line Encryption*
- C-Band, L-Band support*
- 8x TXP/MXP/Regen* per card – 32x per shelf
- In-built PRBS testing
- QDD-OLS, QDD-OTDR*, QDD-PSM* plugs supported

2.4T TXP with CIM8



- 140GBd 1.2T
- 100GE, 400GE, 800GE
- Wire-speed Line Encryption
- C & L-Band support
- Subsea extended CD support, NLEQ support
- Fast SOP tracking for aerial fibers
- In-built client and trunk PRBS testing

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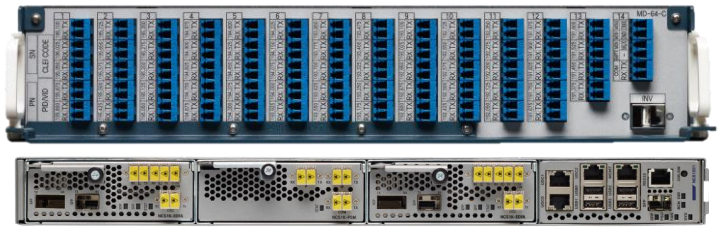
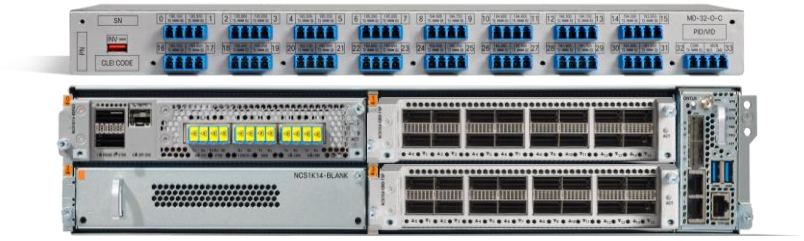
Metro-DCI Line Systems

QDD-OLS



NCS 1001 with MD64



NCS 1014 DCI-OLS with MD32

- Compact
- Built-in OTDR, OCM (NCS 1001, 1014)
- Built-in Coherent Probe and equalization (NCS 1014)
- Different fixed add-drop option – MD32, MD64
- PSM protection (NCS 1001, NCS 1014*)
- QDD-OLS for low-capacity use cases
- NCS 1014 allows TXPs and OLS to be combined in one shelf

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Cisco NCS 1010 C+L Line System

Enhanced Visibility and control

- Equalization Everywhere
- Optical Channel Monitoring (OCM) everywhere
- OTDR everywhere
- ASE loading

Automation First

- ZTP for device turn-up
- Automated E2E link turn-up
- Streaming telemetry

Multi-purpose

- Open Line System
- Spectrum Service Ready
- Terrestrial & SLTE
- HCF ready

Simple & Integrated design

- One degree / ILA per shelf
- Better MTBF
- Easier to deploy

NCS 1010

C+L Long Haul Open Line System

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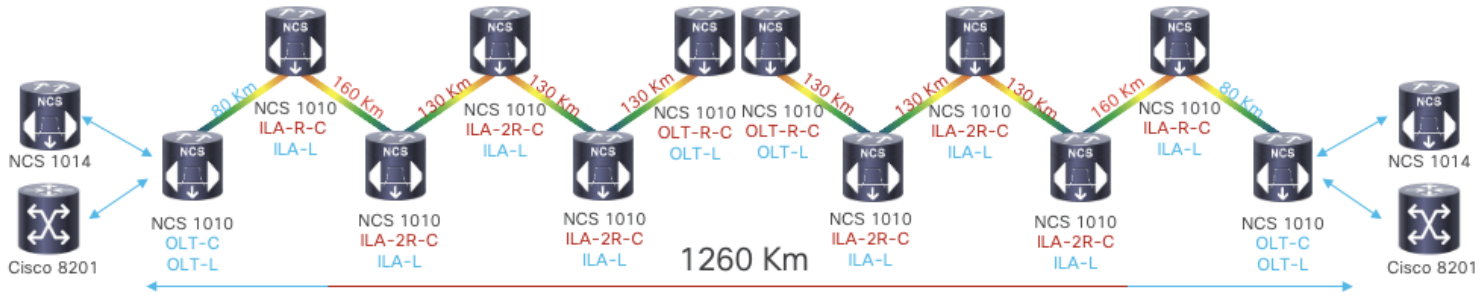
NCS 1014 CIM 8 Delivers 64T for C+L Long Haul

