

Advancements and Applications of Coherent Pluggable Technology in High Bandwidth Transport Networks

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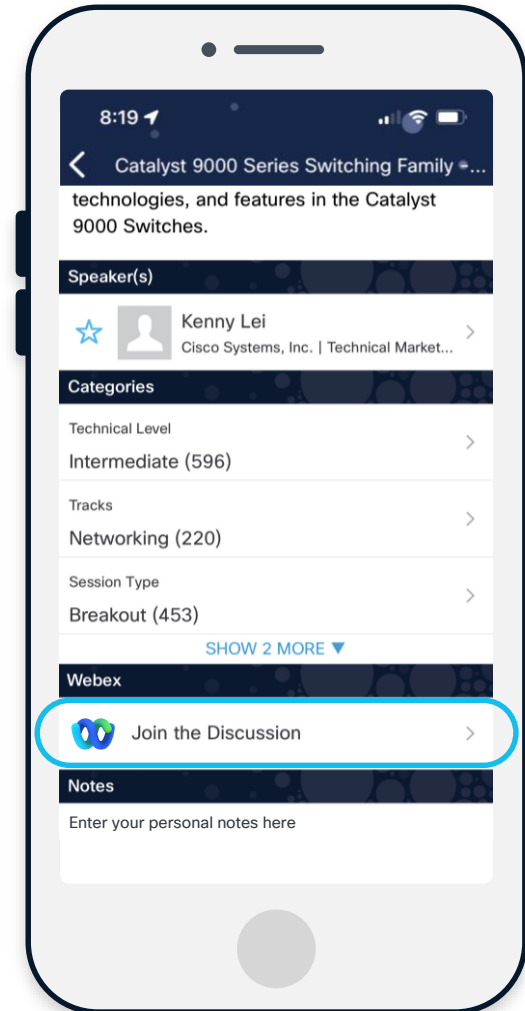
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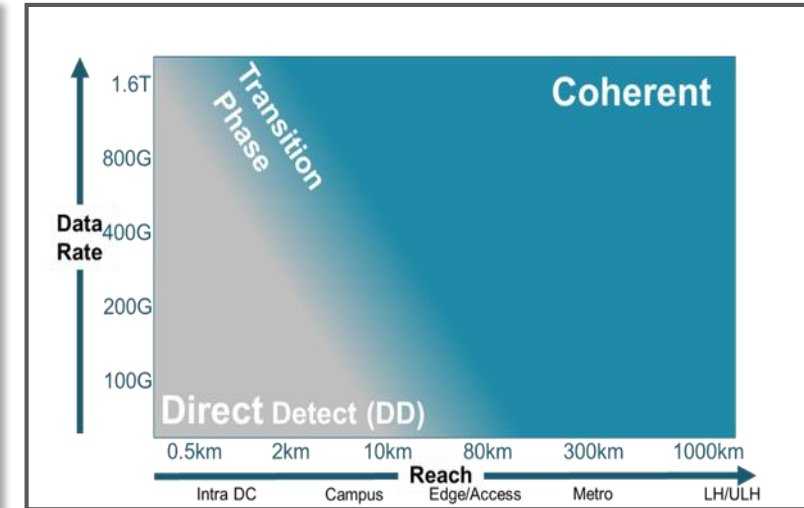
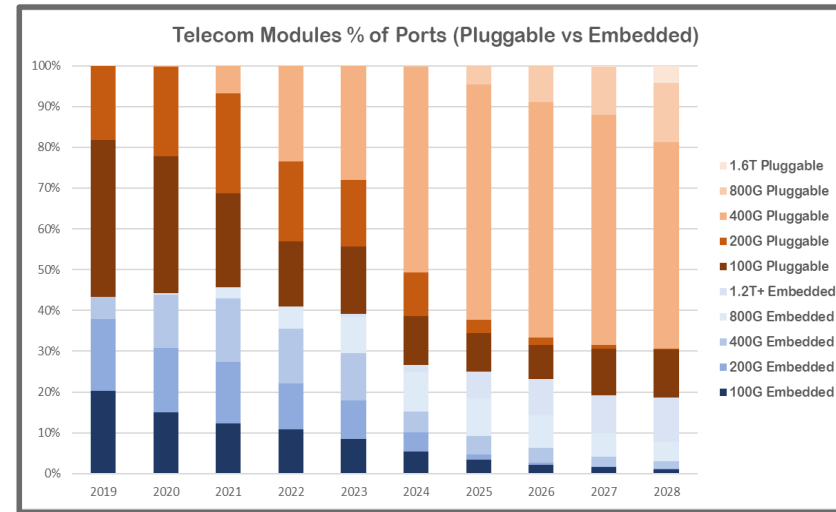
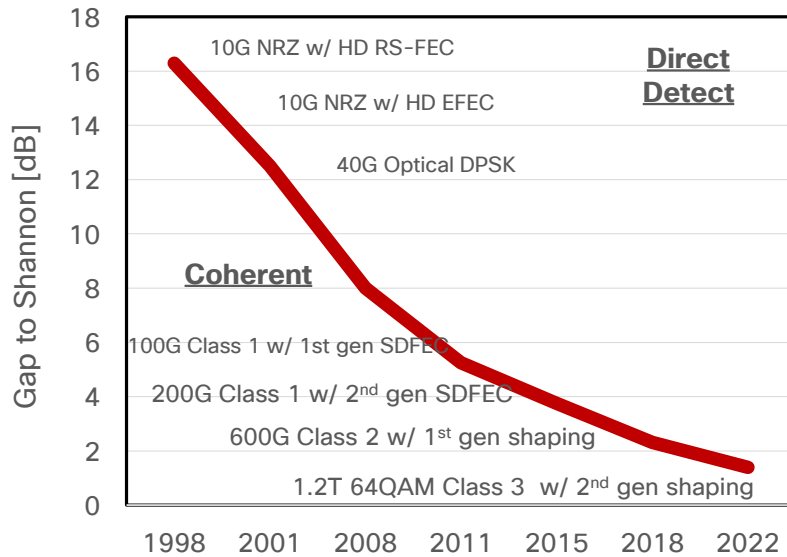


Agenda

- 01 Technology & Market trends**
- 02 Cisco Innovations & Product Portfolio**
- 03 Benefits of Coherent Plugs**
- 04 Product Offerings**
- 05 Customer Use Cases & Applications**

Technology Trends

Trends in Optical Networking



Approaching Shannon Limit

- Incremental improvements in spectral efficiency
- Ongoing investment driven by cost, power, footprint reduction

Shifting trend towards coherent pluggables*

- 400ZRx: fastest coherent product ramp ever
- Gaining share in DCI/Metro

Coherent moving to shorter reach applications

- Higher volume
- Interoperable
- Pluggable

High-volume standardized applications will drive next-generation industry investment

