

400G, 800G, and Terabit Pluggable Optics:

What You Need to Know

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Cisco Webex App

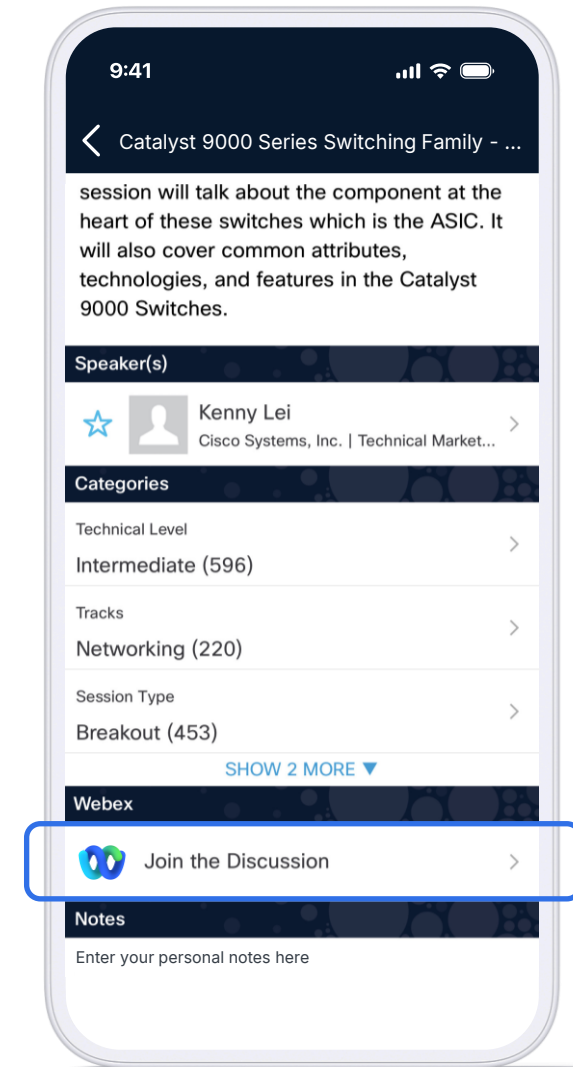
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Myth vs. reality

A quick checkpoint before the 400G, 800G, and 1.6T deep dive.

Myth

Pluggables are dead

CPO replaces everything

1.6T is not ready yet

Optics is a commodity

Reality

→ Pluggables are evolving and remain crucial

→ CPO and pluggables will coexist

→ 1.6T adoption is being driven by AI scale-out

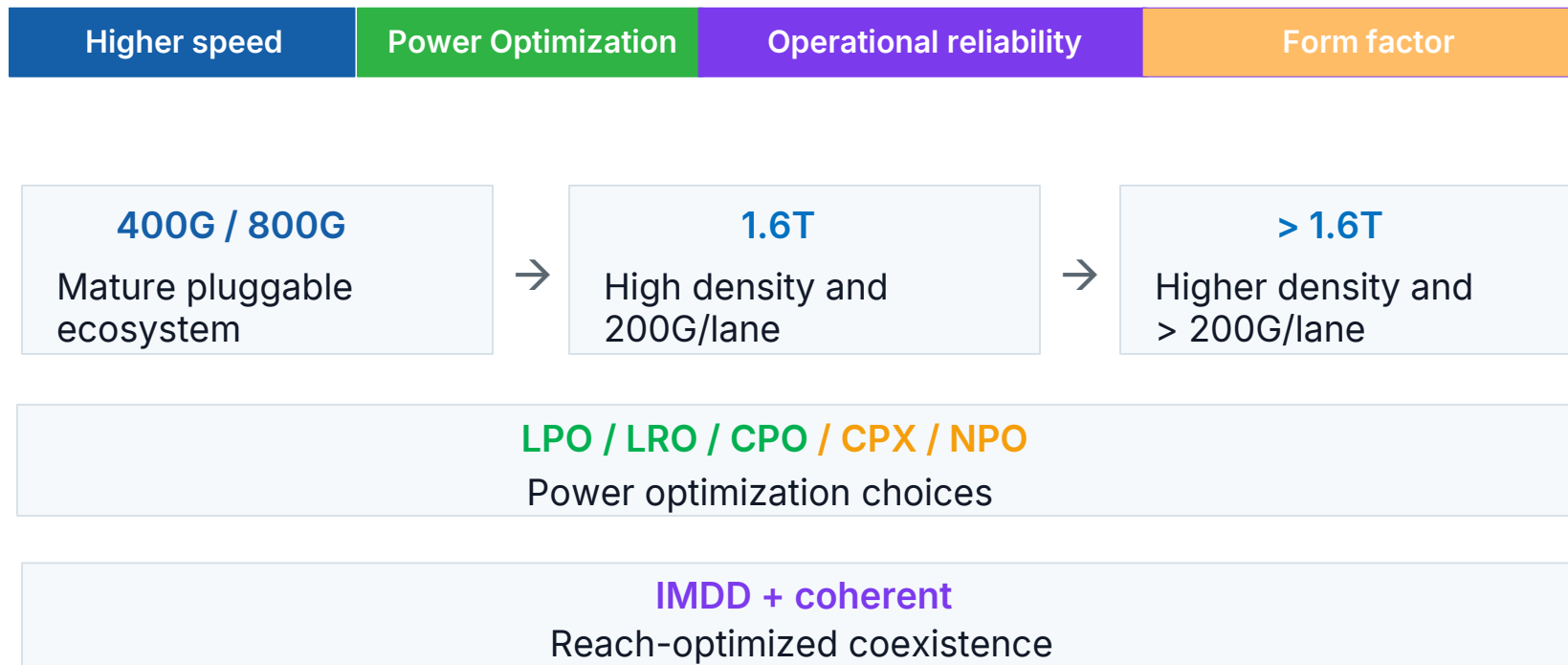
→ Reliability, firmware, telemetry, and validation matter

Optics choices are moving from speed selection to system-level design decisions.

Pluggables are evolving

AI changes the optics requirements, but it does not reduce the answer to one technology.

The next optical era is a portfolio decision: use the right implementation for the reach, power envelope, operational model, and lifecycle.



Agenda

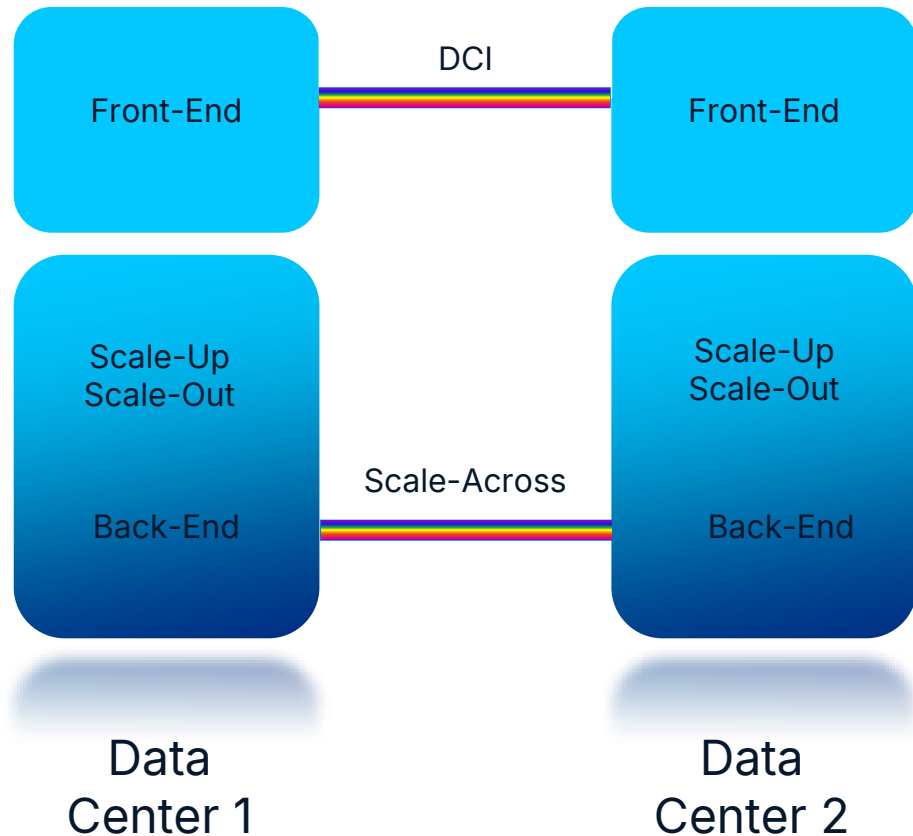
- 01 Market dynamics**
- 02 400G & 800G pluggable
status**
- 03 Optics advancements for
AI infrastructure**
- 04 Wrap up**

Market dynamics

The background features a light gray grid pattern. A large, tilted white rectangle is positioned in the upper right, containing a blurred rainbow gradient. In the bottom left corner, there is a blue circular arc. The text 'Market dynamics' is written in a bold, dark blue font on the left side of the image.

Optics & AI Fabric Architecture

Frontend and Backend



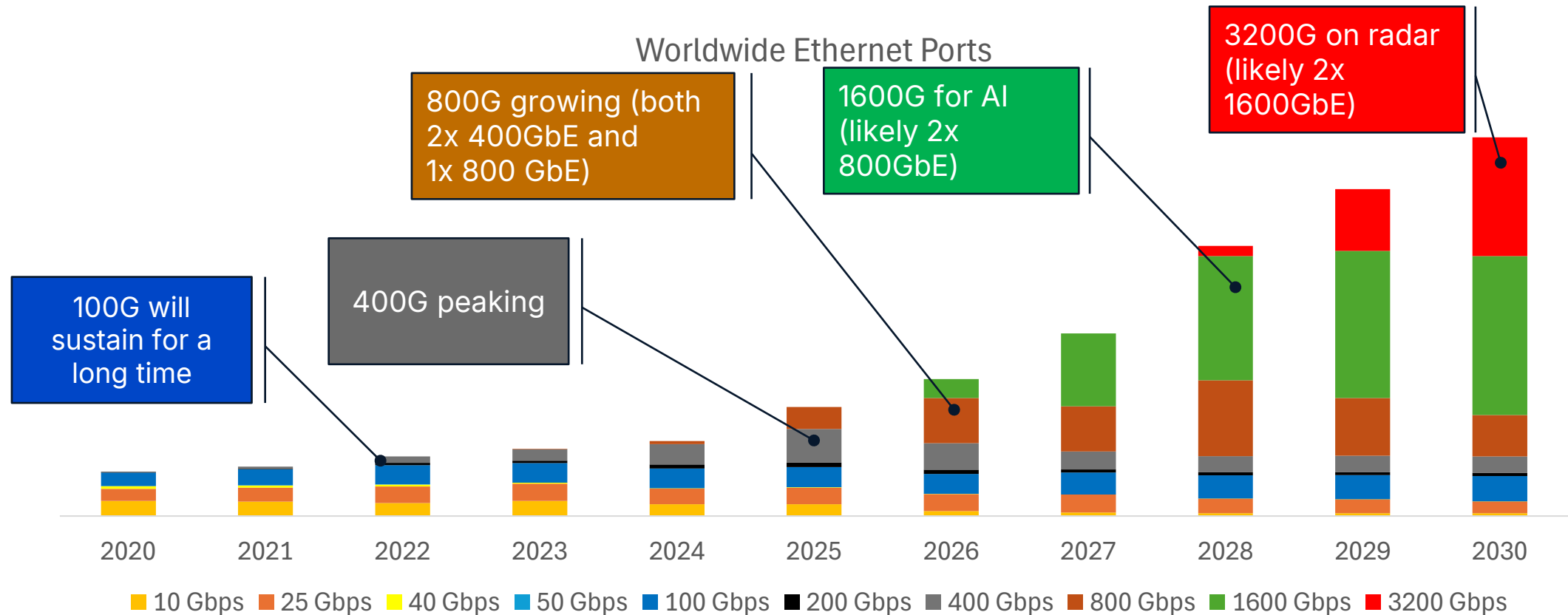
Intra-Building (DC or Campus)

- **Optics Focus:** Shorter reaches, high fiber availability, cost, power, reliability, pluggables or alternatives
- **Technology:** Direct Detect(IMDD) historically sufficient but that may be changing

Inter-DC/ WAN/Metro/Long Haul/Subsea

- **Optical Focus:** Longer Reaches, low fiber availability, link performance.
- **Technology:** Coherent (DWDM) required

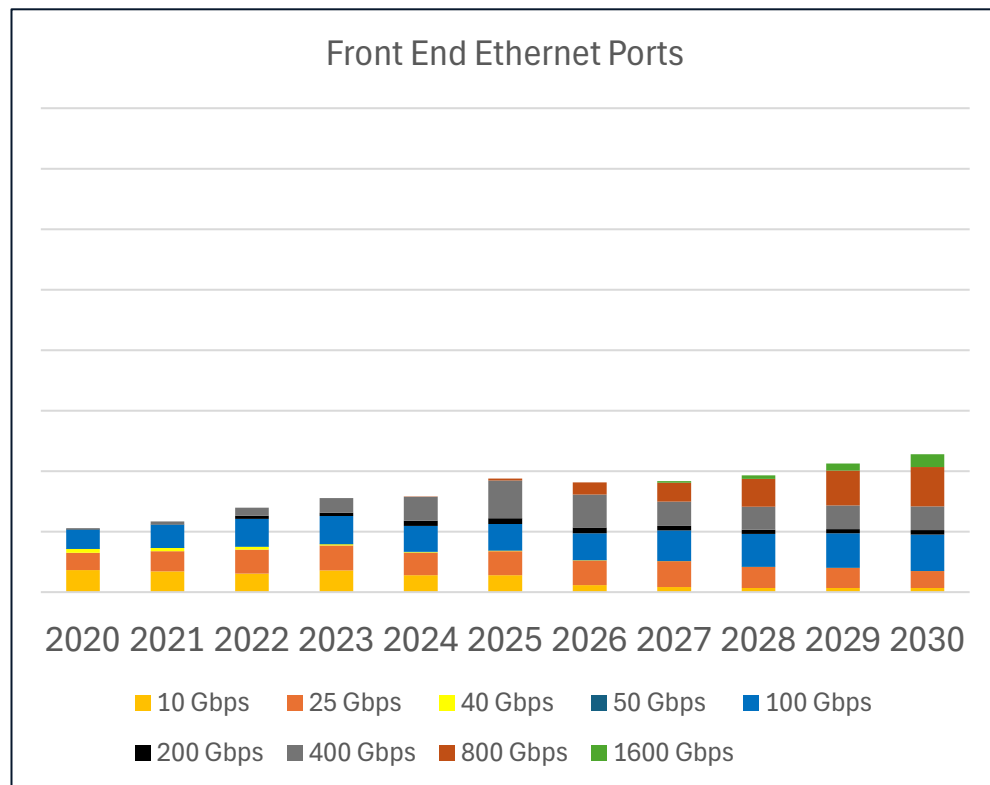
Ethernet worldwide Switch Port speed transitions