64T (32T in C-Band and 32T in L-Band) with NCS 1014 and Coherent Interconnect Module 8 over NCS 1010 C+L Open Line Systems and *Corning Vascade EX2500 fiber*



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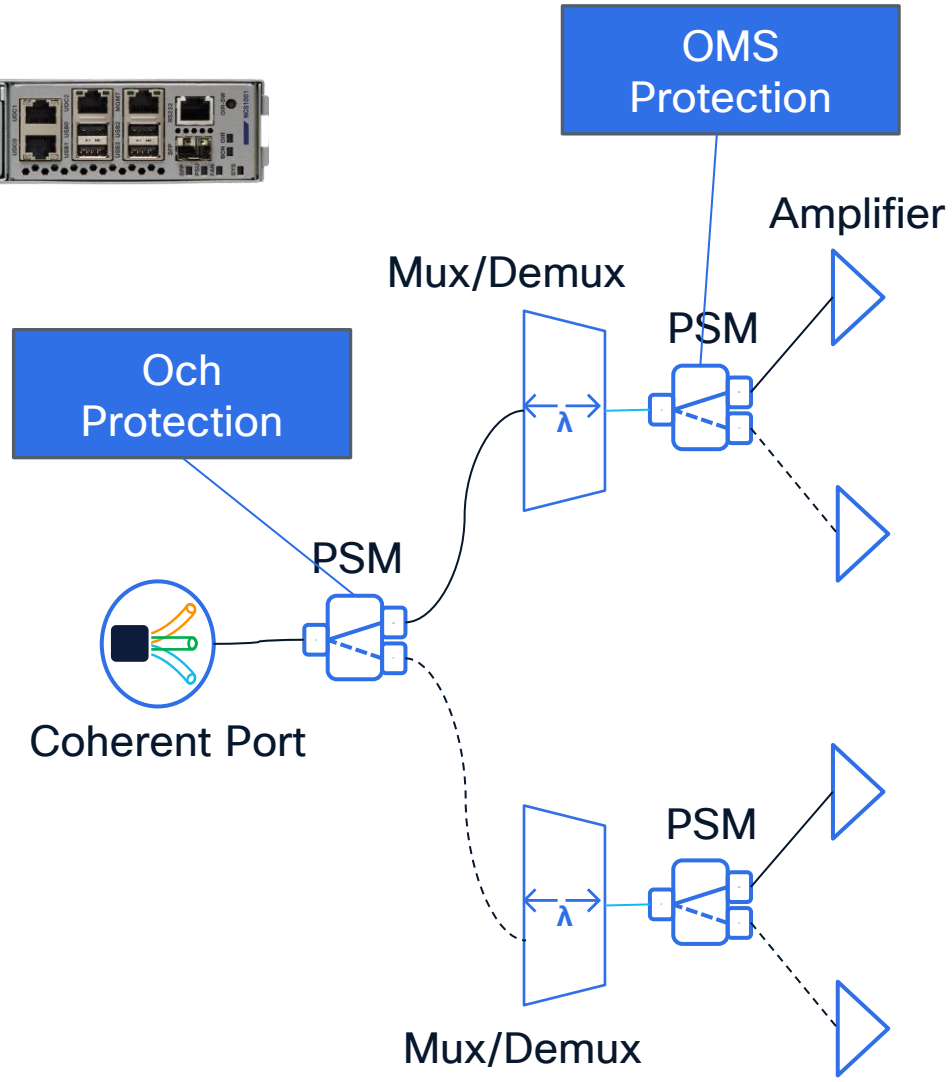
MOFN Optical Transport Protection Options

Optical Protection Options for different customer use cases

- **Optical Channel Protection (with or without restoration)** – mainly used in Long Haul
- **Optical Multiplex Section Protection** – 2-way, 3-way, 4-way – used in metro
- **Optical Transport Section Protection** – 2-way for span protection in Long Haul
- **Client Protection** – E2E protection required by some enterprise customers.