Open Networks

OPEN LINE SYSTEMS

Any vendor-coherent transponder or spectrum connects into line system



ALL Cisco line systems are OPEN

OPEN COHERENT INTERFACES

Interoperable standards-based coherent DWDM interfaces supported in MSA standard form factor



Cisco committed to driving OPEN standards

OPEN MANAGEMENT

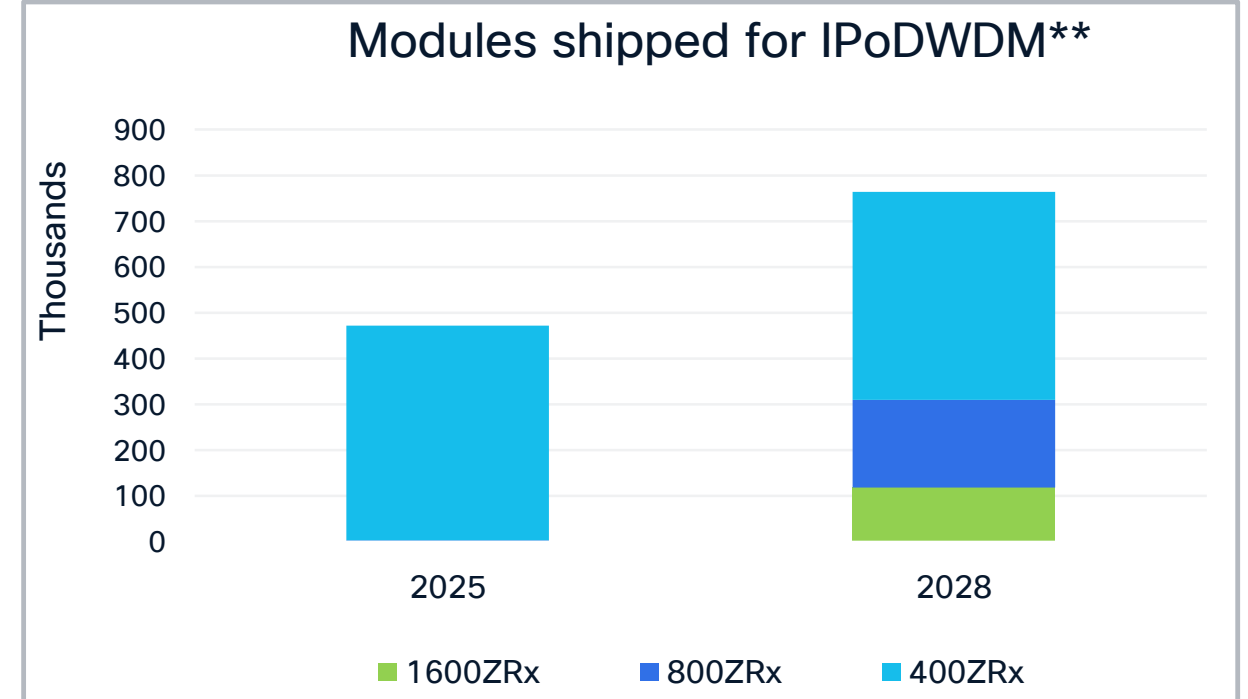
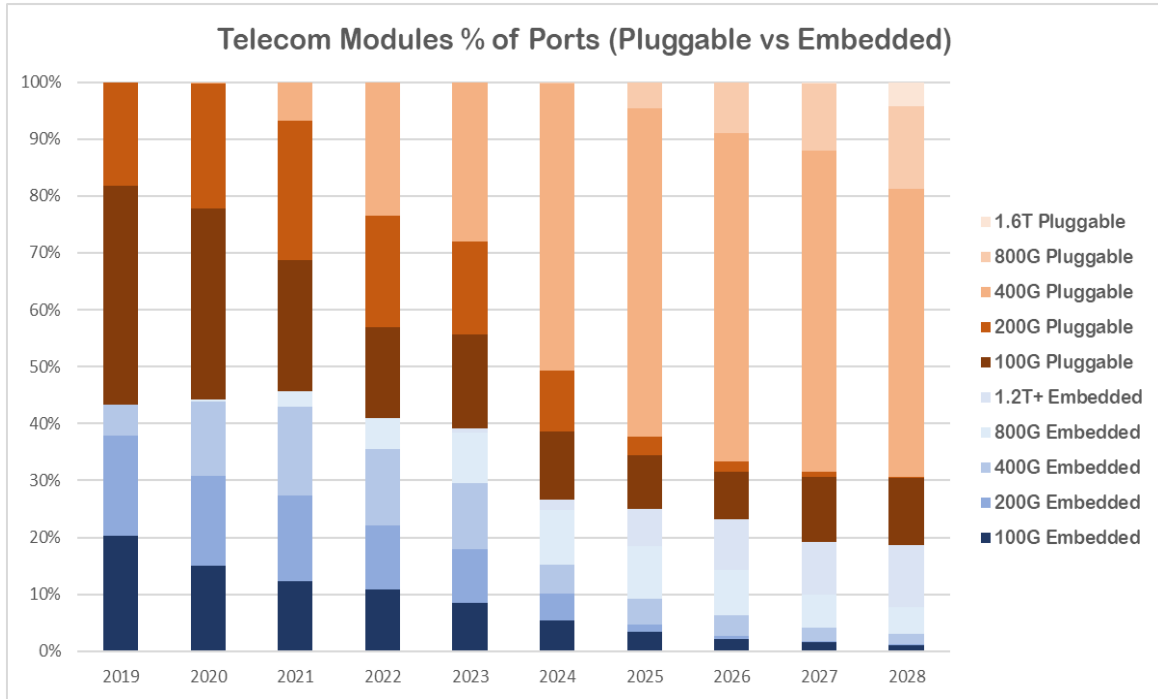
Vendor-neutral device management; multi-layer, multi-domain, multi-vendor management



Cisco participates in key forums and developing MGMT support

Market Trends

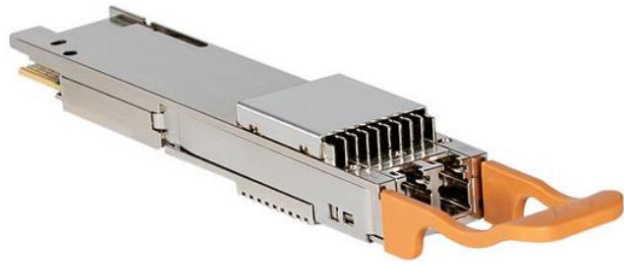
Big Opportunity and rise of “Coherent Pluggables”