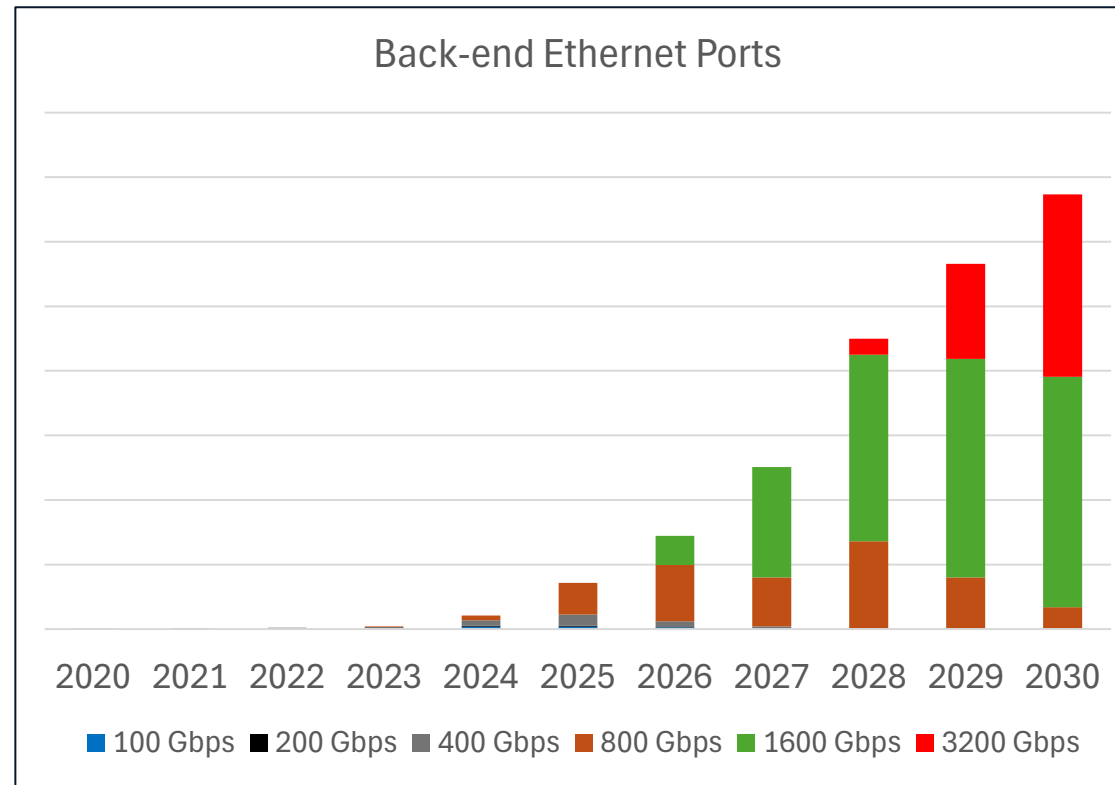
Source: Source: Dell'Oro, "Data Center Switch- Total 2026 – 2030"

- AI Infrastructure is dominating the market (Backend Fabric)
- Hyperscalers will drive these speed transitions quickly to scale
- Rest of the market will leverage that scale in their own time frame

Ethernet speed transitions in AI networks



Source: Dell'Oro, "Data Center Switch – Front-end networks 2026 – 2030"



Source: Dell'Oro, "Data Center Switch – AI Back-end Networks 2026 – 2030"

Majority of the switch ports in AI back-end Networks will be 1600 Gbps in 2027, showing a very fast migration to the highest speeds available in the market.

400G/800G/1.6T optics use cases

Market Drivers



Cloud / NeoCloud

Earliest adopters on next speeds and variants.

High volume drives economies of scale and optimization.



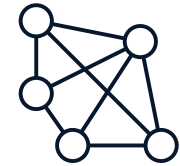
Telco service providers

Leverage early adopter solutions



Enterprise

Later adoption of speeds and feeds.
Strong leverage of previous solutions



Media networks

Strong leverage of existing solutions

AI is accelerating growth across all segments.

Priorities for interconnect in an AI world

Minimize workload impacts

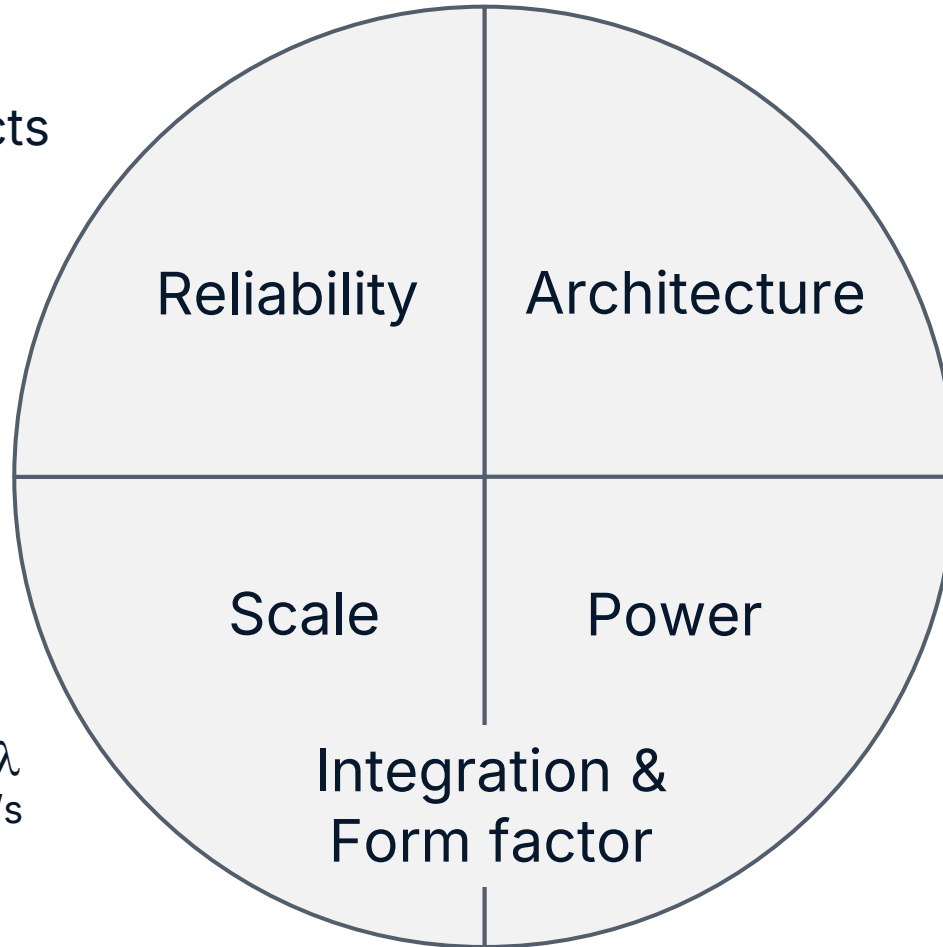
- Physical reliability
- Link Performance

Interfaces:

- Ethernet

800 GbE → 1.6 TbE → 3.2 TbE

- Speeds: SERDES and λ
100 Gb/s → 200 Gb/s → 400 Gb/s



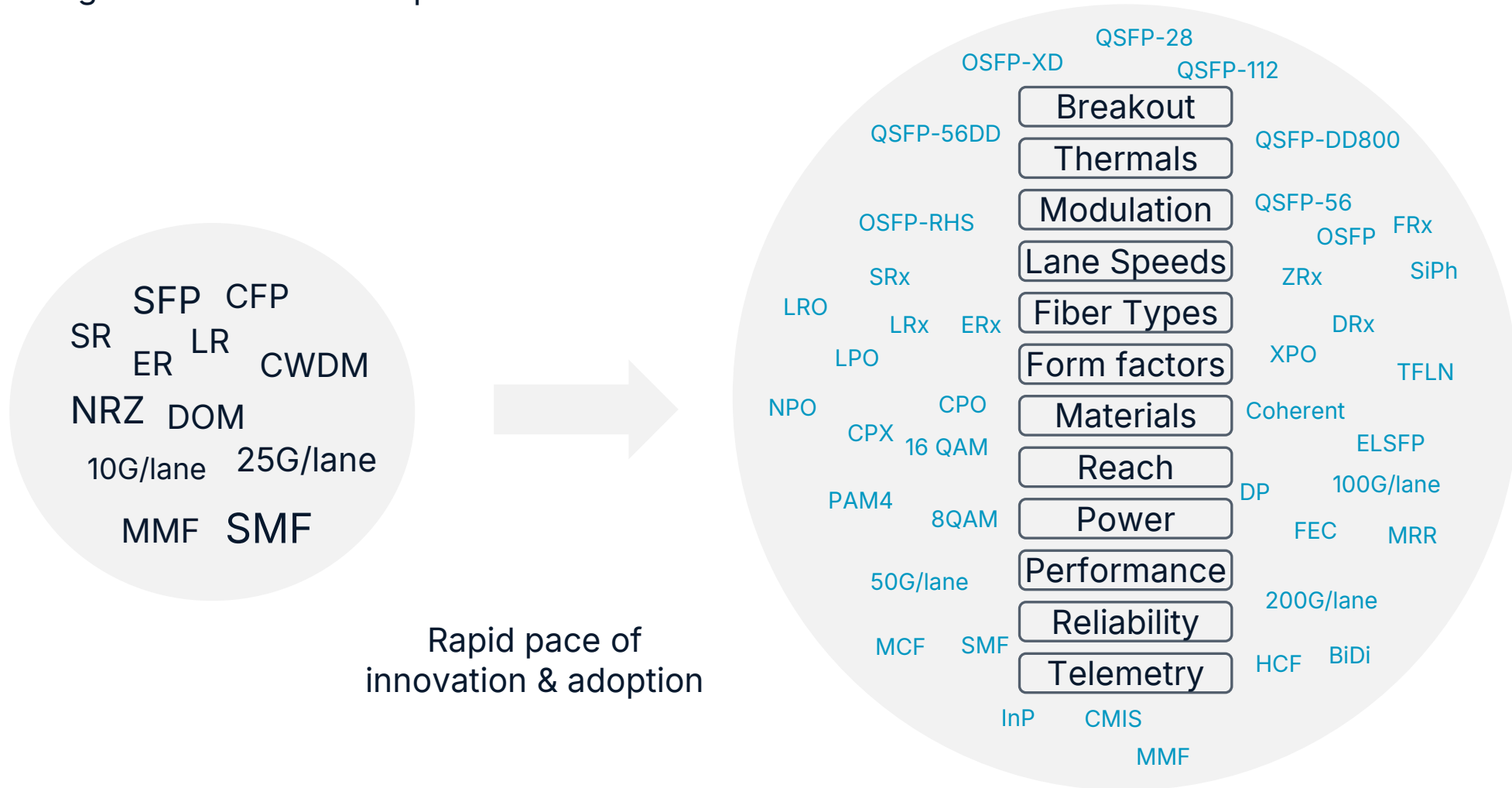
New architectures to support the necessary scale

Power Efficiency

- Copper cables
- Linear Optics
- New approaches

Pluggable optics usage continues to grow

More things to consider as adoption evolves



Reliable connectivity for AI data centers

1

Cisco silicon photonics
and DSP

Higher performance
and reliability

2

Integrated designs

Improve efficiency and
energy consumption

3

Robust qualification

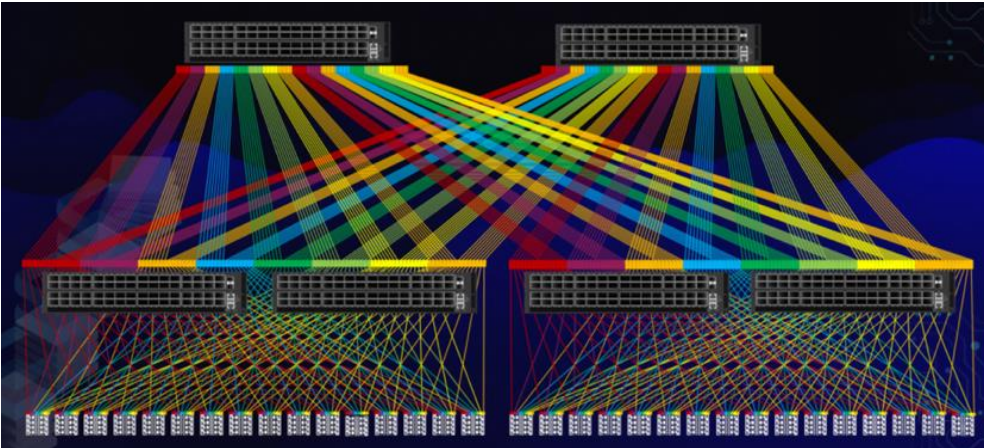
Superior quality
and reliability

4

Software innovations

Maximize AI
workload uptime

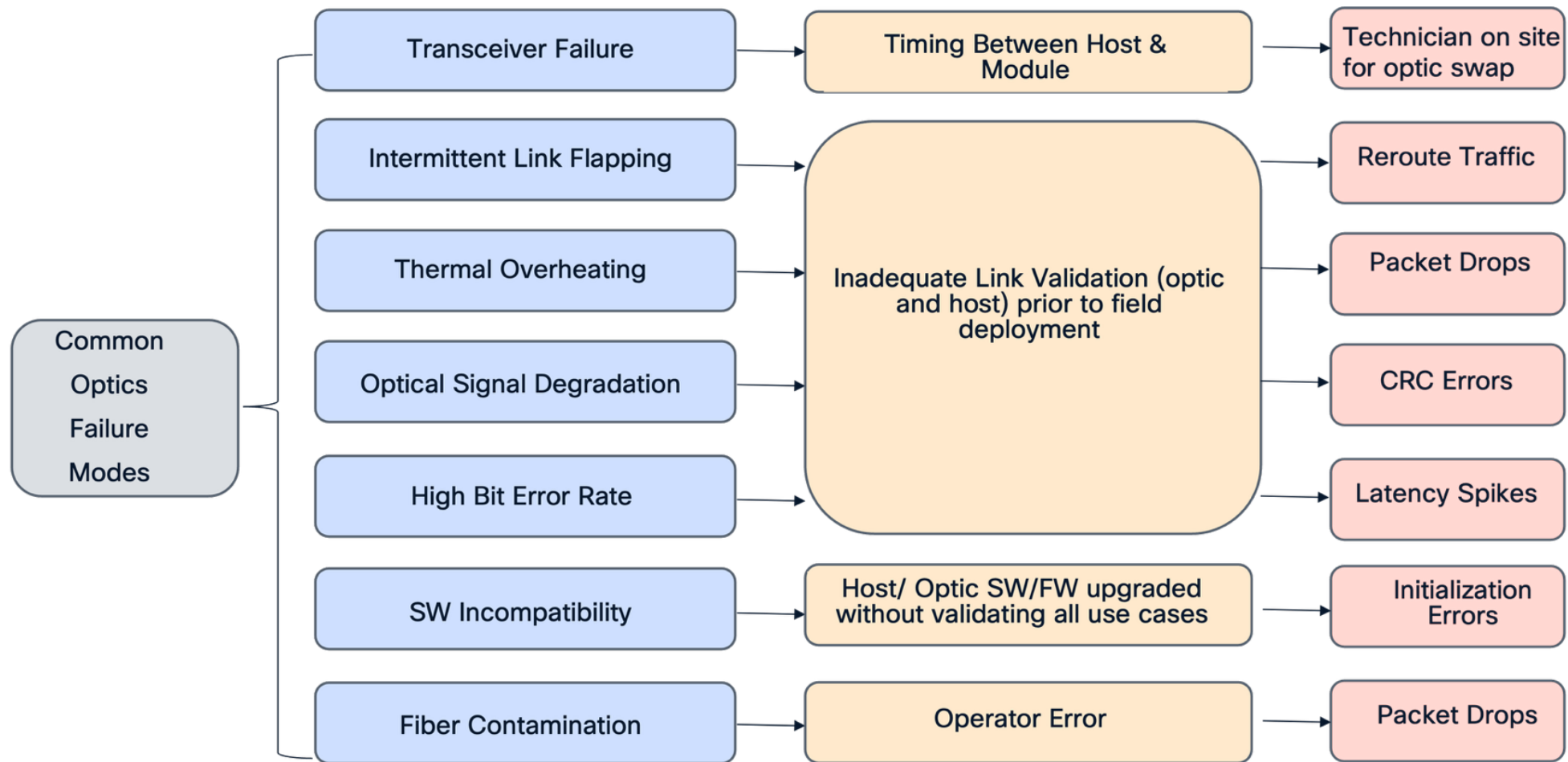
Why optics reliability is critical for all deployments