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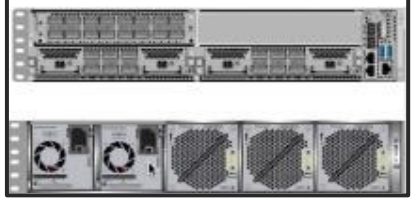
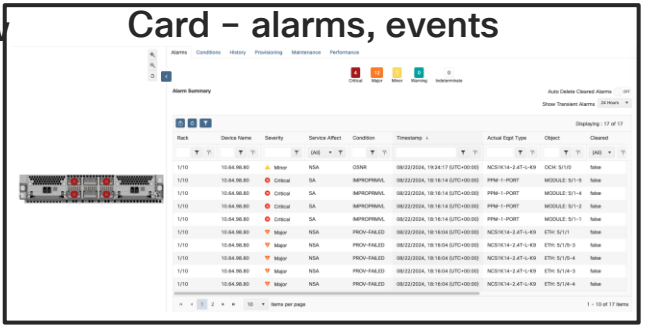
Cisco Optical Site Manager (COSM)

- COSM is a Web UI for NCS1K/2K
  - Run in NCS1K RCP embedded SW (XR) or
  - Run in NCS2K SVO-LC (up to 15 COSM per SVO Controller)
- Rack/Chassis/Module mechanical View
- Visualize Alarms (on chassis/card/port)
- Alarms & events table – Current & History
- Visualize physical and logical Inventory
- Card Mode Configuration vizard (steppers)
- PM Live & Last 32 bins
- PRBS, Loopbacks
- TCA & Alarm profile settings
- SW Database , Upgrade Backup & Restore
- Netconf/YANG NBI