Today >70% of the coherent ports are pluggable coherent optics*

Cisco/Acacia is pioneer and market leader for coherent pluggables

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

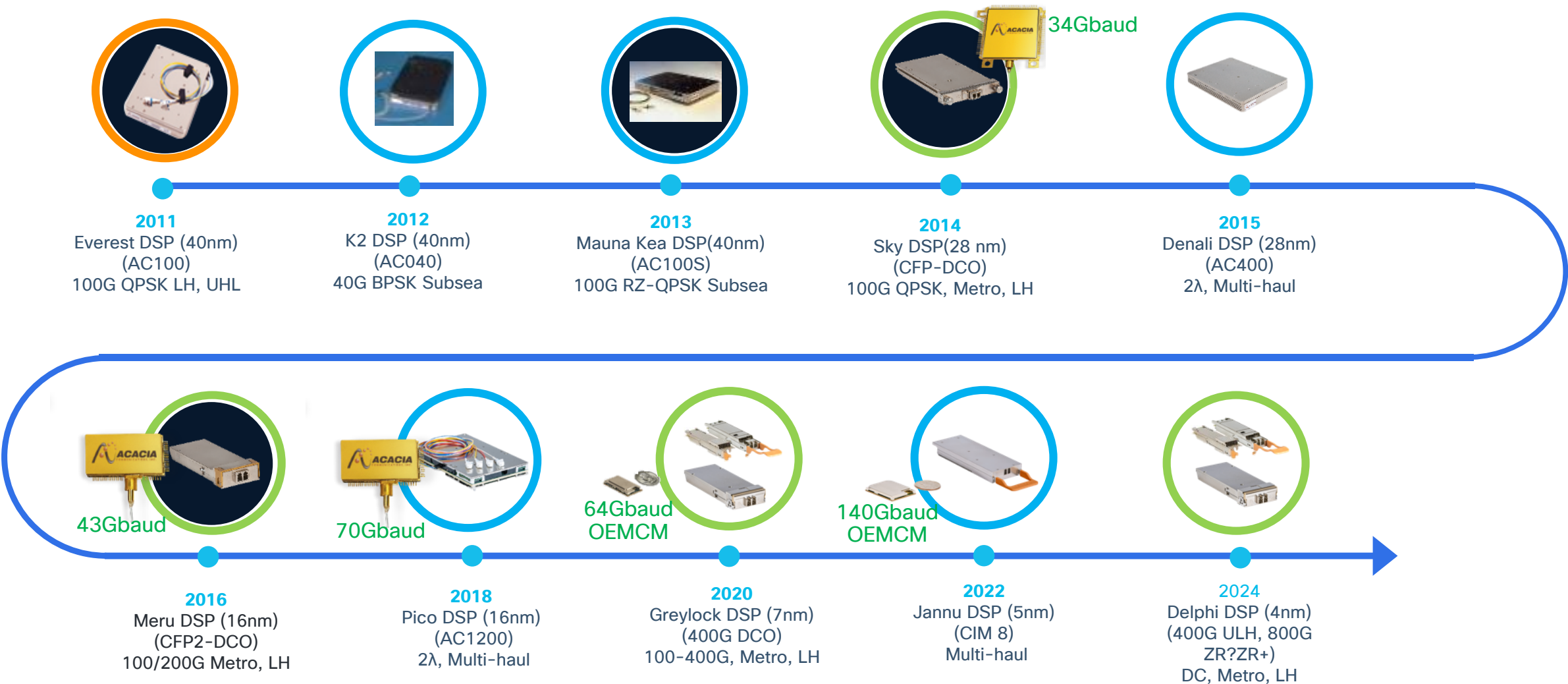
04

Drives interoperability

MSAs/standards, best in breed adoption

Cisco/Acacia Innovations

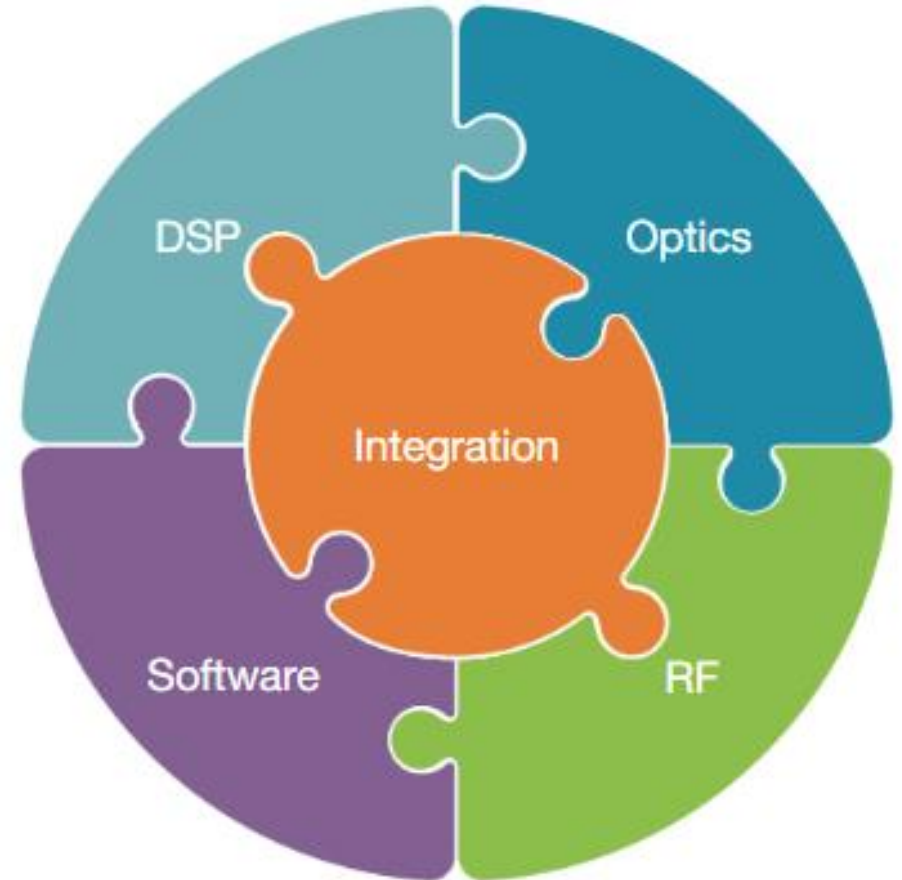
Acacia Coherent Technology Innovation



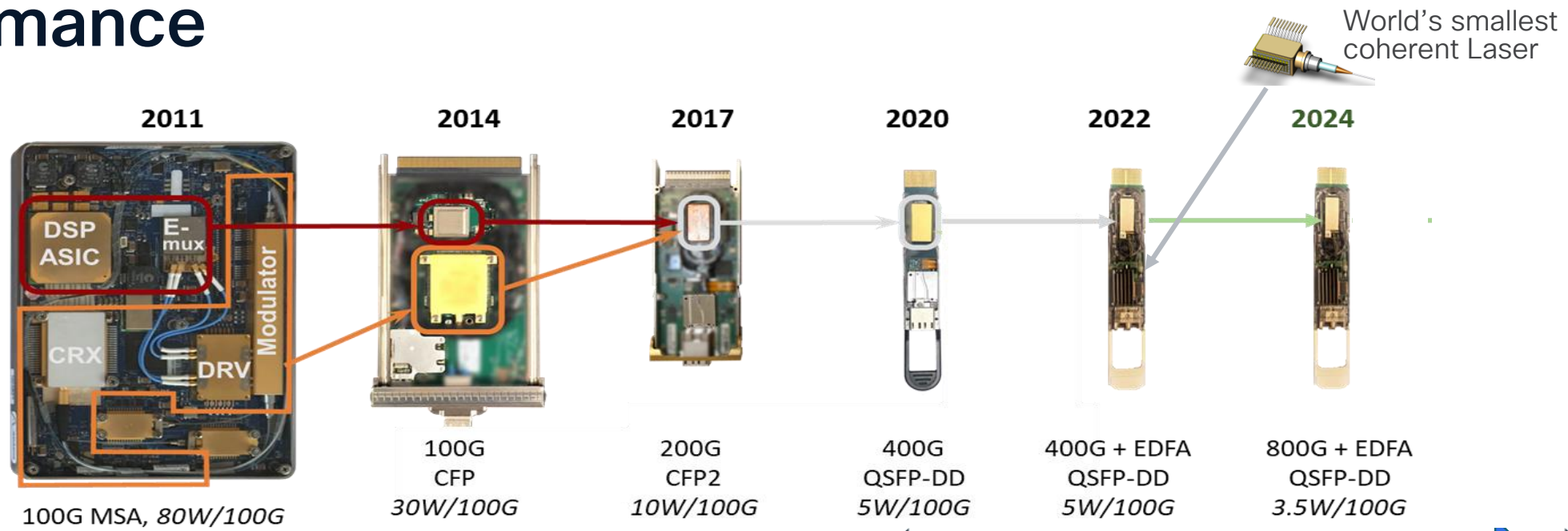
Acacia is part of Cisco

- Leader in Coherent Optical Technology
 - >25% coherent port market share worldwide
- Diverse markets served
 - DCI, Metro, Long-Haul, LEO, Submarine, Access, Campus
- 100% Vertically Integrated
 - In-house key components: DSP/ASIC, Optics, RF
 - Advance 3D packaging

¹Signal AI as of 2Q24



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

Cisco Coherent Optics Value Proposition

Pioneer in Coherent Pluggables