Impact of transceiver failure:

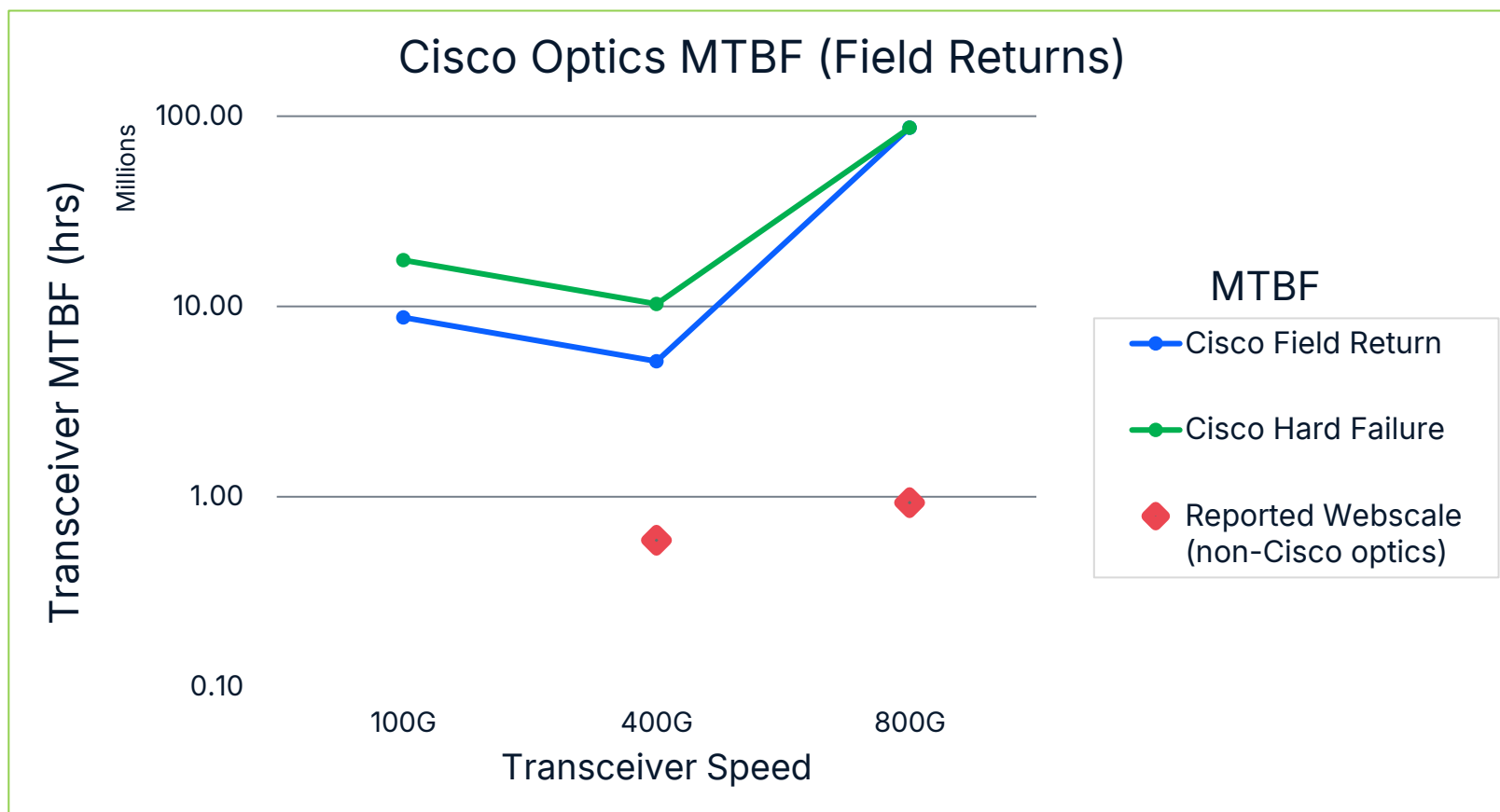
- Field replacement
- Fault location diagnosis
- AI:
 - can affect data synchronization across nodes
 - can slow down parallel computation
 - reduce training accuracy
 - reduce system stability

Causes and consequences of optics failures in AI datacenters



Field-proven reliability for Cisco optics

- Cisco Optics field reliability exceeds reported webscale MTBF
- Most webscale reported failure modes are manufacturing quality and firmware issues
- Highest reliability with newest 800G data rates



Cisco silicon photonics integration and leadership

Increased performance, efficiency, reliability



Higher performance

Electronics and photonics integration



Better power efficiency

Component density in a photonics integrated circuit (IC)

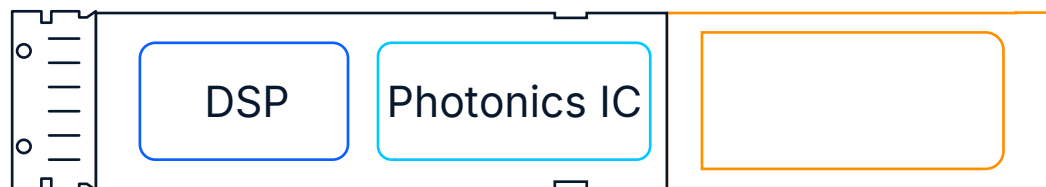


Increased reliability

Semiconductor manufacturing and processes



Host
interface



Optical
interface

The Cisco advantage

Proven high-volume silicon photonics manufacturing and deployment

Technology leadership in silicon photonics and DSPs

Foundation for faster speeds and deeper ASIC integration

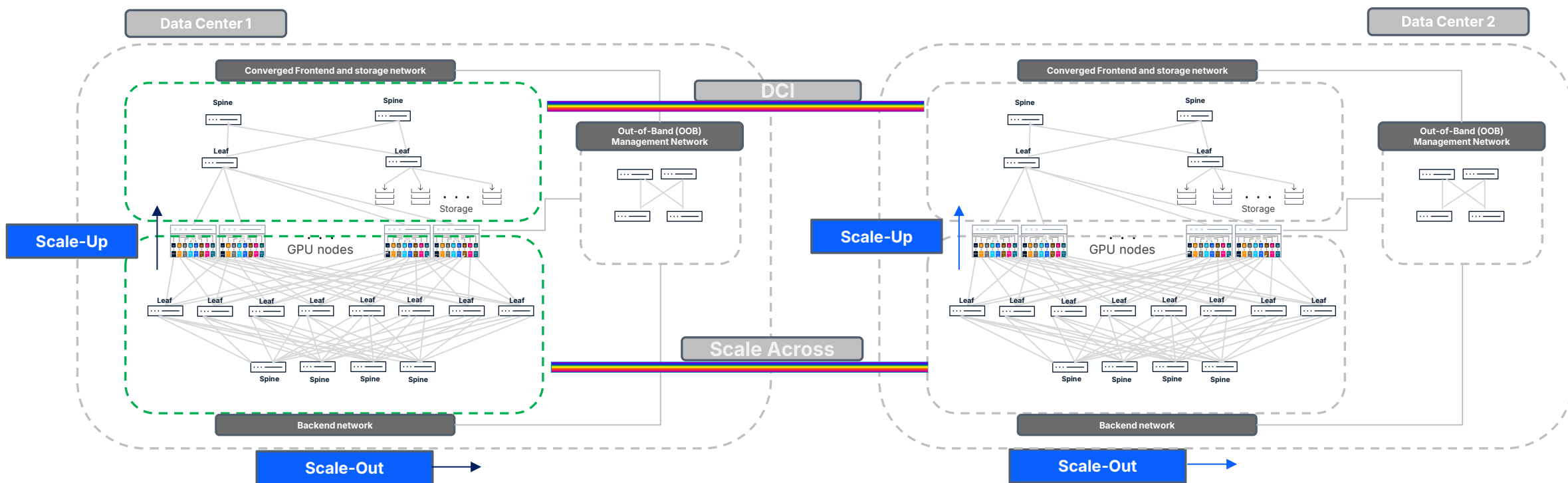


400G & 800G pluggable status

Navigating IMDD & Coherent deployment

Optics & AI Fabric Architecture

Pluggable Optics in Frontend and Backend



**Frontend for User Access & Management -
The "Service Fabric."**

- **Goal:** High-availability, user-facing performance
- **Optics Focus:** Pluggables, DCI, Routed Optical Networking (RON)

**Backend for Model Training/Inferencing -
The "Compute Engine."**

- **Goal:** Massive, sustained bandwidth, ultra-low latency, GPU-to-GPU synchronization.
- **Optical Focus:** AI-optimized interconnect (Power efficiency, reliability, density), Pluggables or alternatives.

400G & 800G: Where are we today?

Client IMDD (Shorter Reach)		Coherent (Long Reach)
400 GbE, 800 GbE	Mature standards	400G (OIF, Open ZR+)
100 Gb/s	Mature technology	400ZR: 16QAM @ 60 Gbd 800ZR: 16QAM @ 118 Gbd
1.6 TbE & 800 GbE @ 200 Gb/s	Next Gen technology	1600ZR: 16QAM @ 240 Gbd
Incl. Breakout	Mature Deployment	400ZR, Bright 400ZR+
CMIS	Optics Management	CMIS

Full range of 400G / 800G pluggable modules

- Copper cables
- Multimode Fiber – 100m
- Single Mode Fiber inside DC – 500m & 2km
- Single Mode Fiber Campus – 10 km
- Outside plant, Scale-across, DCI – 100 km → 3000+ km



Which optic for which job?

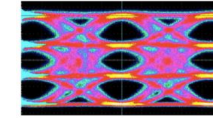
Choose by reach, power, reliability, and operations - not speed alone.

Use case	Typical reach	Starting point	Why it fits
Scale-up / in-rack	<3 m	DAC, ACC, AEC	Lowest power where distance and serviceability allow copper.
Scale-out rack-to-rack	30 m-2 km	IMDD: VR/DR/FR, LPO/LRO/FRO	Pluggable flexibility with power options matched to host and channel quality.
Campus / metro edge	10-40 km	LR/ER or coherent-lite class options	Reach starts to dominate; validate power, FEC, and platform support.
DCI / scale-across	100 km+	ZR / ZR+ coherent pluggables	Router-hosted coherent simplifies architecture and scales over distance.
Mixed-speed migration environment	Varies	Breakout and BiDi where applicable	Protects installed cabling and let's compute and switch refresh cycles differ.

Most 400G/800G standards are done

Standards	IEEE 802.3bs ✓		400 GbE & 200 GbE MAC & Initial Interfaces
	IEEE 802.3cd ✓		50 GbE MAC & Interfaces (also 100 GbE & 200 GbE PMDs)
	IEEE 802.3cm ✓		400 GbE MMF (BiDi and SR8)
	IEEE 802.3cn ✓		Extended reach (40km) 50 GbE, 200 GbE, 400 GbE
	IEEE 802.3ct ✓		100GbE Coherent 80km
	IEEE 802.3cu ✓		100G-FR, 100G-LR, 400G-FR4, 400G-LR4-6
	IEEE 802.3ck ✓		100GE serdes
Standards	IEEE 802.3db ✓		100/200/400GE MMF (100Gb/s short wavelength)
	IEEE 802.3df ✓		200G/400G/, 800G Ethernet Task Force @ 100Gb/s per lane
	OIF400ZR ✓		400 GbE Coherent 120km
	OIF800ZR ✓		800 GbE Coherent 120km
	OIF1600ZR		1600 GbE Coherent 120km
	Open ZR+ ✓		Long Distance 400G
	CMIS		Common Management Interface Specifications
Standards	802.3ds		200 Gb/s per Wavelength MMF PHYs Task Force
	802.3dj		200G/400G/800G/1.6T Ethernet Task Force @ 200Gb/s per lane
	802.3dk ✓		Greater than 50 Gb/s Bidirectional Optical Access PHYs Task Force.
MSAs*	LPO MSA ✓		100G Linear pluggable
	100G Lambda MSA ✓		100G-FR, 100G-LR, 400G-FR4, 400G-LR4
	QSFP-DD MSA ✓		400G/800G/1.6T Form factor, started CMIS
	OSFP MSA ✓		400G/800G/1.6T Form factor
	400G-BiDi MSA ✓		400 GbE MMF BiDi

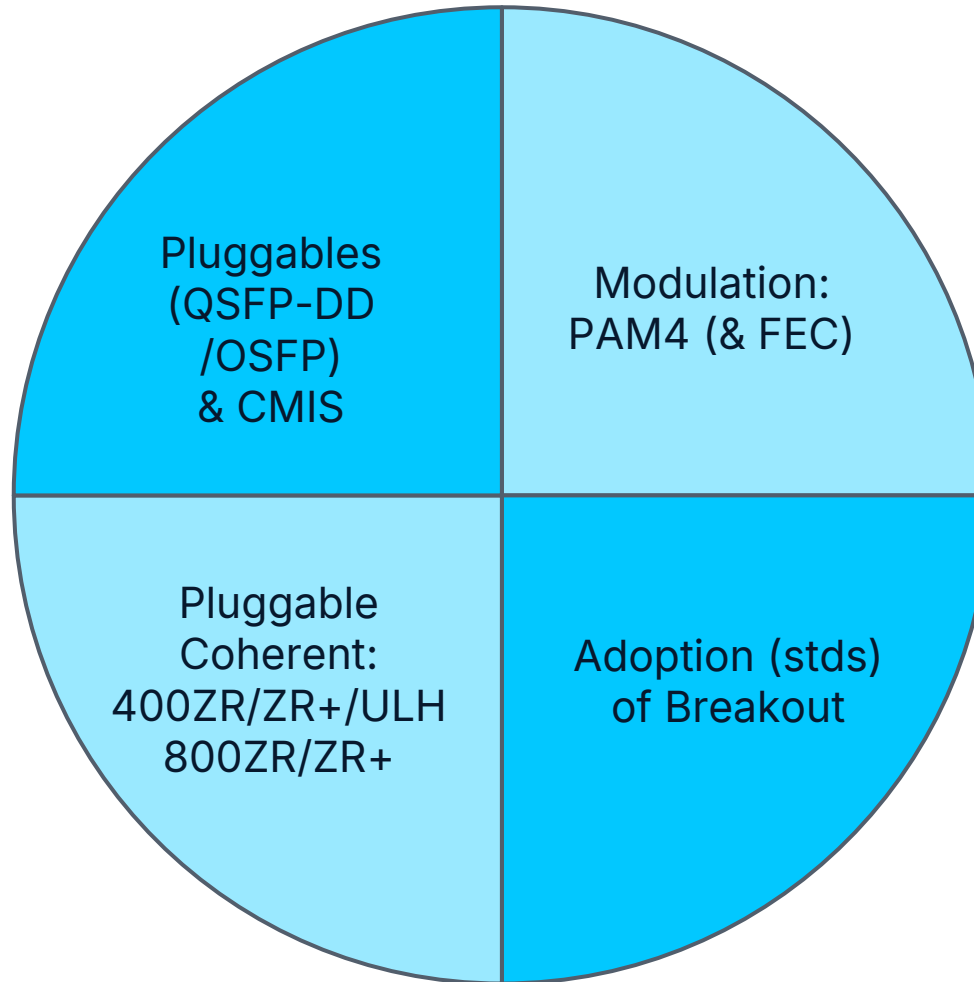
Key elements of 400G & 800G optics



Higher speed interfaces
PAM4 modulation.

Ubiquitous use of FEC.