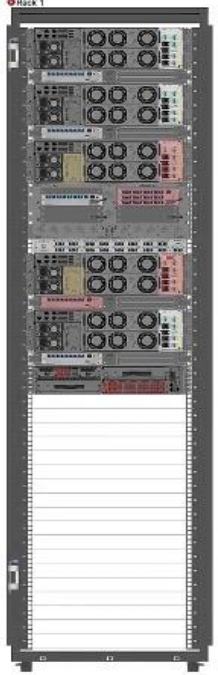
Chassis front/back View



Card – alarms, events

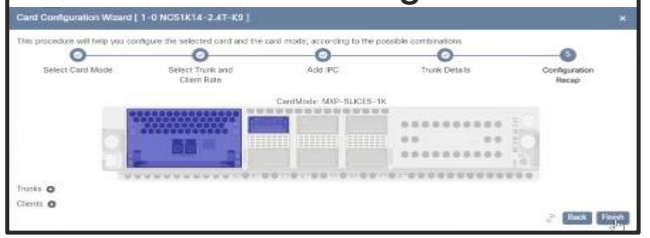


Rack View

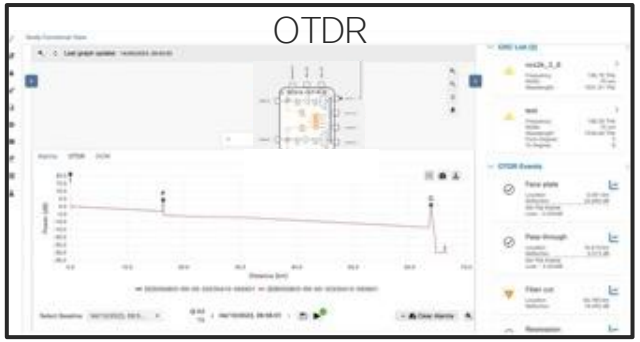


Card View

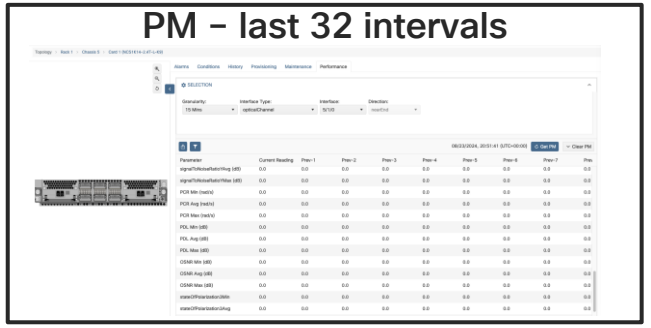
Card Mode Configuration



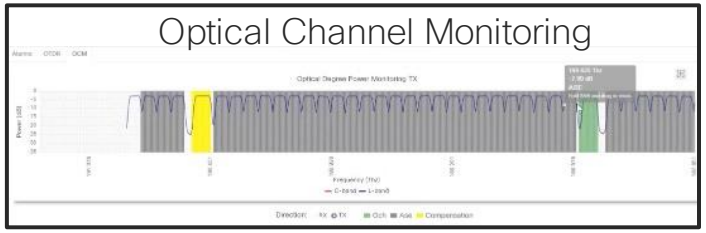
OTDR



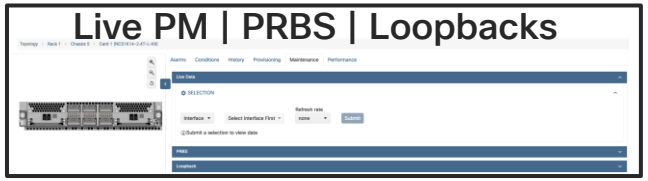
PM – last 32 intervals



Optical Channel Monitoring



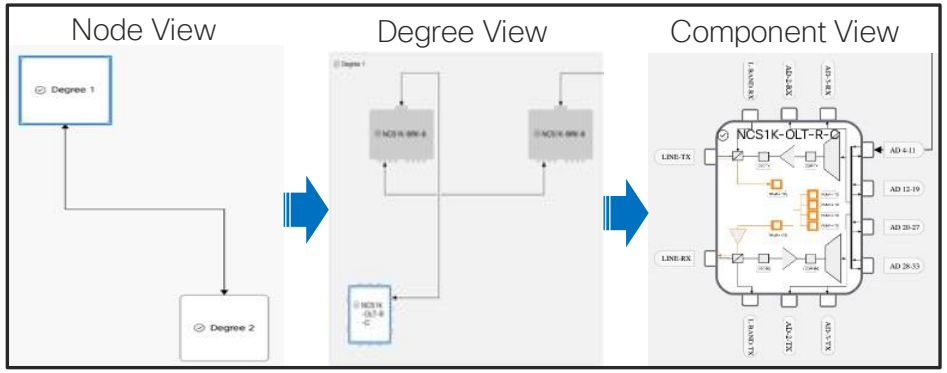
Live PM | PRBS | Loopbacks



Node View

Degree View

Component View



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Cisco Optical Network Controller (CONC)

CONC is web-UI, Microservices K8s software

NCS 1000 and NCS 2000 – available on 25.x

Telemetry & KPI

OUTCOME: *Reduce time to identify anomalies, time to act*

Configuration/Provisioning)

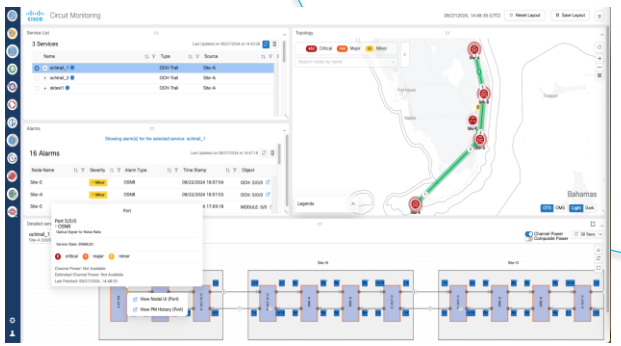
OUTCOME: *Reduce time to monetize, Eliminate errors in provisioning, TAPI or REST NBIs for multi-later orchestration*