- 4th generation DSP for MSA coherent pluggables
- Market leader in 400G pluggable ports

Industry leading performance

- Low power consumption
- Designed for C/CD/CDC ROADMs architectures

Best in class Quality

- Very high MTBF
- 100M+ service hours without failure for Bright ZR+

100% Vertically Integrated

- In-house DSP, PIC, Laser, RF components

Scalable and Reliable Global Supply Chain

- Fabless manufacturing
- Scalable module build/test capacity to meet demand

Product Offerings

Approaches of Coherent Implementation



MSA
Pluggable
(aka DCO)



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



100G/200G CFP2-DCO



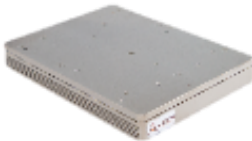
400G pluggable portfolio in QSFP-DD, OSFP and CFP2



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.)

Comprehensive 400G MSA Pluggables Portfolio

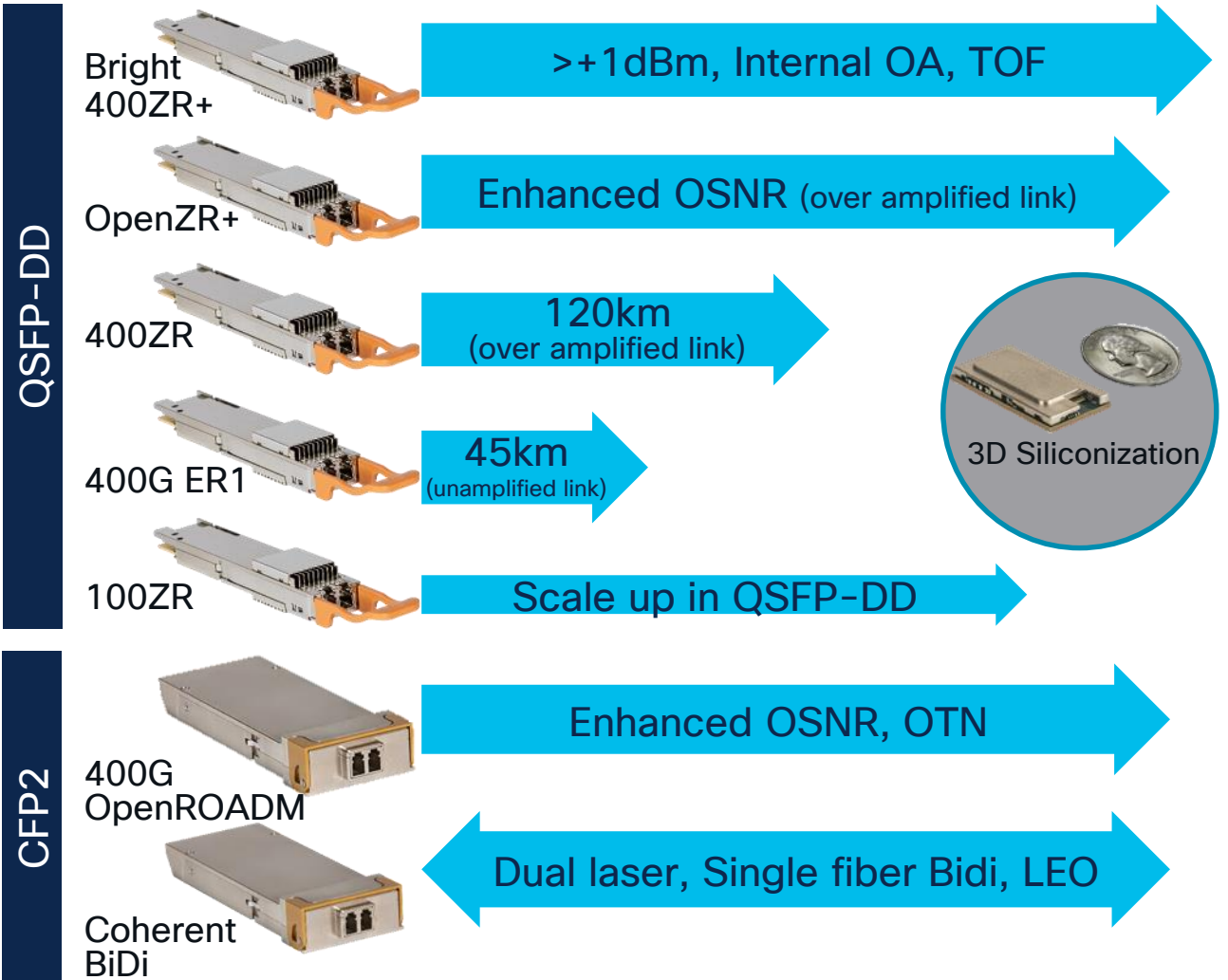
Industry leading 400G
pluggable deployments - 500K+*