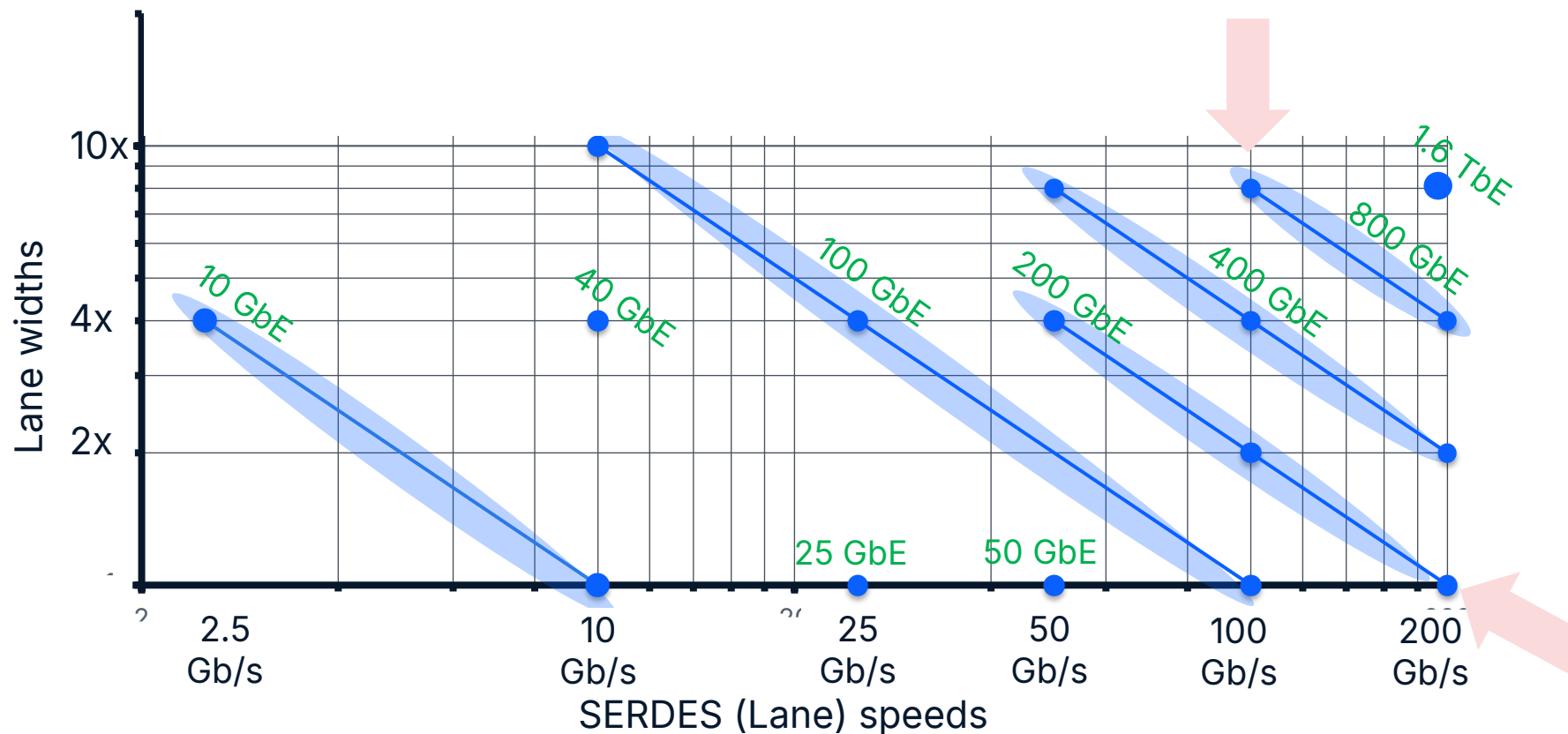
Pluggable modules
supporting multiple
lower speed interfaces



Pluggables with 8-wide
connector to support
400G and 800G ports

Long reach coherent
without any system port
density reduction
→ Routed Optical
Networking

400 GbE / 800 GbE – Uses mature 100 Gb/s technology



- (almost) nothing is new or only used once
- 8x100 "mature"
- nx200 "new"
- Requires (yet more) integration
- (yet) higher mechanical and thermal densities

Newer 200 Gb/s technology used in 1.6T modules

Technology maturity of 100 Gb/s technology enables:

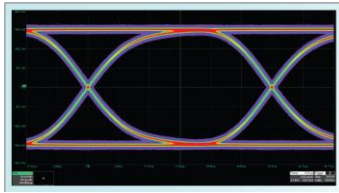
- Excellent performance
- Excellent interoperability
- Broad adoption

Technologies used for 400G, 800G optics

Using more complex modulation allows us to increase the data rate (Gb/s) without increasing the signaling speed (Gbaud)

Advanced Modulation

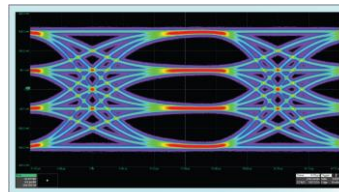
Client optics (IMDD)



NRZ

1 bit/sec/symbol

Non-Return-to-Zero (NRZ) used for 25Gb/s per lane and below

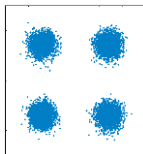


PAM4

2 bit/sec/symbol

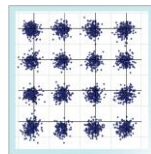
Four level Pulse-Amplitude Modulation (PAM4) for 50Gb/s per lane

Coherent optics



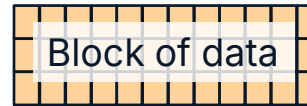
Coherent QPSK
2 bit/sec/symbol

Coherent signaling (both in-phase and quadrature modulation) for 100Gb/s per lane and above



Coherent 16-QAM
4 bit/sec/symbol

Forward Error Correction (FEC)



Allows correction of errors at receiver

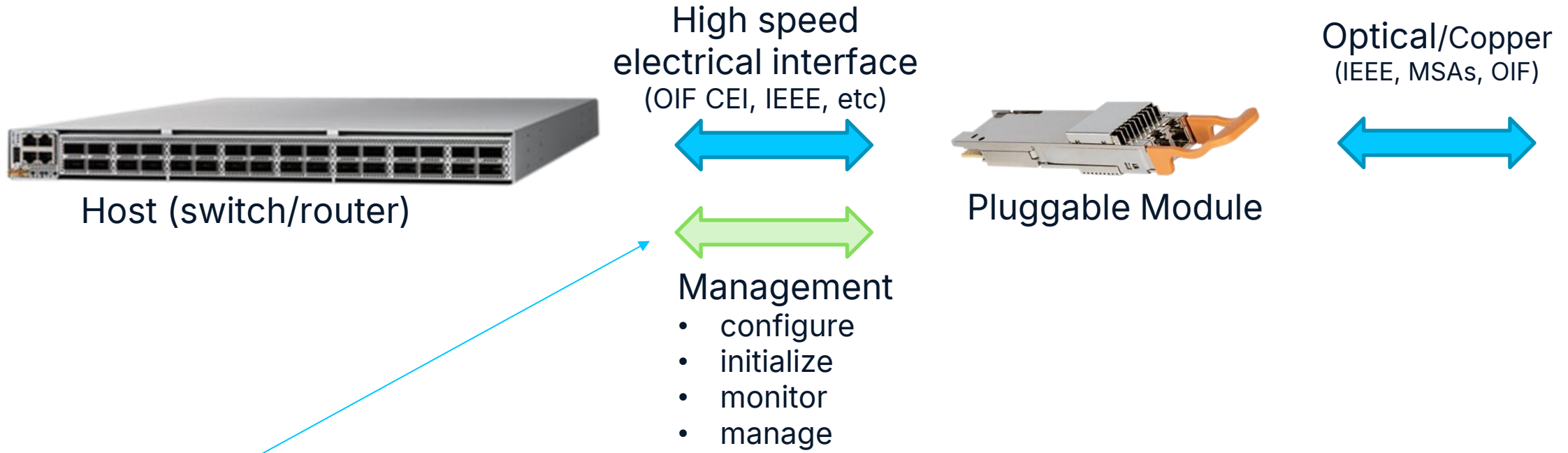
Enables use of relaxed specs (saves \$) to get same performance or enables much higher performance.

Usually embedded in Ethernet switch or module DSP ASIC

Some overhead (faster data rate needed)

Common Management Interface Spec (CMIS)

Standardized now in OIF → 100G modules, ubiquitous adoption for 400G modules and above



Often overlooked, CMIS standardizes management between **modules** and **hosts**

Consistent definition for configuration, **initialization**, **monitoring**, **telemetry**, **firmware update** etc.

Host and module **coordination of supported application modes** (AppSel)

Critical for monitoring and telemetry – more hooks into the DSP for **quality and performance**, critical for AI

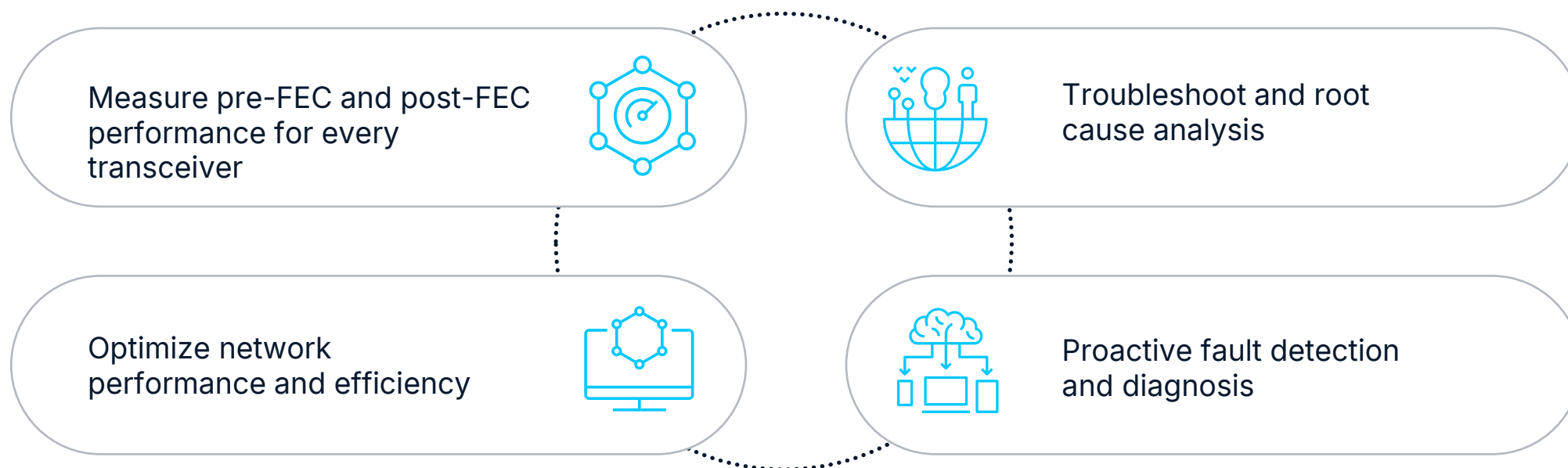
Versatile Diagnostics Monitoring – observables for link performance e.g. pre FEC BER, SNR...

Virtual Diagnostic Monitoring

Including optical module firmware upgrade in the field

Virtual diagnostic monitoring (VDM)

Real-time insights into performance and health across thousands of deployed pluggable optics



Versatile Diagnostics Monitoring (VDM) features



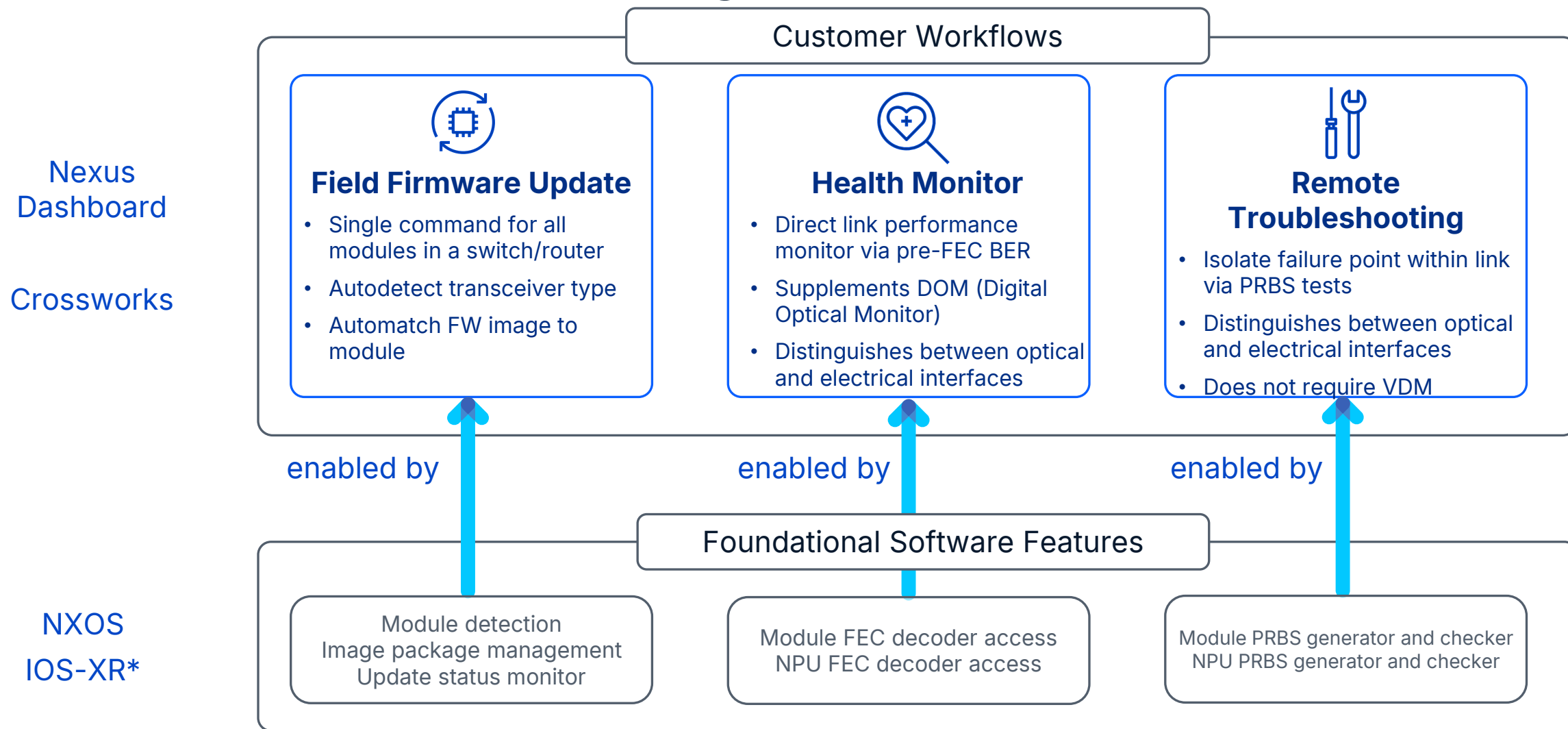
Implementation Agreement (IA)

Common Management Interface Specification (CMIS)
Revision 5.3

- Observables include real time samples and threshold

VDM observables supported by Cisco	Benefit of VDM monitor
Laser Age	Track module lifetime and help with estimate/plan field replacement
Laser Temperature	Monitor laser temperature along with module temperature for optimizing system fan speed
SNR Media Input	aid in telemetry for degraded optical signal from remote Tx
SNR Host Input	aid in telemetry for degraded electrical input from host
PAM4 LTP Media Input	aid in telemetry for noise characterization at optical input
PAM4 LTP Host Input	aid in telemetry for noise characterization at electrical input
Pre FEC BER Media Input	pre-FEC BER monitor to diagnose faulty/degraded remote transmitter
Pre FEC BER Host Input	pre-FEC BER monitor to diagnose faulty/degraded host electrical input signal
FERC Media Input	uncorrectable post-FEC errors at optical input – link health telemetry
FERC Host Input	uncorrectable post-FEC errors at electrical input – link health telemetry
SEWmax Media Input	FEC statistics monitor (optical input) for maximum FEC codeword error bin count
SEWmax Host Input	FEC statistics monitor (electrical input) for maximum FEC codeword error bin count