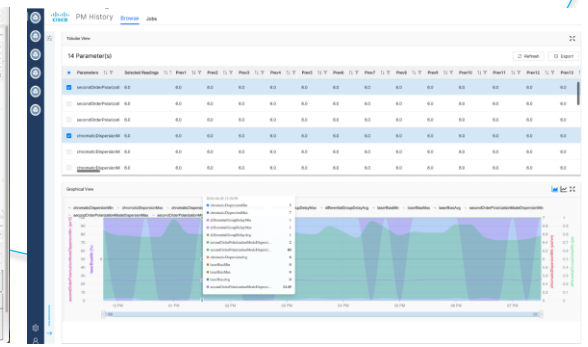
Fault Management

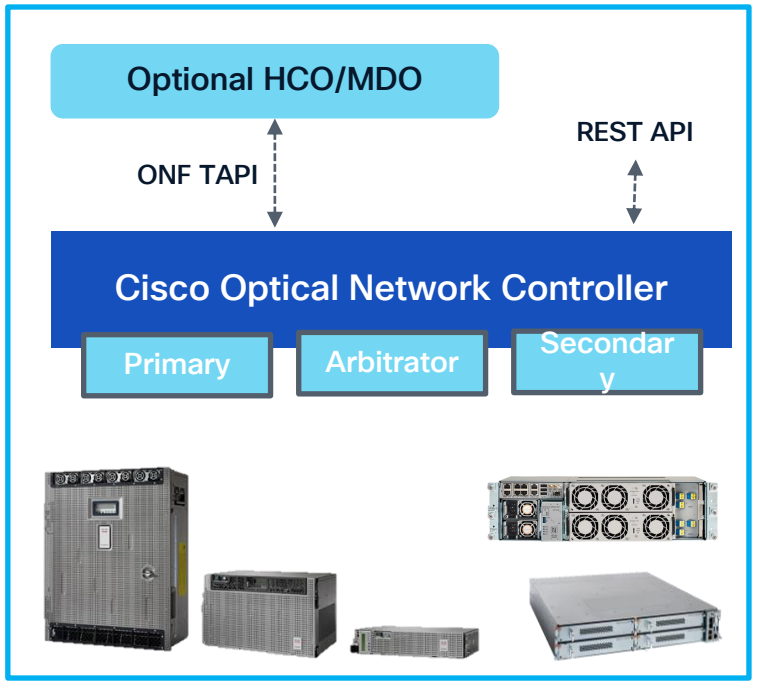
OUTCOME *Reduce time to identify anomaly, time to restore services, time to plan maintenance/growth*