Best in class quality

Standards compliant

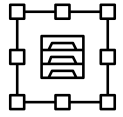


CableLabs®



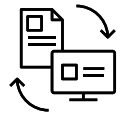
400G QSFP-DD Digital Coherent Optics Portfolio

ER1



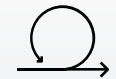
Point to Point

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

Use Case %



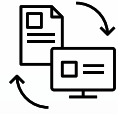
Network Coverage

ZR



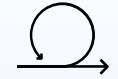
Point to Point

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



Low Cost

Lowest cost 400G DCO option for very simple designs



Short Reach

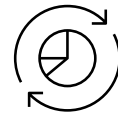
Up to 120KM for P2P amplified links

Use Case %



Network Coverage

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

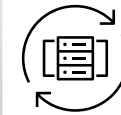
TOF, OTN and L1 Encryption features; integrated optical amplifier

Use Case %



Network Coverage

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

Use Case %



Network Coverage

Next-Generation Coherent MSA Pluggables

Powered by Delphi DSP



Welcome to the Next-Gen Coherent Pluggables!

- Latest 4nm CMOS process
- Up to 131 Gbaud Optics
- 1st to support interop PCS 800G ZR+ (OpenROADM) and OIF 800ZR modes
- Supports CMIS 5.3
- C & L Band

800ZR

800G ZR+ (Interop PCS, +1dBm)

400G Ultra Long Haul

Silicon Based

Delphi
DSP
800G



OIF

OpenZR+
MULTI-SOURCE AGREEMENT

OpenROADM

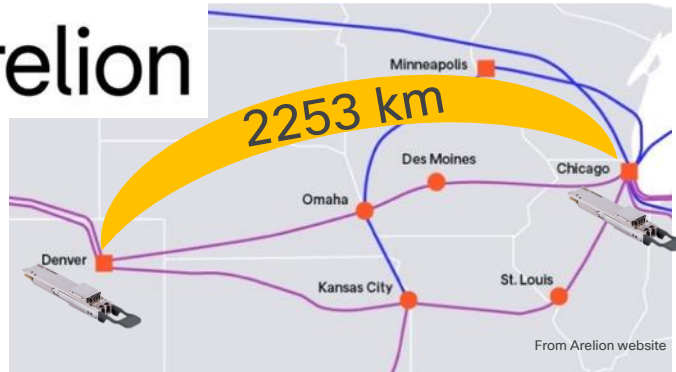
400G ULH QSFP-DD Field Trials

Enables Ultra Long-Haul Routes

Arelion: 2,253km Link

- Denver-Chicago, w/ margin
- 112.5 gigahertz spectrum
- 400G ULH pluggables
- Cisco 8000 series routers

*Arelion



Reduces
Costs

35%
CAPEX

84%
OPEX

Internet2: 3,000km Link

- Albany-Indianapolis
- 400G ULH pluggables
- Cisco 8000 series routers
- Third-party OLS



Reduces
Power

68%*

* Enabled by optical and routing advancements

800G ZR+ Successful Service Provider 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



Reduces
Power

33%
compared to 400ZR+

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

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



Reduces
Costs

66% 95%
CAPEX OPEX

400G Pluggables Specs Comparison: Today & Future

		400ULH	Bright ZR+
Data rate	Baudrate/Format	Modes	Modes
400G	PCS Modes	✓	
	66Gbd - 118Gbd	✓	
	60Gbd 16QAM	✓	✓
200G	60Gbd QPSK	✓	✓
100G	30Gbd QPSK	✓	✓

→ 400G ULH with PCS provide multiple line side modes for different reach/capacity requirements

400G ULH provides 1.5x performance wrt Bright ZR+ in same channel plan (76 GHz)

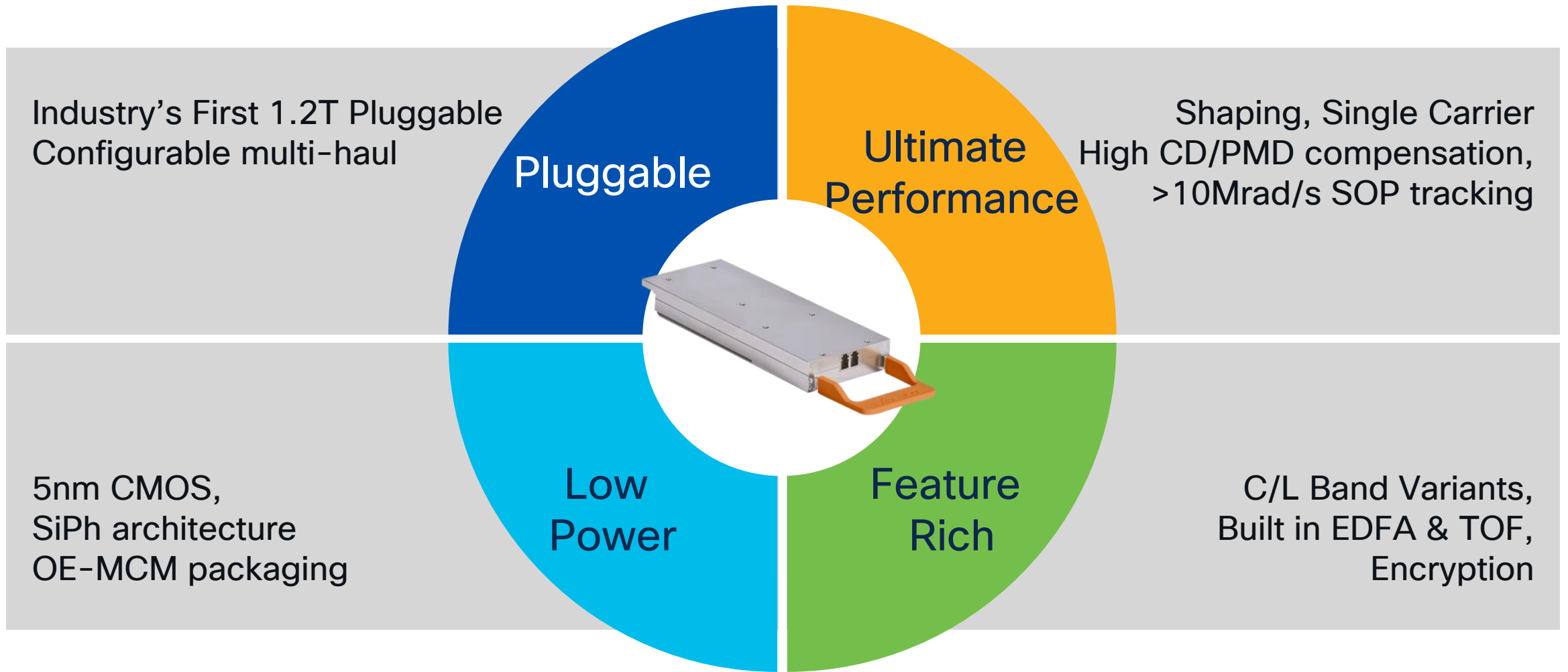
→ Backward compatible with Bright ZR+ in OpenZR+ 2.0 modes