Optics Software: Building for smarter operations



Field updatable firmware

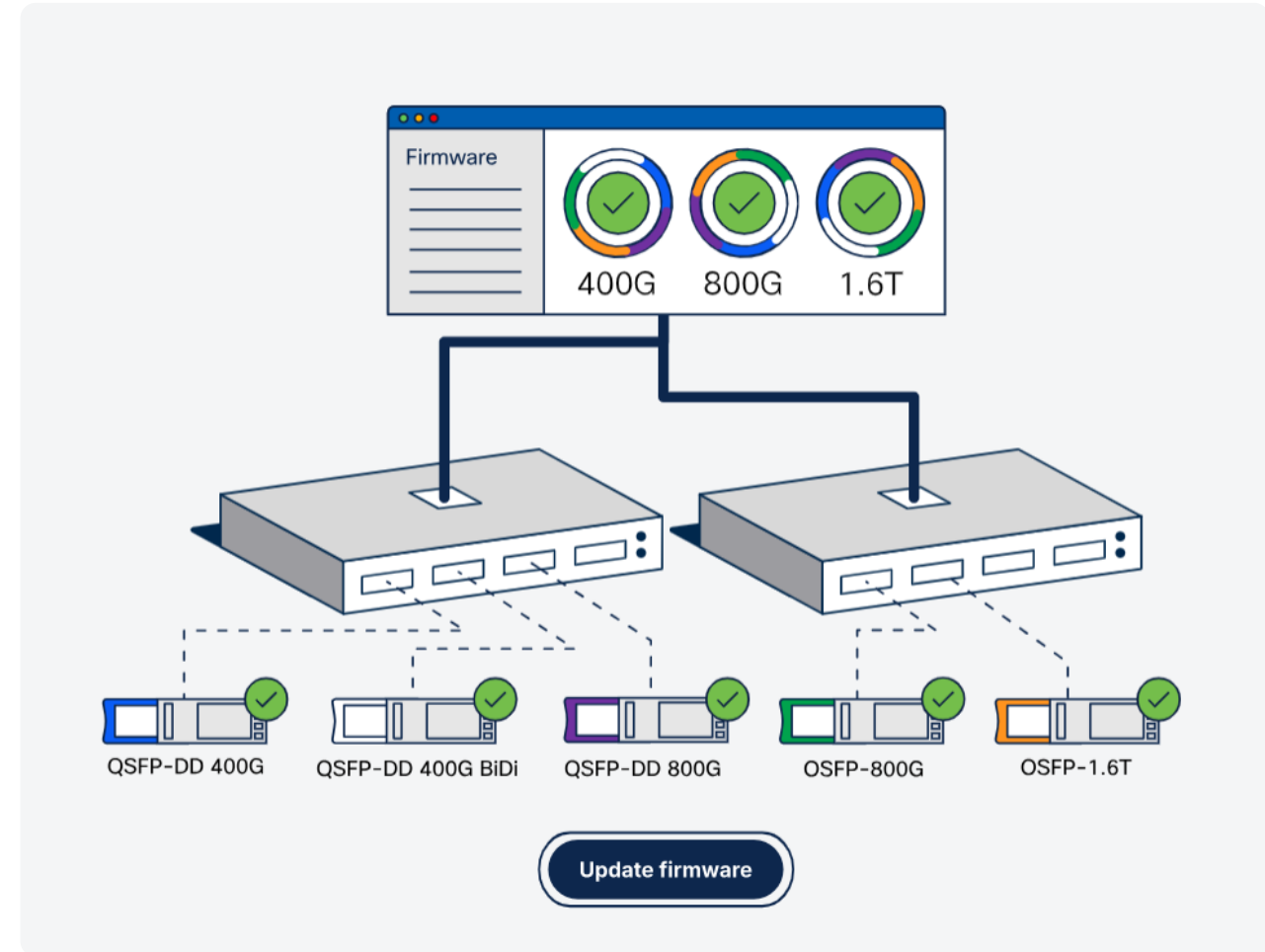
- Update firmware with advanced features: diagnostics, telemetry, monitoring, and bug fixes
- Validated firmware available for download in the field to minimize disruption

Streamlined process

- Download a single firmware package that includes all images for a product family or form factor
- System detects every module and matches it to the correct firmware image—making updates across all modules fast and easy

Operational benefits

- Maximize AI workload uptime
- Future-proof investments

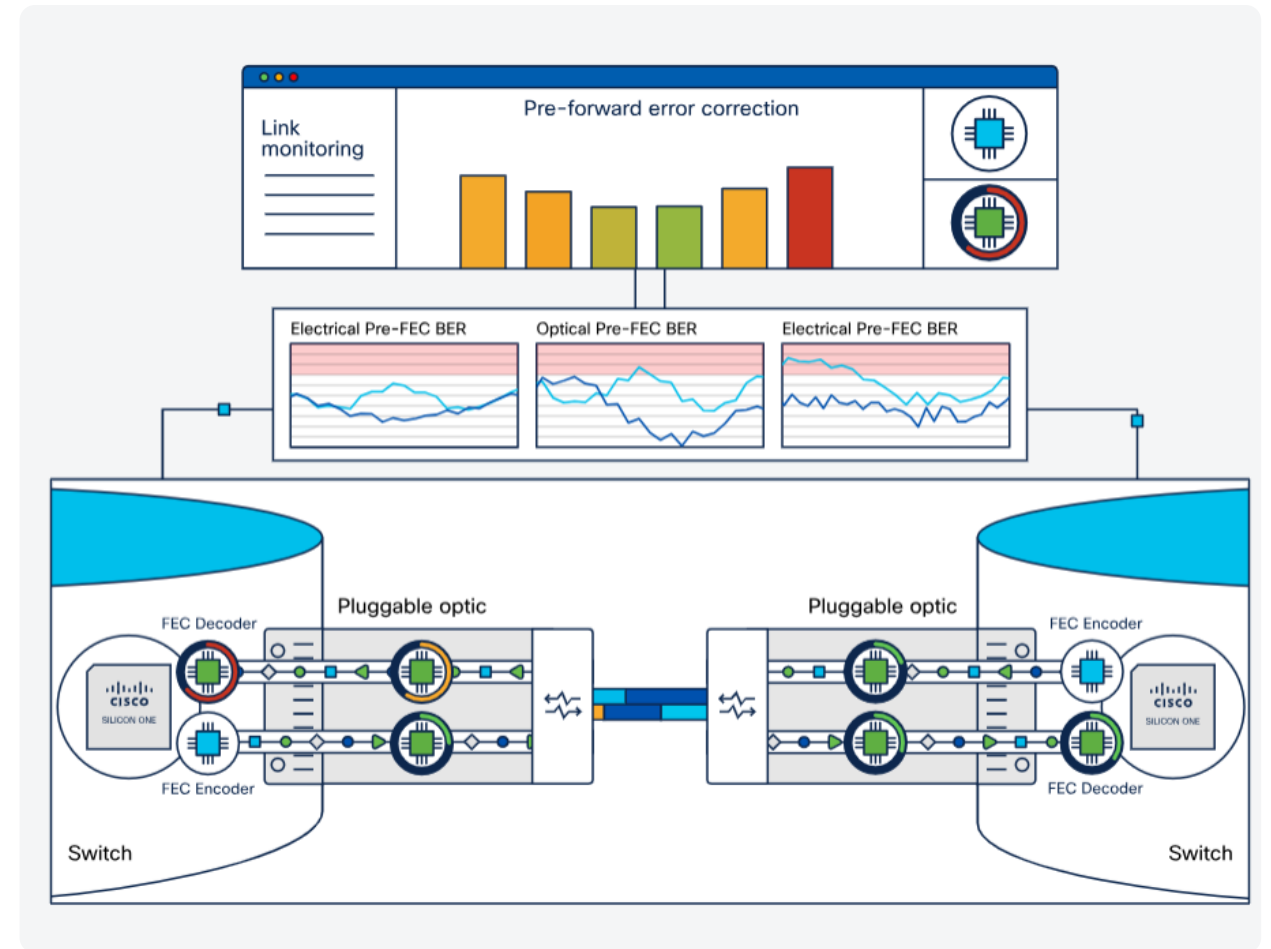


Intelligent Health Monitoring

- DSP decoder functionality in the optics module enables fine-grained detail of link health.
- Measurement points from the DSP are correlated with statistics from the host ASIC
- Software intelligence isolates degradation across the entire link by correlating the pre-FEC BER parameters across measurement points.
- Measure pre-FEC BER across 6 six unidirectional segments — even while running real traffic.

Operational benefits

- remote, detailed monitoring
- automated fault isolation

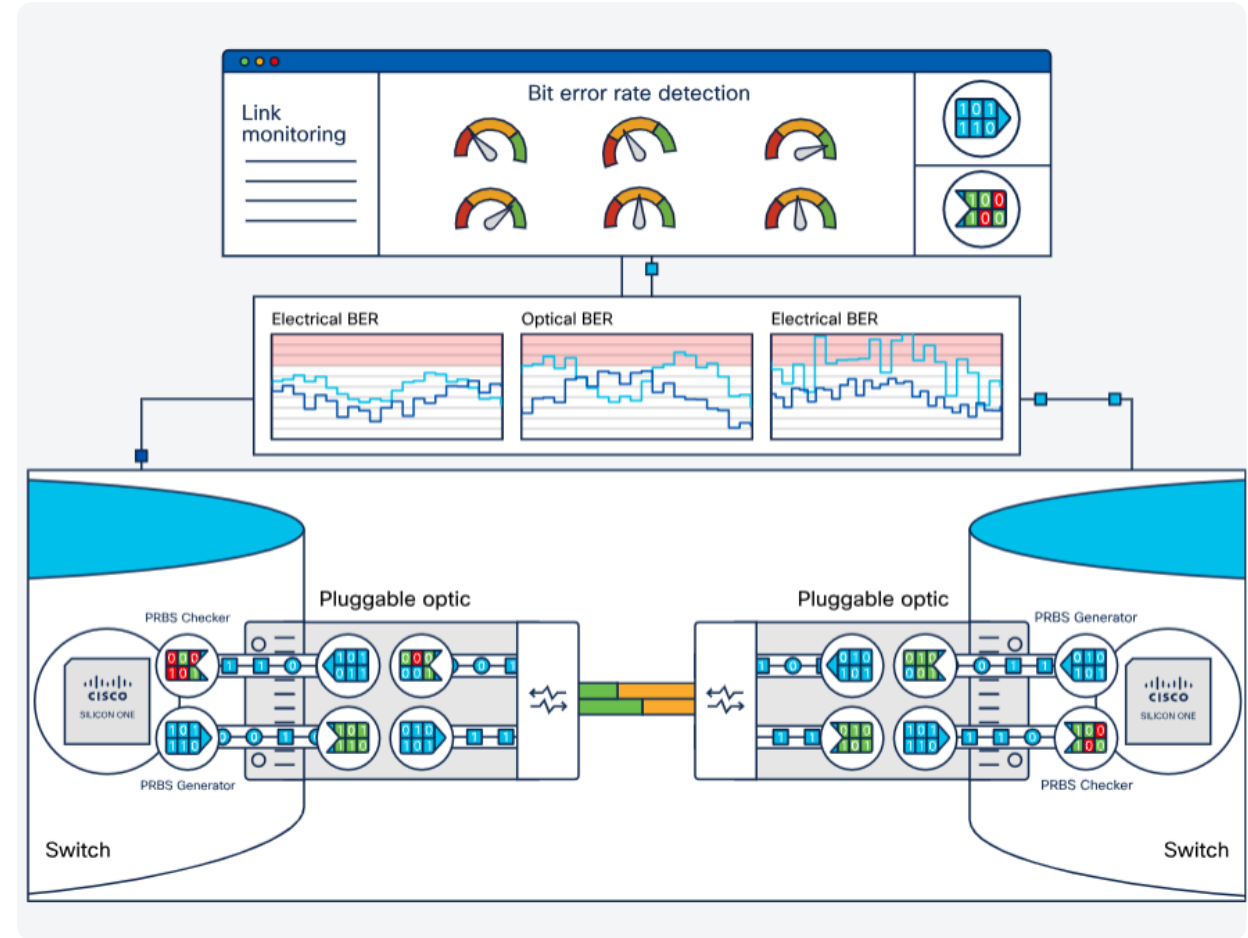


Intelligent Link Troubleshooting

- DSP functionality in optical modules add PRBS measurement points to enable fine-grained link troubleshooting is enabled.
- DSP generator and checker statistics are correlated with host ASIC statistics to isolate bit errors across the link.
- Software intelligence correlates the BER parameters across the measurement points to isolate faults across the electrical or optical links.

Operational benefits

- Remote (no physical interaction with hardware)
- Granularity enables fault isolation, which improves root cause analysis



Operational checklist

Use telemetry and software hooks as part of the deployment workflow, not only after trouble starts.

Before deployment

Turn-up and telemetry

Operate at scale

Optics readiness is a workflow

Use this as the bridge from module telemetry into day-0/day-1 operational discipline.

1 Validate optics-to-device compatibility.

2 Confirm breakout modes.

3 Track pre-FEC BER, SNR, temperature, laser age.

4 Plan field firmware update process.

5 Use PRBS/fault isolation workflows.

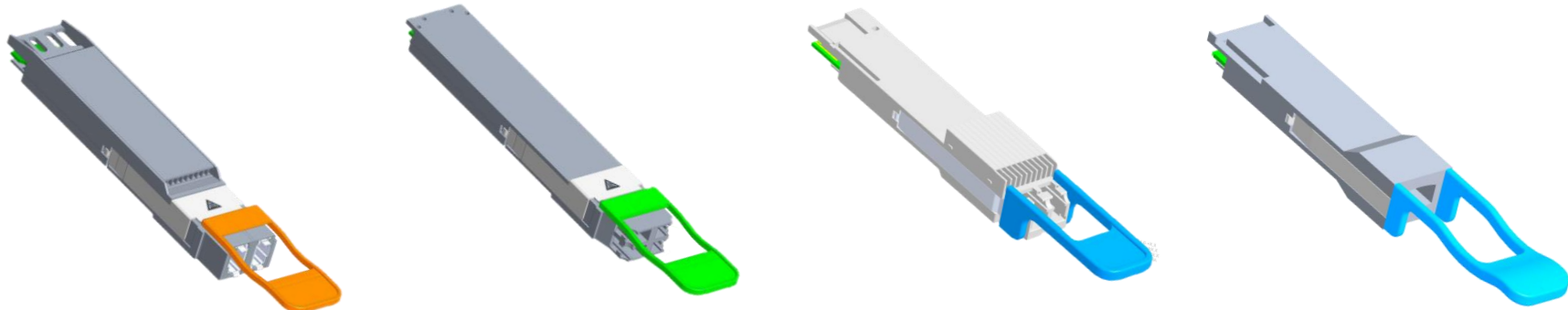
6 Build sparing and lifecycle strategy.

7 Confirm support boundaries for third-party optics.

Operational point

The module is only one part of readiness; the device, channel, telemetry, software process, and support model all need to close together.