Inventory and Topology Management

OUTCOME *Know your network, simplify operations*







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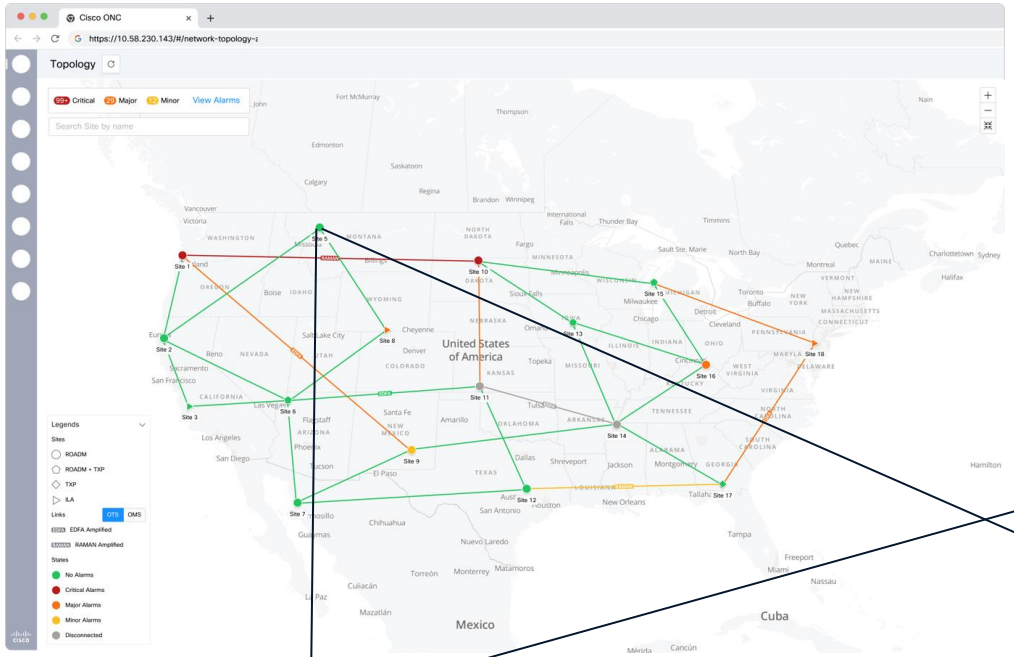
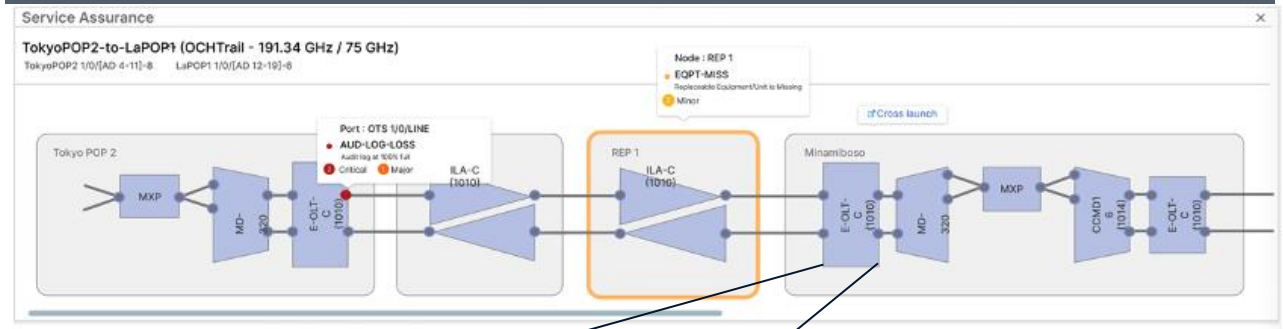
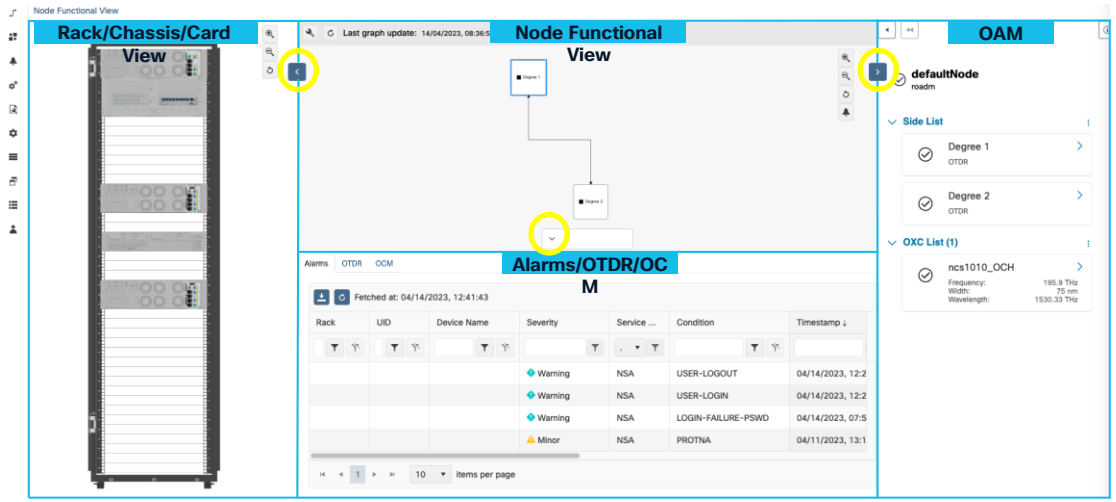
Network: Topology view