400G ULH modes with Delphi

OpenZR+ 2.0 MSA modes

Performance Optimized Coherent: CIM 8

Coherent Interconnect Module 8 (CIM 8)



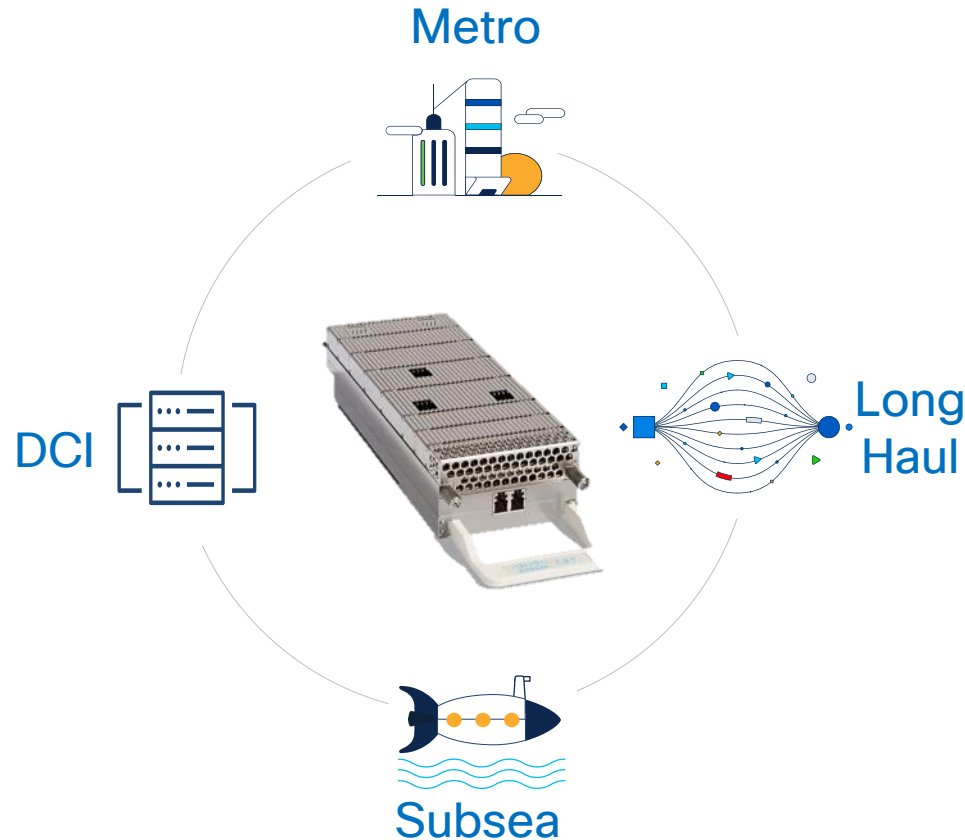
First Pluggable to Break into the Terabit Era

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

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



800Gbps on the Amitié transatlantic communications cable



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

NCS 1014 CIM8 Delivers 64T for C+L Long Haul



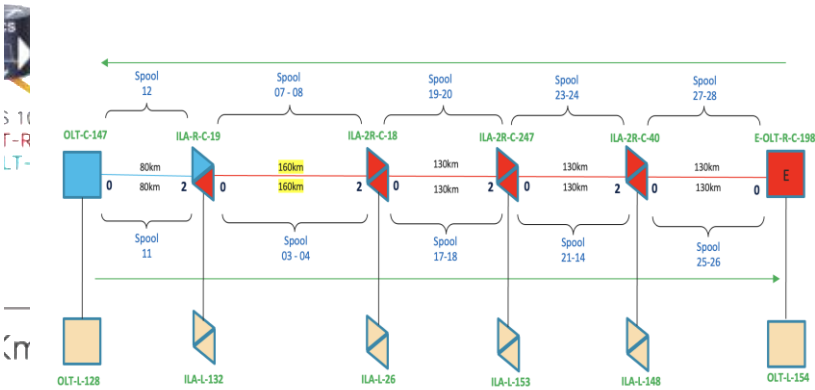
64T (32T in C-Band and 32T in L-Band) with NCS 1014 and CIM8 over NCS 1010 C+L Open Line Systems and *Corning Vascade EX2500* fiber

Demo 3: NCS 1010 LH



Rack 1 - Front Rack 2 - Front Rack 1 - Back Rack 2 - Back

Demo 3: Fiber Spool per Span + Direction



**Cisco Service Provider**
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Cisco achieves cutting-edge 64 Tbps data transmission on 1260 km Corning® Vascade® EX2500 fiber using NCS 1010 and NCS 1014 with CIM 8 at Cisco Packet Optical Networking Conference today.

Learn more about NCS 1014 

<http://cs.co/6043oR4CS>

#CiscoServiceProvider #PONC2024



Applications and Customer Use Cases

Routed Optical Networking Deployments

350+

Customers
Engaged

300+

Customer
deployments

4x

Growth in
deployments

Majority of the RON deployments are over 3rd party line system (Ciena, Nokia, Infinera etc.)