Pluggable optical modules options



OSFP

OSFP-RHS

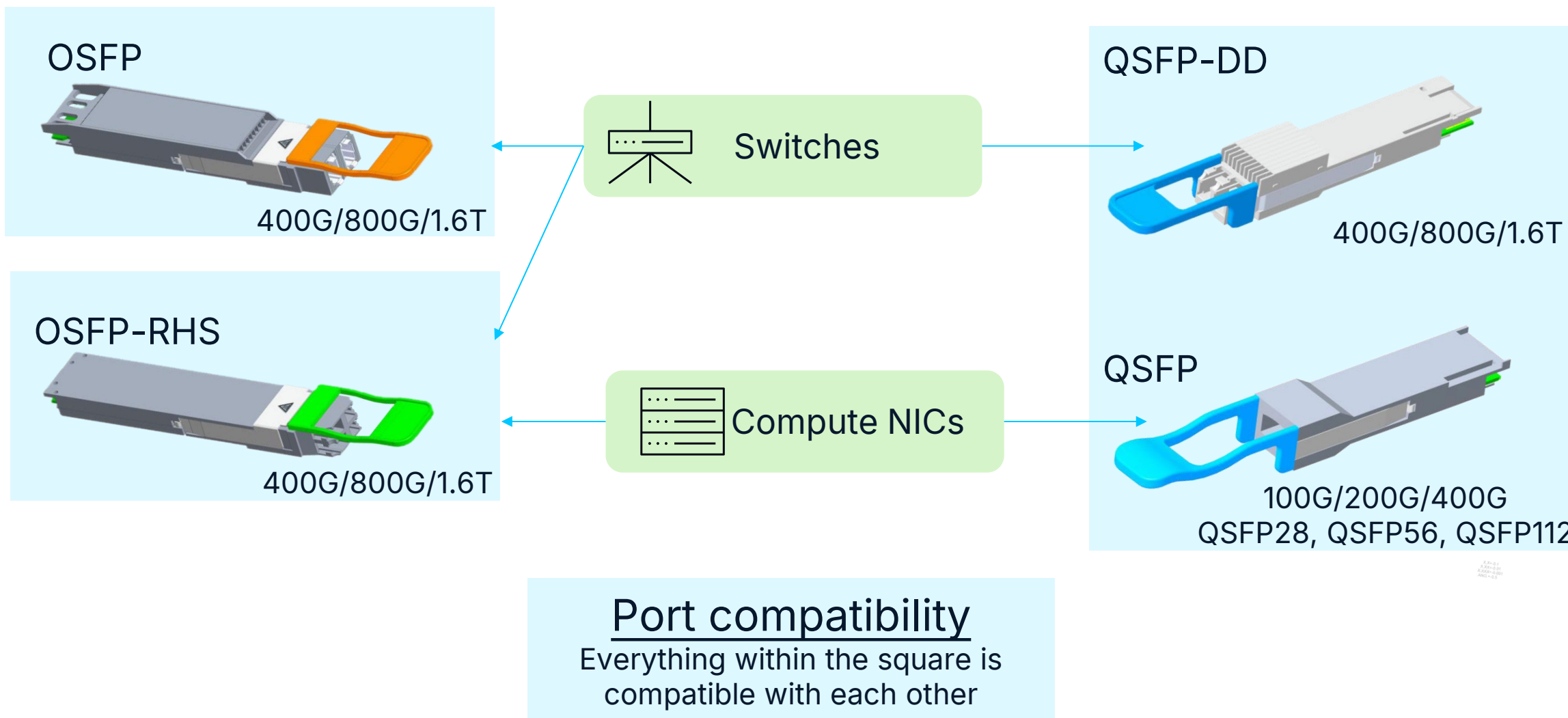
QSFP-DD

QSFP

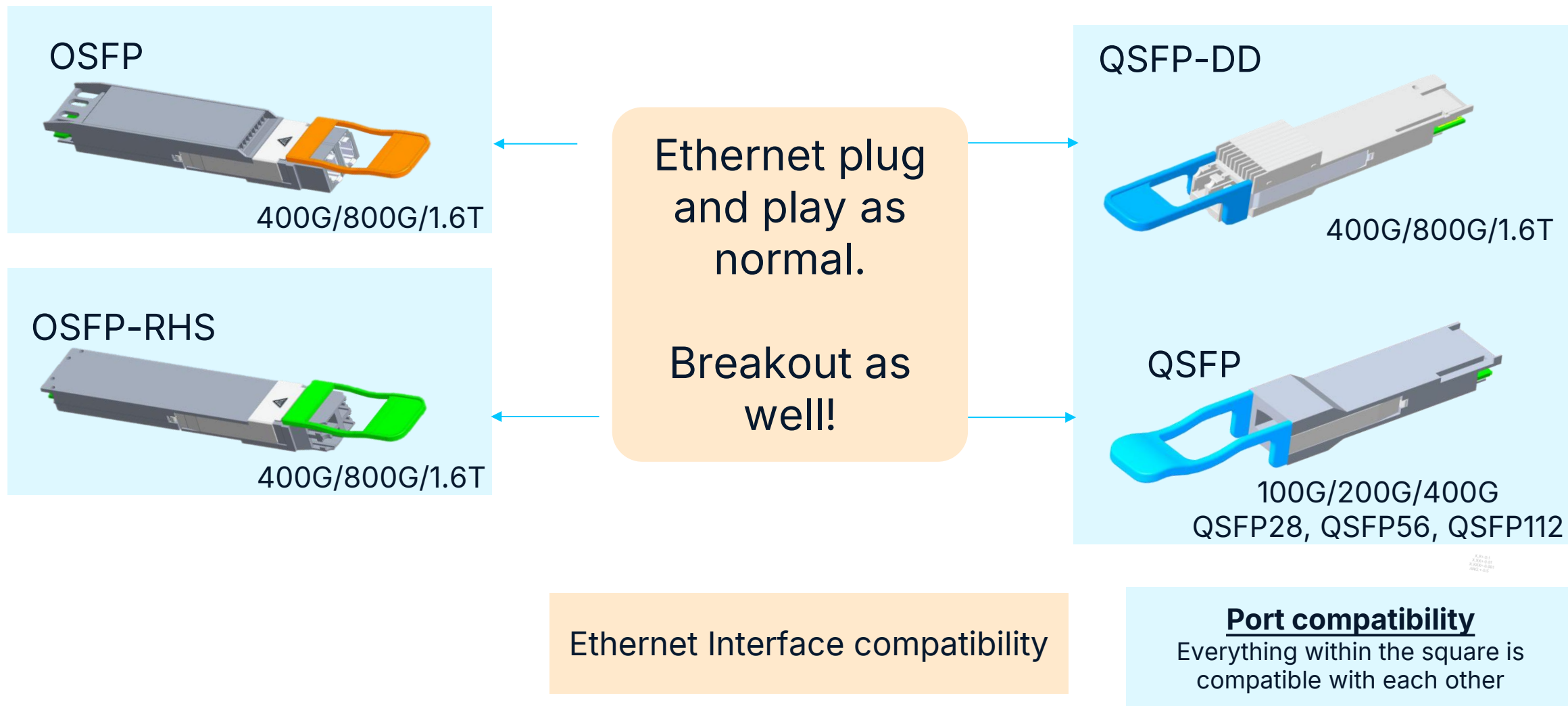
Host high-speed pins	8	8	8	4
Module capacity (Gbit)	400, 800, 1600	400, 800, 1600	400, 800	40, 100, 200, 400
Cooling	Integrated heatsink	Riding heatsink	Riding heatsink	Riding heatsink
High-speed IO Compatibility (Gbps)	50-100-200	50-100-200	50-100-200	1—25-50-100
Port compatibility	OSFP	OSFP-RHS	QSFP-DD & QSFP	
Management	CMIS			

System and ASIC design dictate which modules are supported and speed backwards compatibility

Pluggable form factors – a wealth of options



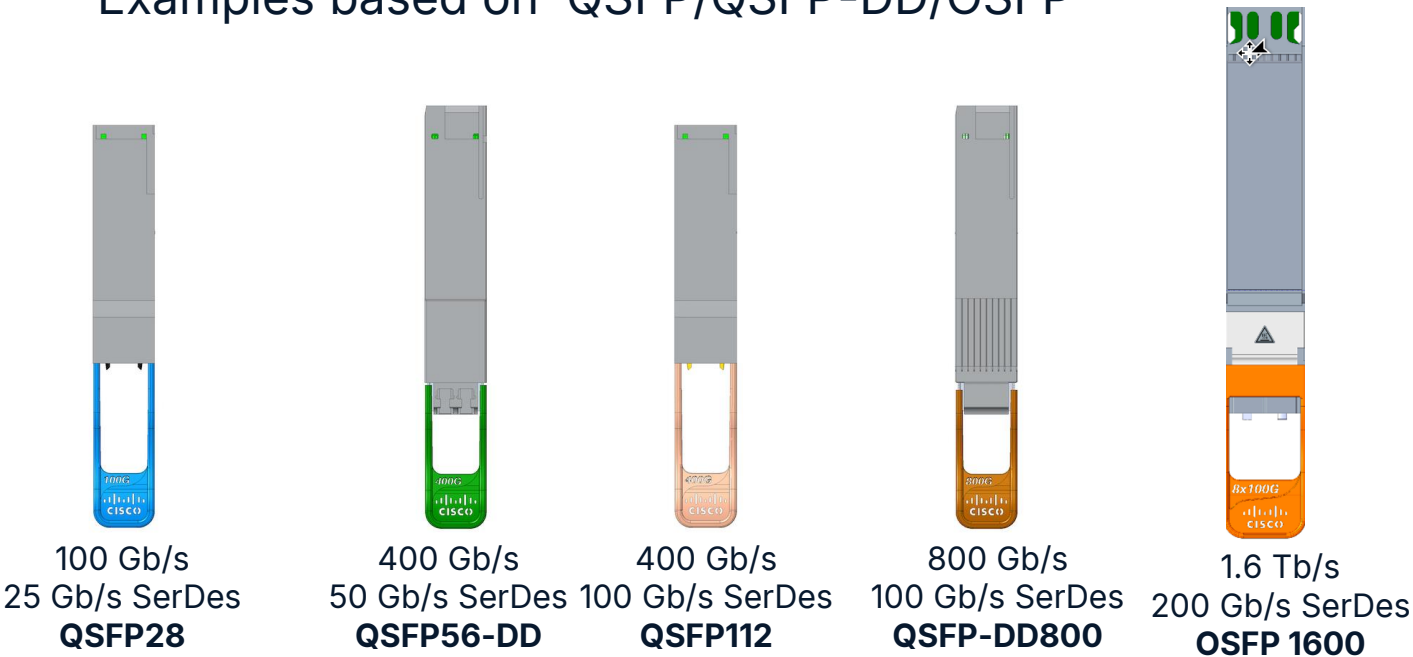
Pluggable form factors – interface interoperability



Key Trend: Modules support breakout

Examples based on QSFP/QSFP-DD/OSFP

Pluggable modules allow wide range of deployment options between switch and compute equipment with compatible modules



100 GbE	1x	4x	4x	8x	-
200 GbE	-	2x	2x	4x	8x
400 GbE	-	1x	1x	2x	4x
800 GbE	-	-	-	1x	2x
1.6T					1x

Broad Cisco availability for 200/400/800G



Distance	1-3+ m*	50/100 m	500 m-2 km	10 km	100+ km
200G QSFP56	QSFP-200-CUxM QDD-2Q200-CUxM	QSFP-200G-SL4 QSFP-200G-SR4-S	QSFP-200G-FR4-S		
400G QSFP-DD	QDD-400-CUxM QDD-2Q200-CUxM QDD-4ZQ100-CUxM QDD-400-AOCxM	QDD-400G-SR8-S QDD-400G-SR4.2-BD QDD-400G-VR4 QDD-400G-BD	QDD-400G-DR4-S QDD-4X100G-FR-S QDD-400G-FR4-S	QDD-400G-LR4-S QDD-2X100-LR4-S	QDD-400G-ZR QDD-400G-ZRP
400G QSFP112		QSFP-400G-VR4	QSFP-400G-DR4 QSFP-400G-DR4-2 QSFP-400G-FR4		
800G QSFP-DD	QDD-800-CUxM QDD-2Q400-CUxM QDD-4Q200-CUxM	QDD-800G-VR8	QDD-800G-DR8 QDD-8X100G-FR QDD-2X400G-FR4	QDD-800G-DR8-10 QDD-2X400G-LR4	
800G OSFP/R	OSFP-800-CUxM OSFP-2Q400-CUxM OSFP-4Q200-CUxM	OSFP-800G-VR8 OSFP-800G-VR8P OSFPR-800G-VR8	OSFP-800G-DR8 OSFP-800G-DR8P OSFP-L800G-DR8P OSFP-800G-DR8-2 OSFP-2X400G-FR4 OSFPR-800G-DR8	OSFP-800G-DR8-10 OSFP-2X400G-LR4	

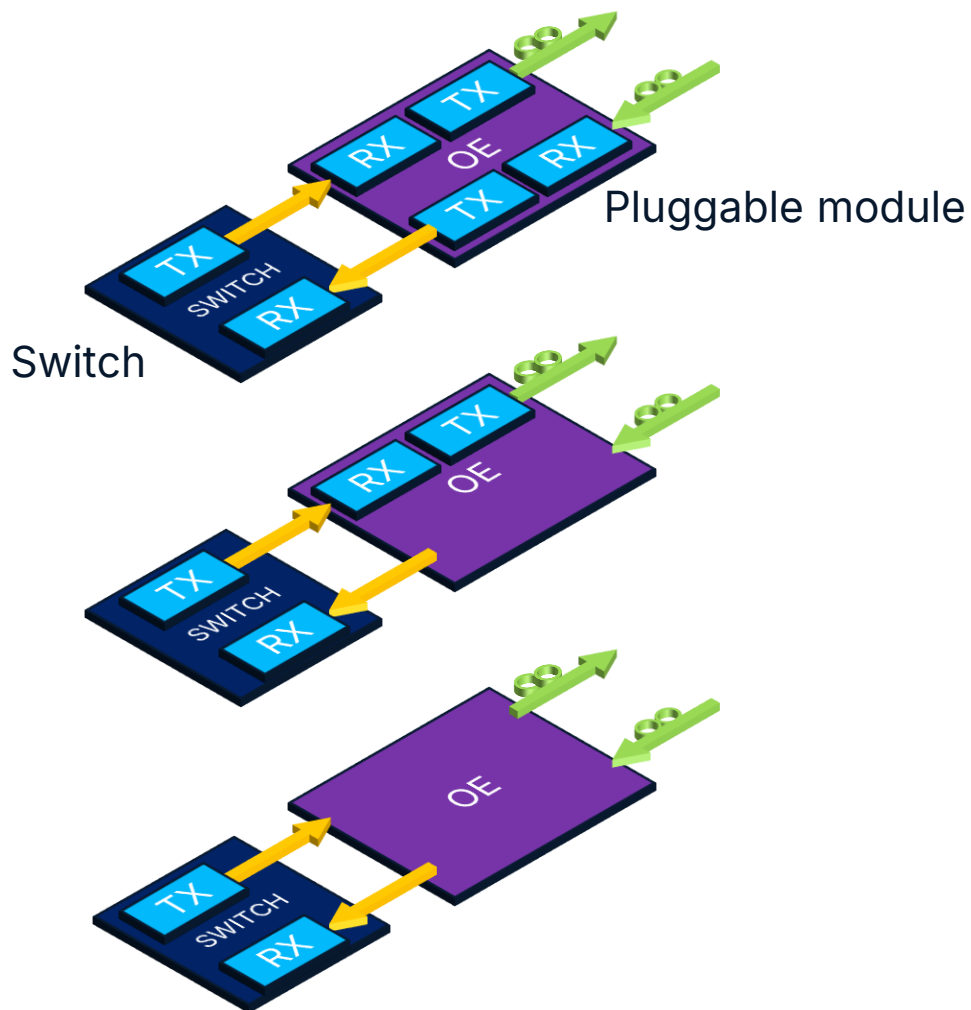
Unhighlighted PIDs are in production

OSFPR modules are OSFP-RHS form factor

New Form Factors

Reducing power (by removing functionality)

Linear, Partially Retimed, Retimed



Fully Retimed (aka FRO)

The pluggable module has active electrical receivers and drivers in both directions

Example: Most pluggable optics modules deployed today

Partially Retimed (aka LRO, TRO, RTL)

The pluggable module is linear in one direction and has an active electrical receiver and driver in the other direction

Example: 1.6T LRO OSFP

Linear (aka LPO)

The optical engine is a pure electrical to optical conversion without an electrical driver