Network: Circuit view



Site view



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MOFN Optical Transport Network Planning & Design

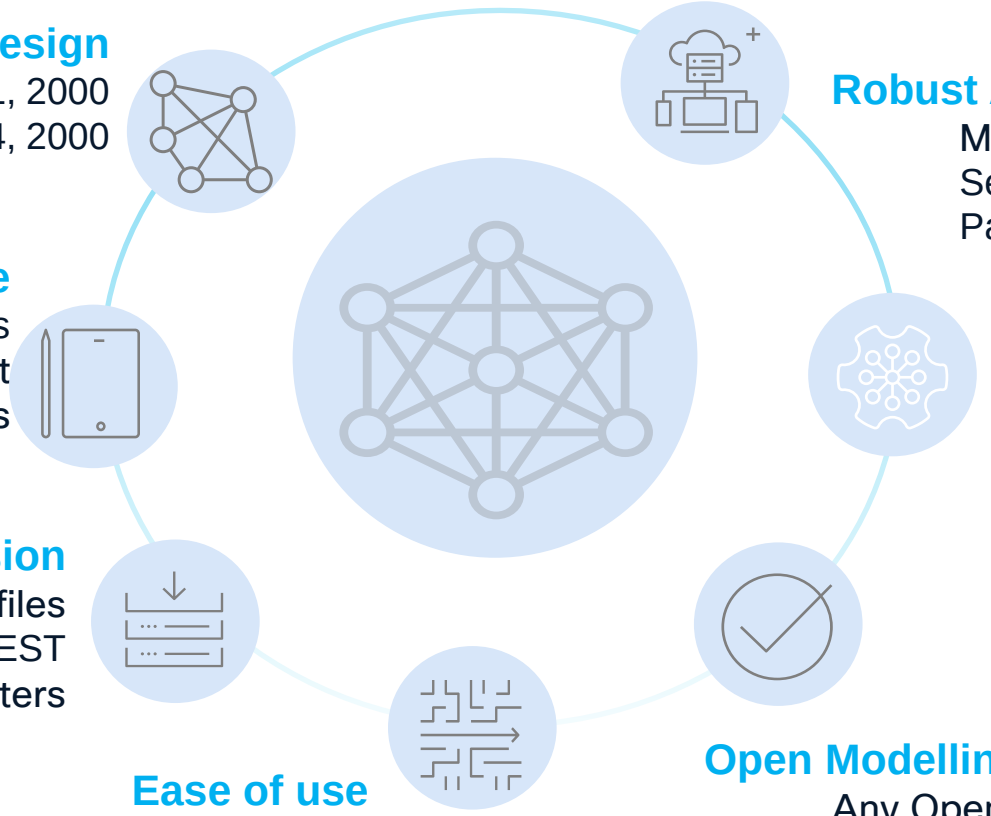
Cisco Optical Network Planner: The Next generation Multi-layer Design and Planning tool from Cisco

Complete Network design
OLS: NCS 1010, 1001, 2000
TXP: NCS 1014, 1004, 2000

Journal: Purchase, Install, Upgrade
Bill of Materials, Optical Results
Connection diagram, Rack Layout
Locked upgrade, Diff reports

Provision
Configuration files
Netconf, COSM/REST
Installation parameters

Ease of use
Forcing Manager
Direct import from CTP



Robust Architecture
Microservices based
Server-based, Multi-user Environment
Path Computation En

Advanced feature set
Failure scenario analysis
Live network import
API support for

Open Modelling
Any Open Optical Source (Alien)
Open Line Systems
Customizable

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Summary

Market Momentum	Explosive growth in AI, DCI traffic; hyperscalers are turning to managed models for scalability and speed of deployment.
MOFN is Win-Win	MOFN delivers scalable, and reliable optical transport to hyperscalers while offloading operational complexities.
Cisco Advantage	End-to-end solution: optics, automation, management, and support with 100% vertical integration

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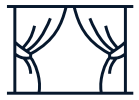

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