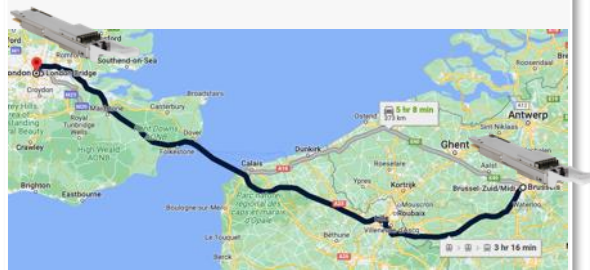
40G DCO Can Go the Distance

SP in EMEA



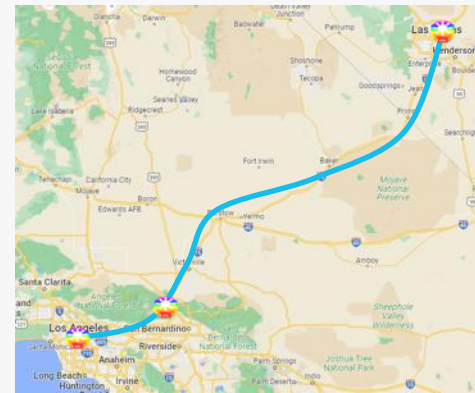
- Bright 400ZR+ QSFP-DD
- Alien λ over 3rd party line system
 - CDC ROADM, EDFA only
- Good deployable margin
- Plug and play!

colt



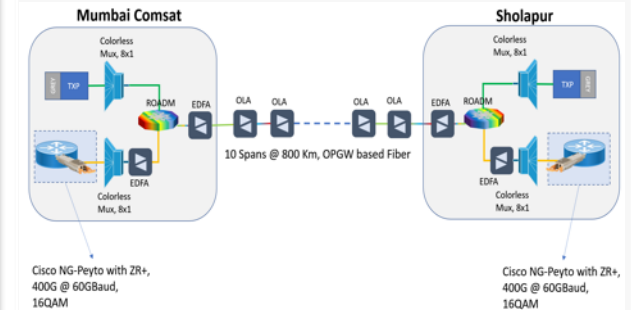
- Bright 400ZR+
- Across the English Channel with challenging high loss span
- Trial 1 at 430km; Trial 2 at 640km
- Good deployable margin

MSO in NA



- Bright 400ZR+ with 8201
- 520km high loss E-LEAF fiber, span > 26.5dB
- Two different OLS vendors
- Error free with margin

Tier 1 SP in India



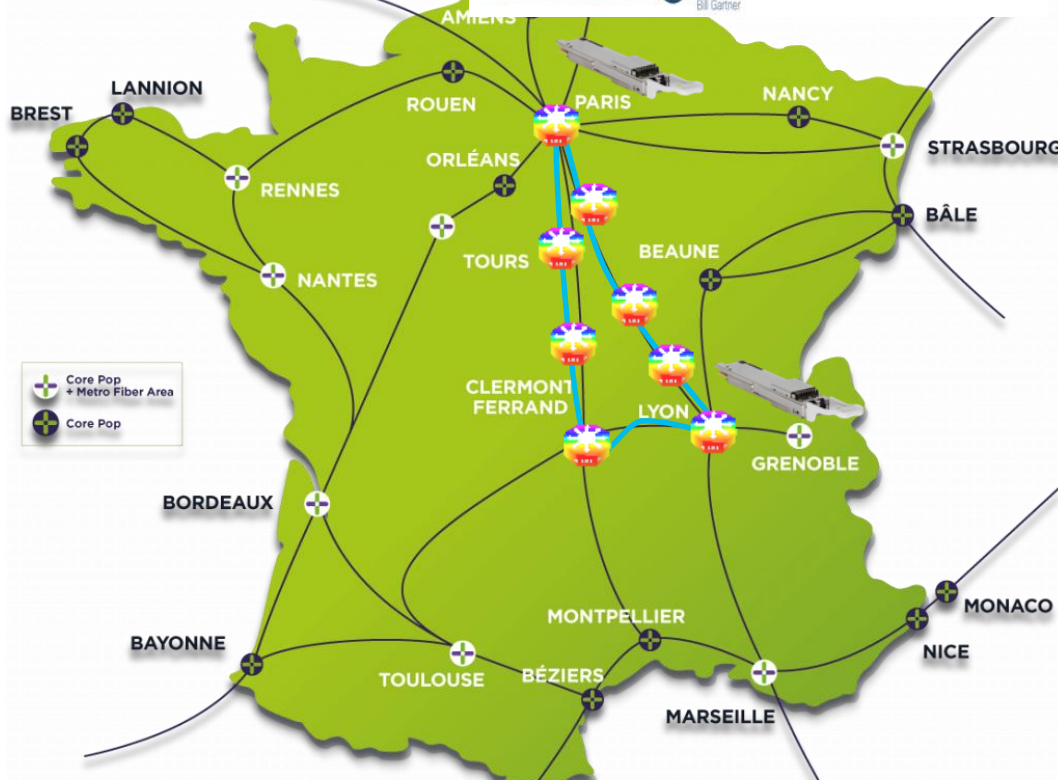
- 400ZR+ with Cisco routers
- >800km longest route
- Core network over 3rd party ROADM OLS

Bright ZR+ has reach 600-800KM with good deployable margin over ROADM based OLS

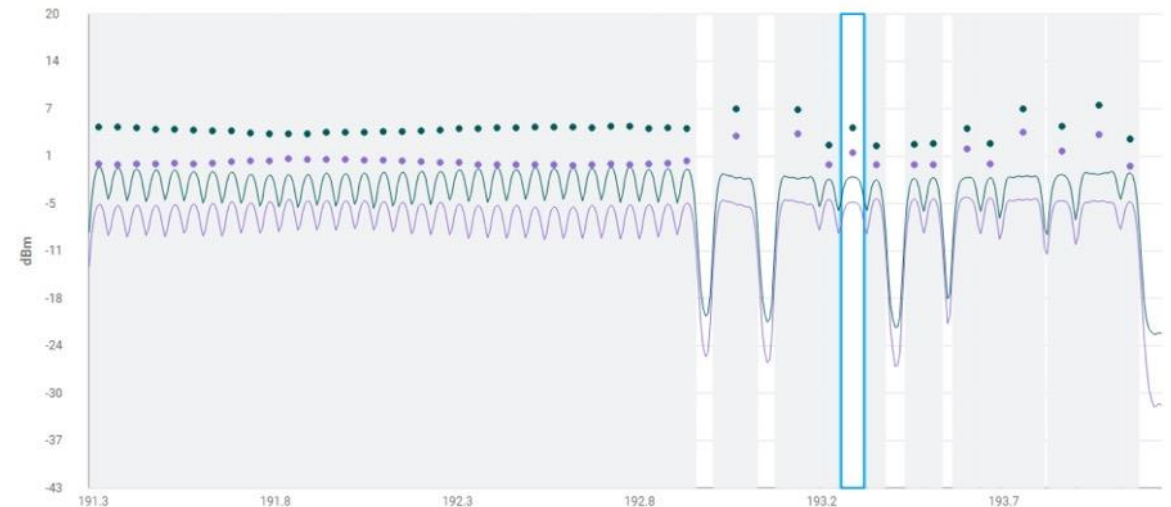
Sipartech – 400GbE over 1337km with Bright ZR+



SP360: Service Provider
Cisco at OFC 2023: Announcing Successful
Test with Sipartech to Deliver 400G Over
1,337 km
Bill Gartner



- Mixed SMF28 and E-LEAF fiber with 8 ROADM sites
- Alien λ over 3rd party CDC ROADM line system, plug and play!