Example: 800G LPO OSFP

Cisco 800G Linear Pluggable Optics (LPO) Solutions

AI Scale-out power efficiency and reliability for 800G Networks



Cisco L800G OSFP LPO

<8W power dissipation for DR8 SMF (500 m)

<5W power dissipation for VR8 MMF (50 m)

Shift power consuming optics DSP functionality to Cisco Silicon One platform

High signal integrity driven by Cisco Silicon One SerDes

High reliability with lower thermal stress

Increase port density without power upgrades

Extending Multimode BiDi to 400G

Cisco's 400G BiDi pluggable optic



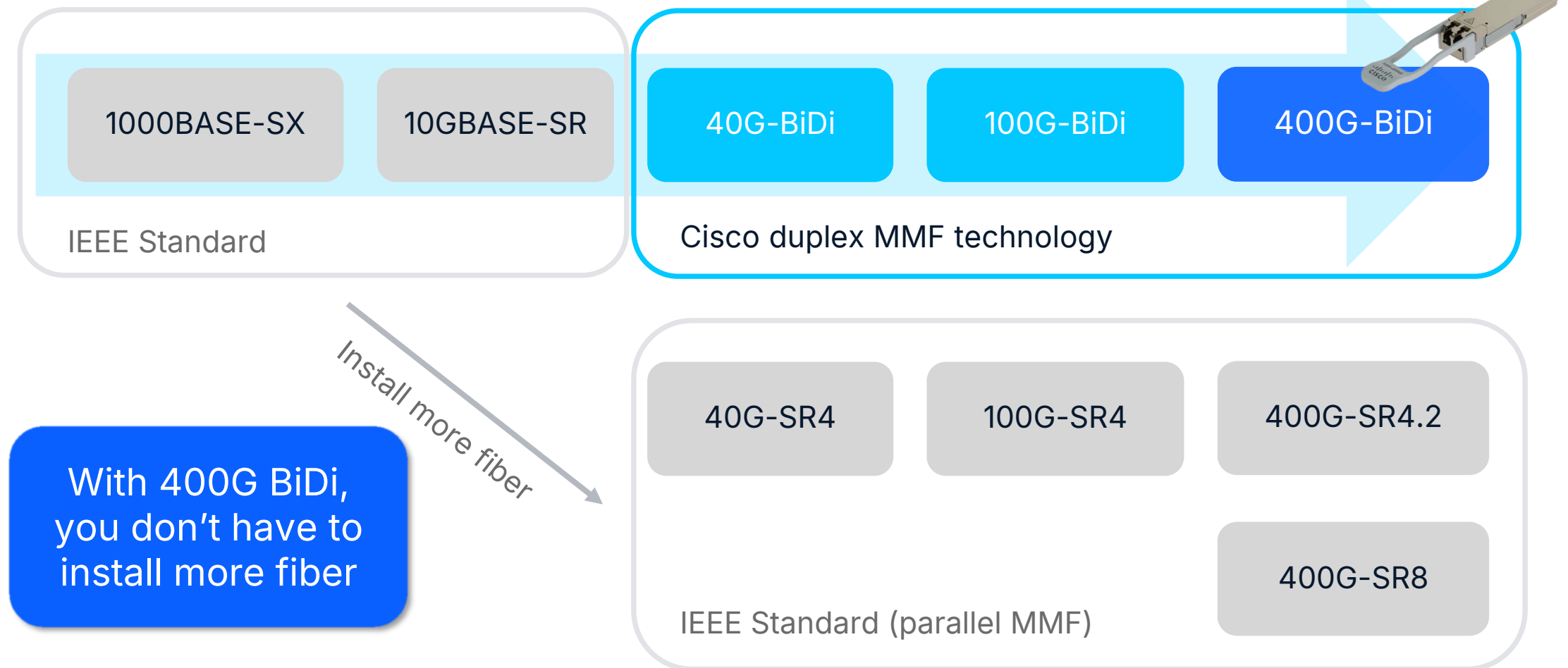
What's special about it?

It's the next generation of the popular 40G and 100G BiDi optics deployed widely in data centers.

- Breakthrough optical technology enabling 400 Gigabit link data rates over **duplex multimode fiber** (MMF).
- Cisco proprietary DSP design with advance equalization.
- The industry's only solution for 400G over duplex MMF today.

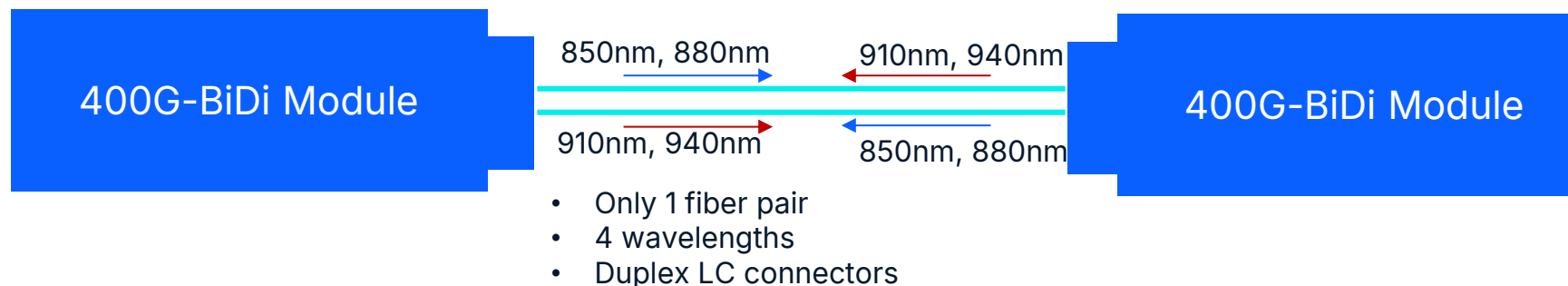
Increase the capacity of installed multimode fiber

Introducing Cisco 400G BiDi for duplex fiber



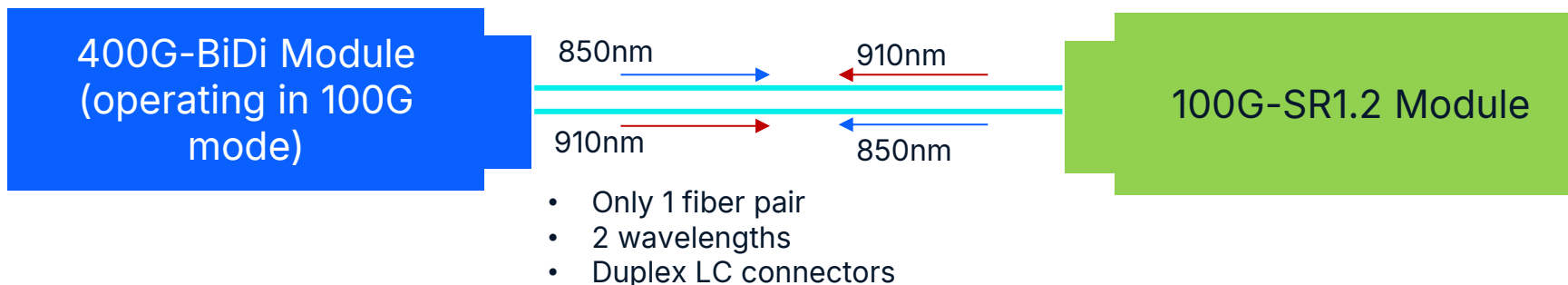
Dual-rate and interoperability with 100G SR1.2

400G Link



100G Link

Useful for partial upgrades of network



Investment protection with 400G BiDi optics

Brownfield deployments: save 65% per link by re-using fiber infrastructure

- No new fiber on trunks
- Re-use patch panels
- Re-use patch cords
- No network disruption or new fiber install

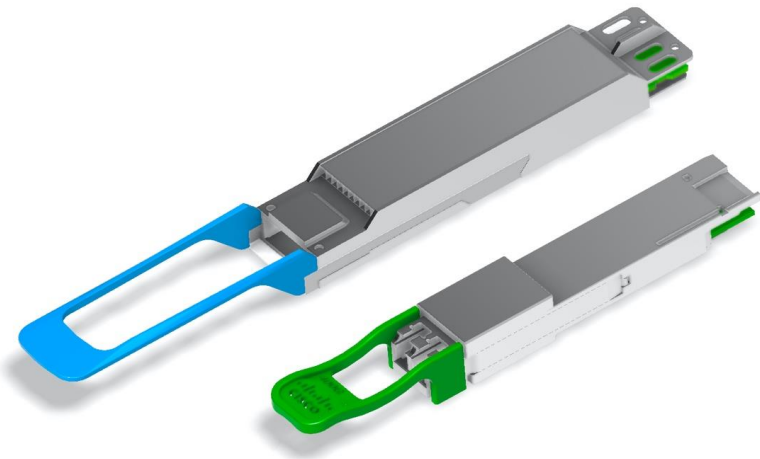
Green-field deployments: use 8 times less fiber compared to IEEE 400G SR8 optics

- Less expensive patch panel cassettes
- Less expensive patch cords

Fiber investments for duplex fiber and parallel fiber

Fiber infrastructure	Duplex MMF	Parallel MMF
400G optic	Cisco 400G BiDi	IEEE 400G SR8
Fiber trunks	2 fibers per link	16 fibers per link
Patch panels	Duplex LC connectors	MPO16 connectors
Patch cords	2 fibers and duplex LC connectors	16 fibers and MPO16 connectors

Key takeaways – client (IMDD) reaches



400G & 800G Standards are mature. Ethernet interop is guaranteed regardless of form factor

Optics and copper interconnect available in all reaches. [New](#) 400G MMF BiDi & 800G LPO.

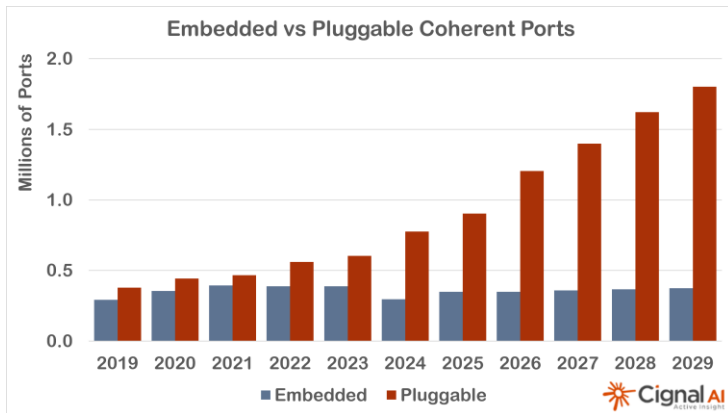
Cisco has a wide variety of high-density transceiver and cabling breakout solutions

Simplified deployment options are available

Coherent pluggables - Market/technology trends

Coherent Pluggables % Continue Increasing

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



Coherent Pluggables Expanding Applications

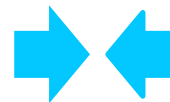
Farther: 400G ULH



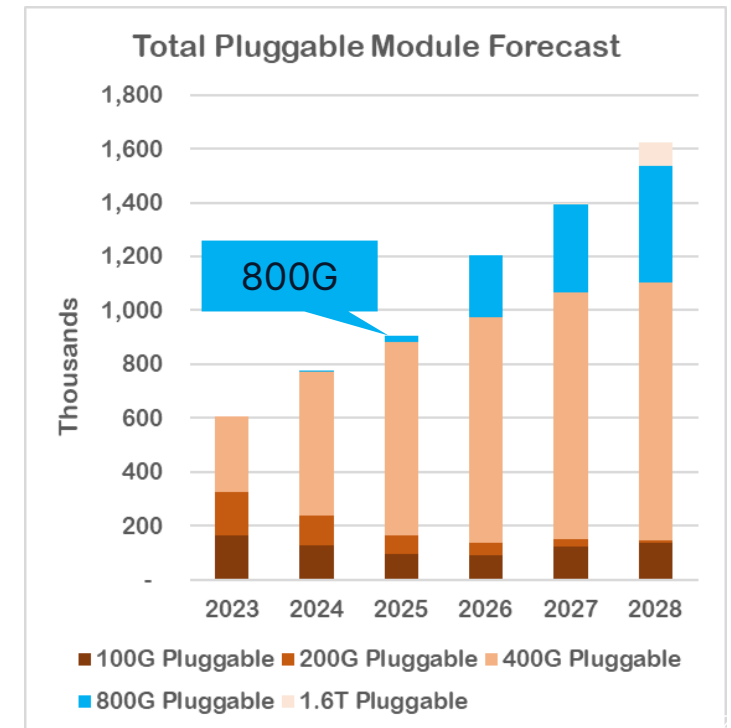
Wider: L-Band



Shorter: Coherent Lite



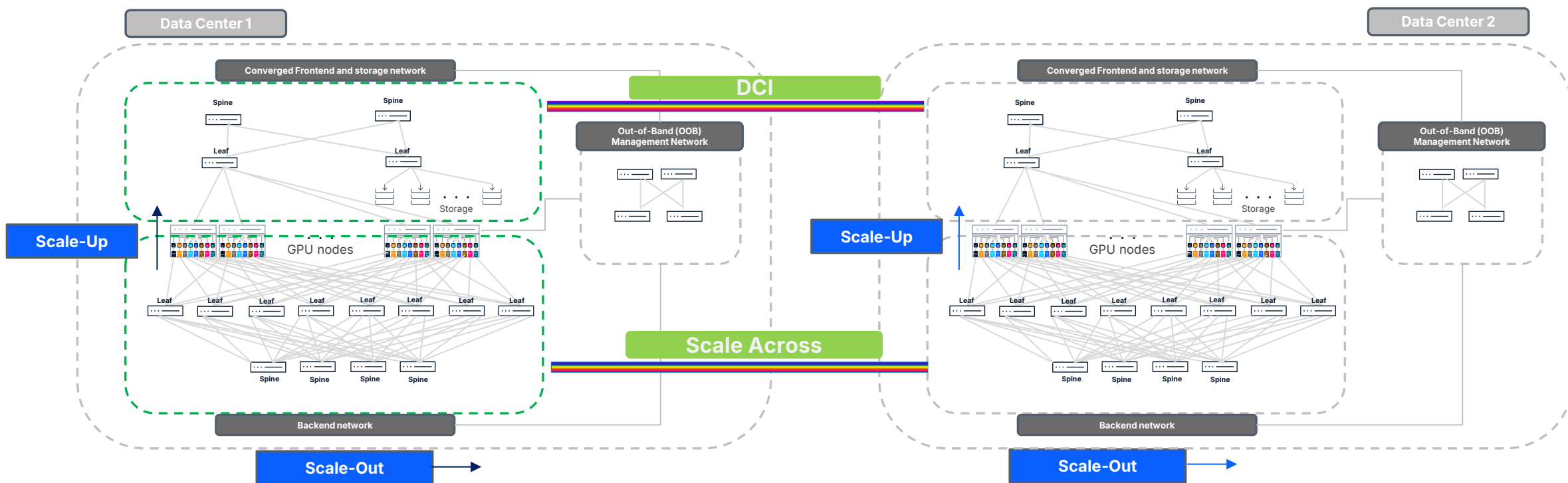
800G Coherent Market Takes Shape



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

Optics & AI Fabric Architecture

Pluggable Optics in Frontend and Backend



**Frontend for User Access & Management -
The "Service Fabric."**

- **Goal:** High-availability, user-facing performance
- **Optics Focus:** Pluggables, DCI, Routed Optical Networking (RON)

**Backend for Model Training/Inferencing -
The "Compute Engine."**

- **Goal:** Massive, sustained bandwidth, ultra-low latency, GPU-to-GPU synchronization.
- **Optical Focus:** AI-optimized interconnect (Power efficiency, reliability, density), Pluggables or alternatives.