“With the interoperability of Cisco’s equipment, we can deploy our next generation 400G+ services with speed, simplicity, and flexibility to meet our customers’ needs, while optimizing energy expenditure and our carbon footprint as part of our global strategy.” – Julien Santina, Sipartech CEO

Reshaping network architecture for AI connectivity

Challenge

- Deliver bandwidth demands
- Support customers' AI-driven initiatives
- Reduce latency and costs to drive business

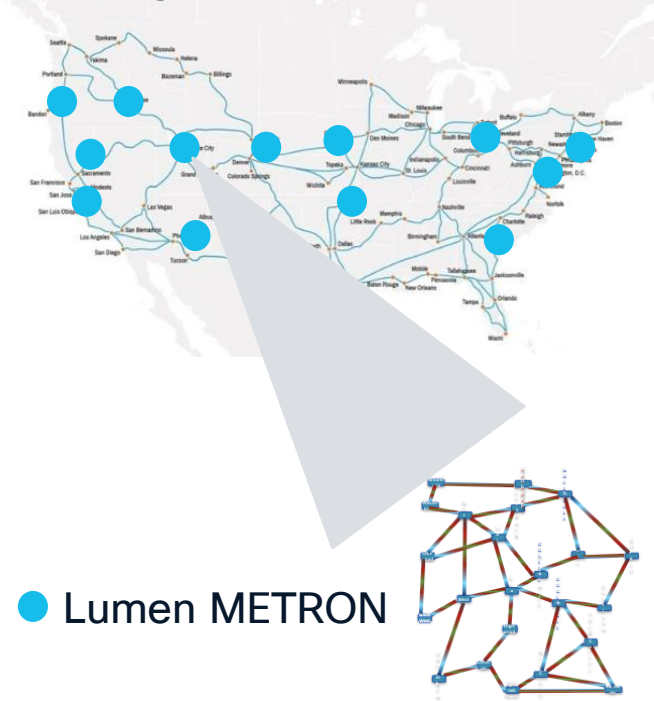
Outcomes

- Satisfies demanding bandwidth, latency, and resilient transport for AI workloads.
- API-driven control and automation of its network to include wavelengths, Ethernet, and IP
- Reduces costs and increases fiber network capacity with direct paths to data centers and clouds

Routed Optical Networking

- Cisco 400G ZR/ZR+ coherent optics
- Cisco 8200 Series
- Cisco NCS 5700 Series
- Cisco NCS1001 efficiency

Lumen 400G Wavelength Network - North America



Scaling network to 400G



Customer Goals

- Modernize network for efficiency
- Agility to grow business through differentiated services

Business Results

- Savings up to 125 million Canadian dollars over next ten years, with ~27% reduction in CapEx.
- CapEx savings will more than double when deployed directly over dark fibers
- Strengthen financial health and generate more value for shareholders
- Deliver new fixed and wireless services more cost-effectively and speed time to market
- Provide visibility to troubleshoot in an instant

Solution

- Replace transponders with Bright plugs
- Cisco 8K routers
- Alien line system

“It will enable us to reduce the space and power consumption of our network by a staggering 76%.”

- Marc-André Gilbert,
Senior Manager of Transport Planning at Bell Canada

Energy Utility – RON Win

- SNAM – Italian Energy Infrastructure Company
- High-Capacity RON with more than 100 sites
- Brownfield with exiting Cisco DWDM nodes (NCS-2K)
- Networks consolidated to **NCS 57xx and ASR9K** routers with 100/200G/300G/400G uplinks
- Transponder/Muxponder functions moved to IP network with coherent pluggable transceivers **400G QSFP-DD High-Power (Bright)**



IP Layer
200G/400G
NCS 57C3

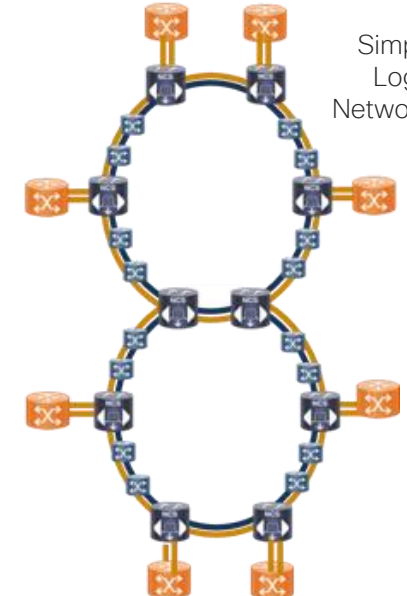


Transport Network
NCS 2000 ROADM
200G/400G λ

NCS 57C3



Bright ZR+



Simplified
Logical
Network View

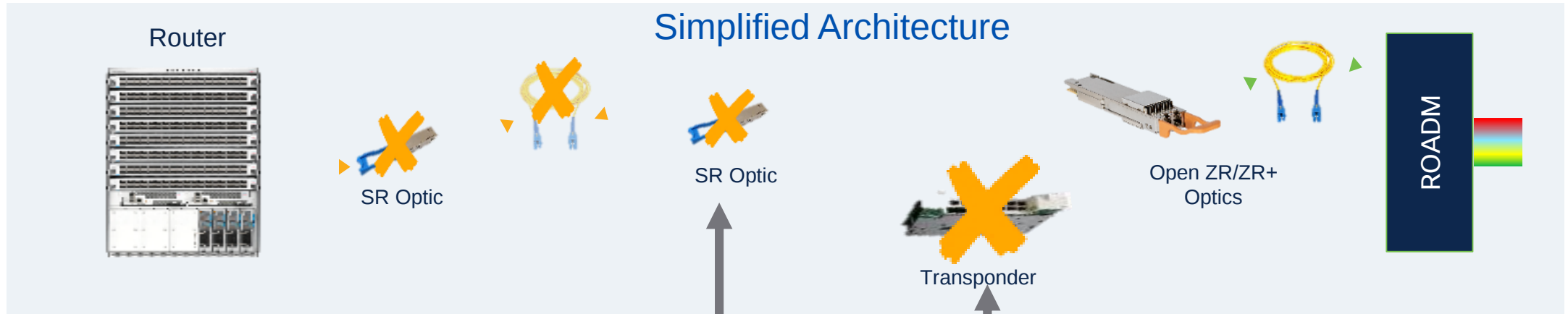
Pluggables expanding in Subsea Market

400G ULH trial on Indigo Central

- Field trial of 400G ULH on Indigo Central in collaboration with AARNET
- More than 92,000 ps/nm of dispersion, >4600KM with terrestrial extension
- 400G ULH designed for existing 400G QSDD slots
- Used in NCS1014 3.2T transponder



Summary – Coherent Optics enables IP-Optical Convergence



- Eliminate transponder and associated shelf/chassis
- Eliminate client optics

“Simplicity is the ultimate sophistication” – Leonardo da Vinci

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