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

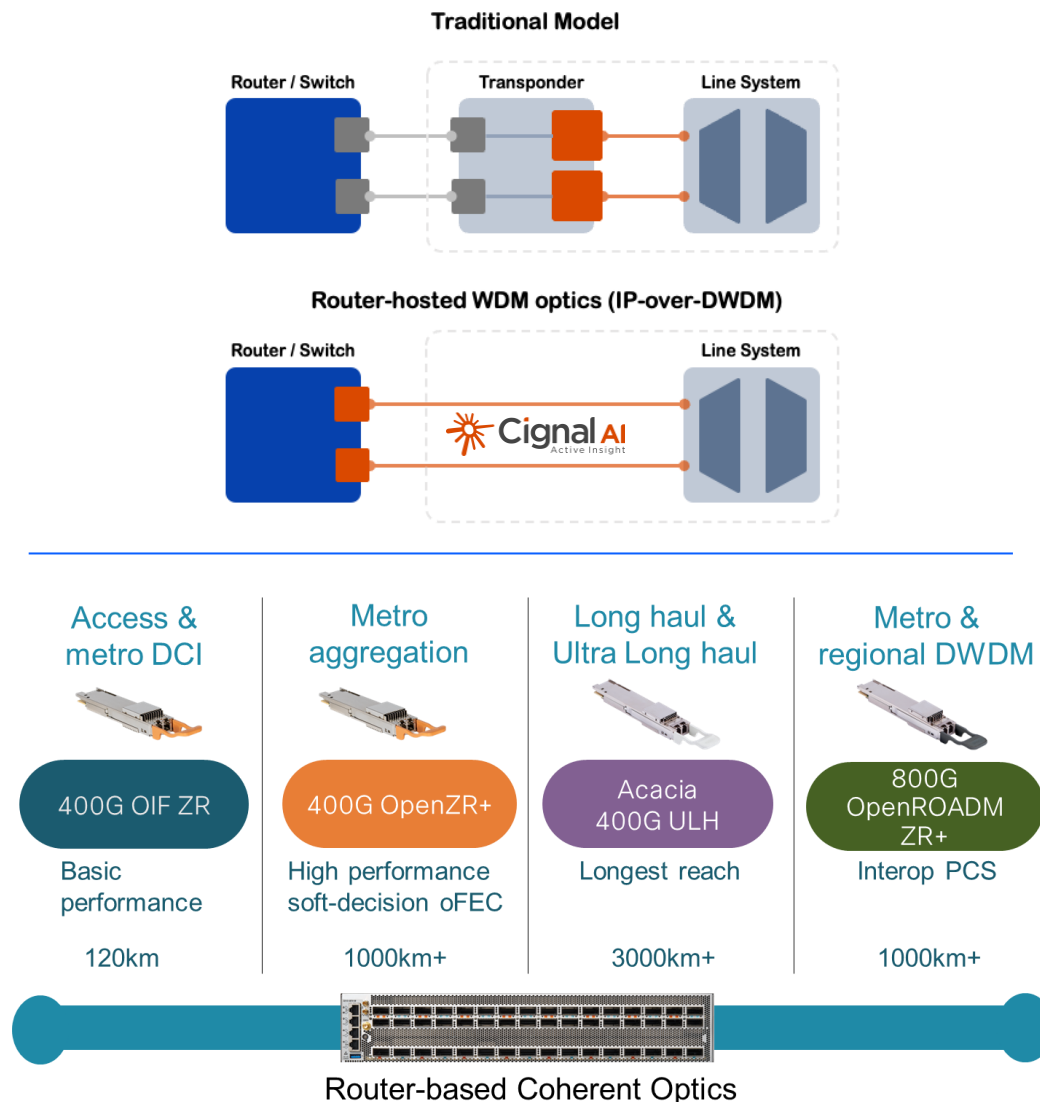
04

Drives interoperability

MSAs/standards, best in breed adoption

Pluggable coherent scales across the network

- Coherent interfaces in routers save power
- Designs optimized for power and performance
- Eliminate extra client optics interfaces between routers and transponders
- Based on standardized interfaces with proprietary options for challenging applications
- Use cases expanding from metro to regional and long haul

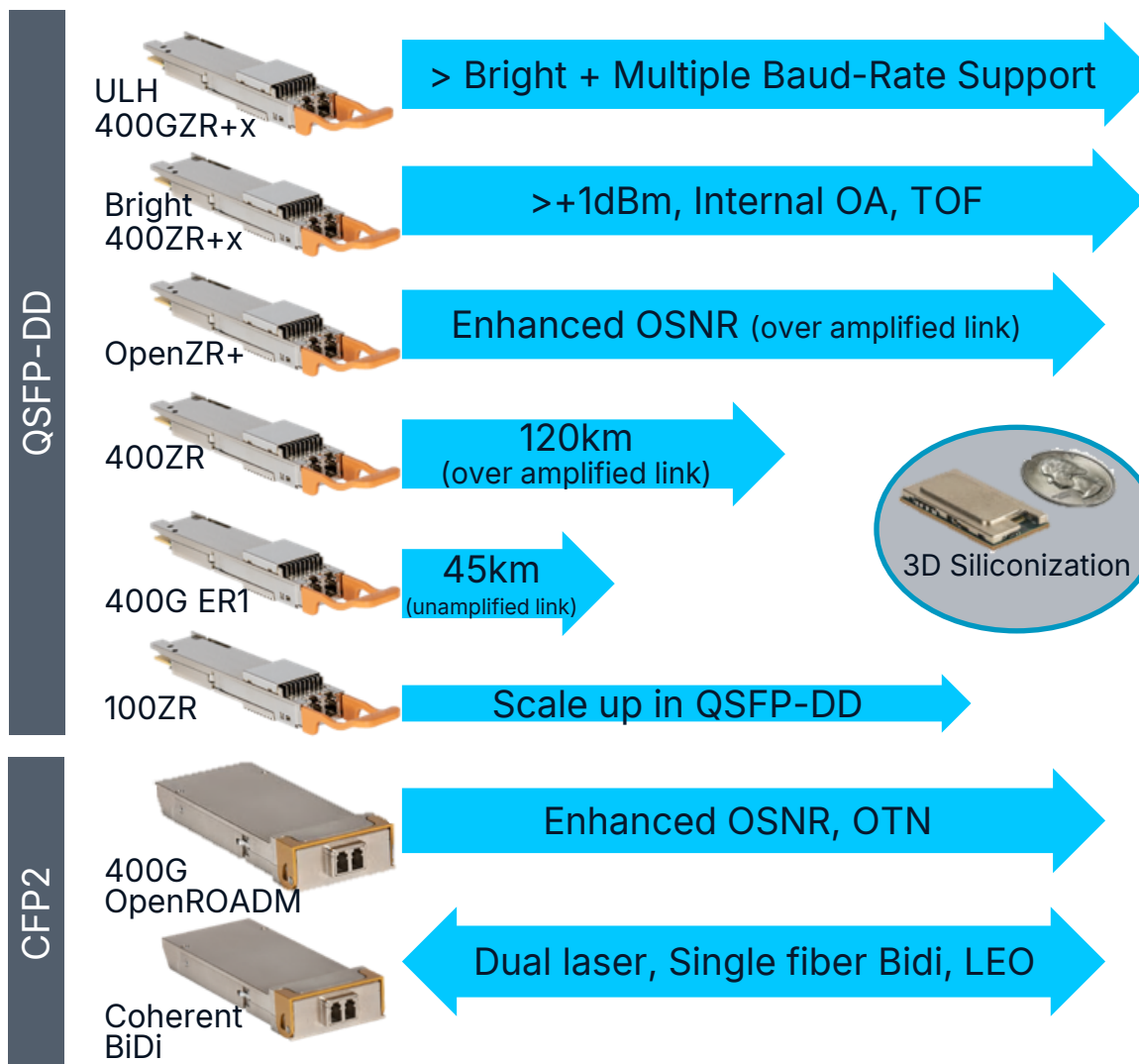


Current 400G MSA pluggables portfolio

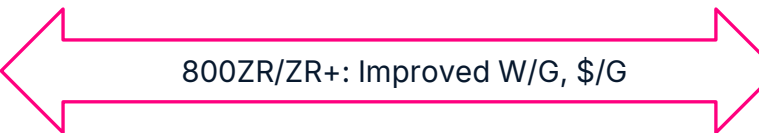
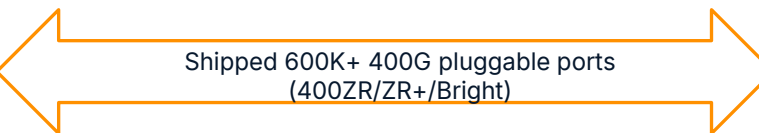
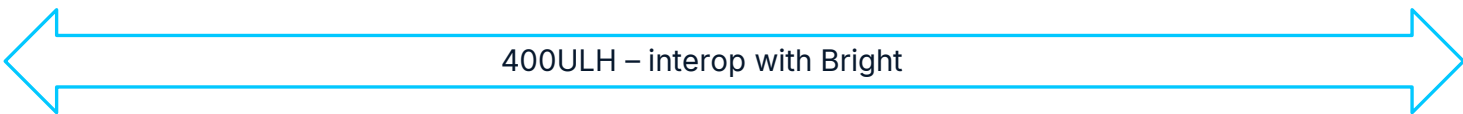
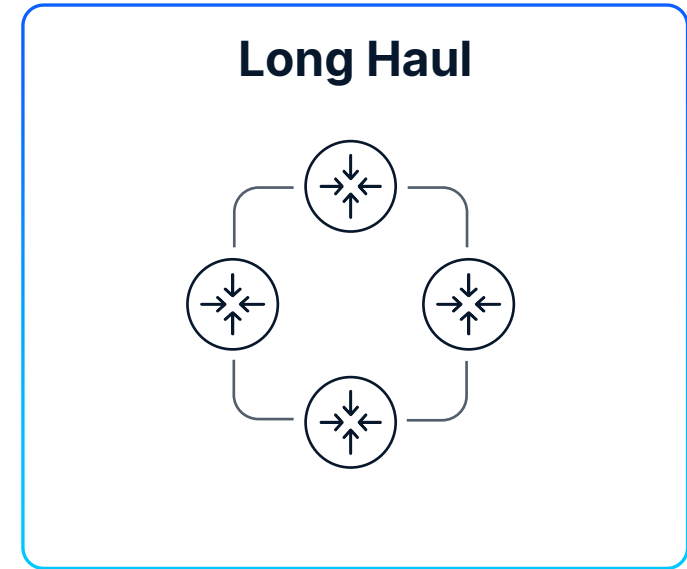
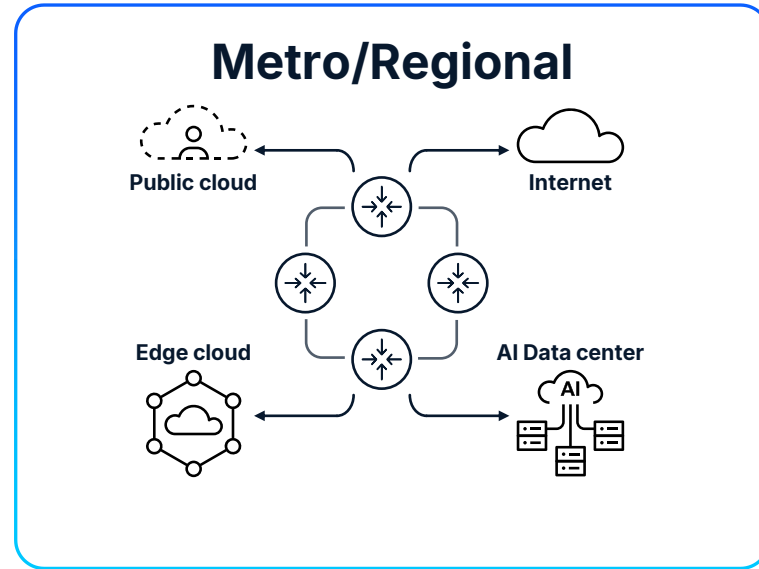
Industry leading 400G
pluggable deployments

Best in class quality

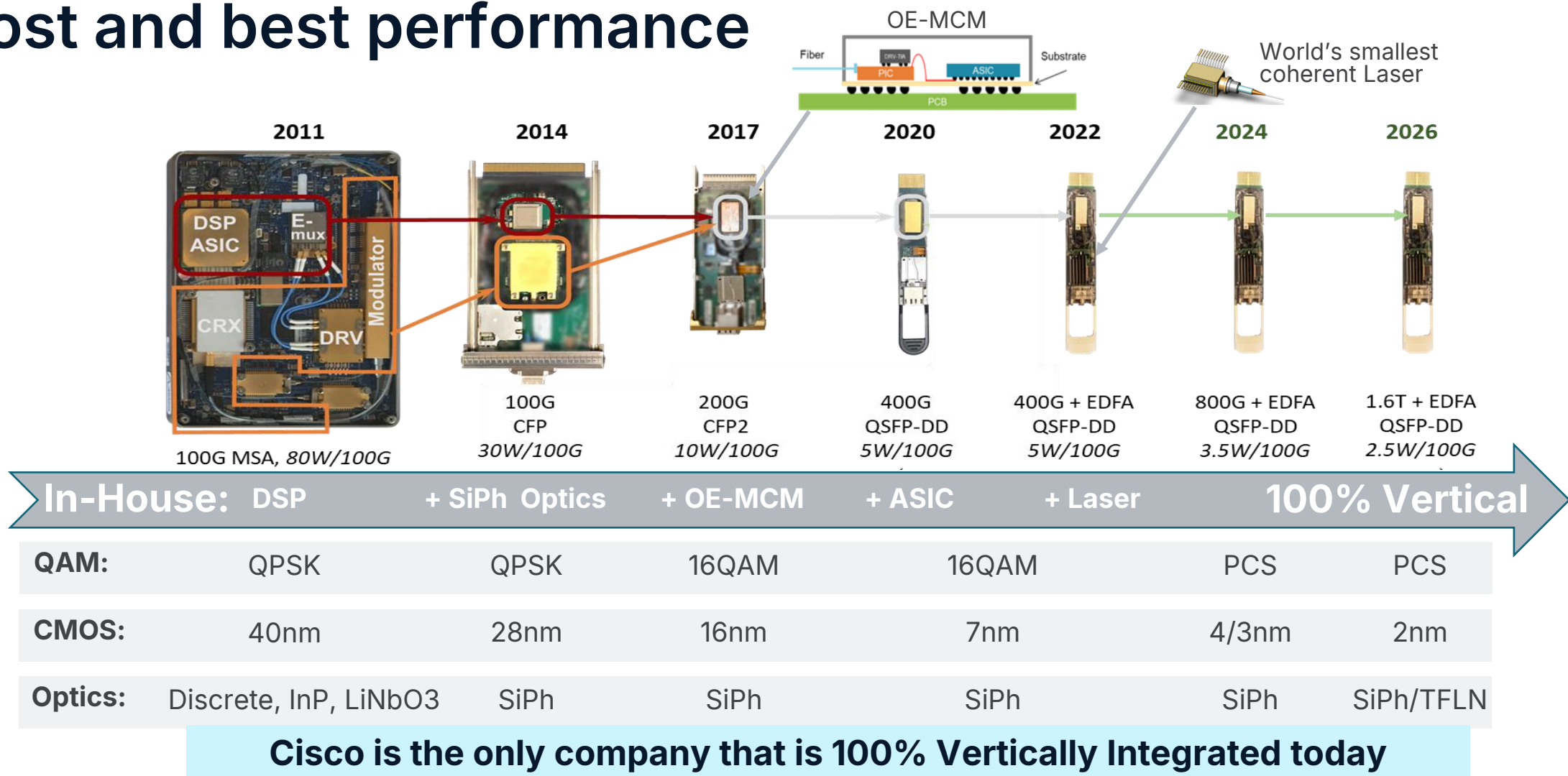
Standards compliant



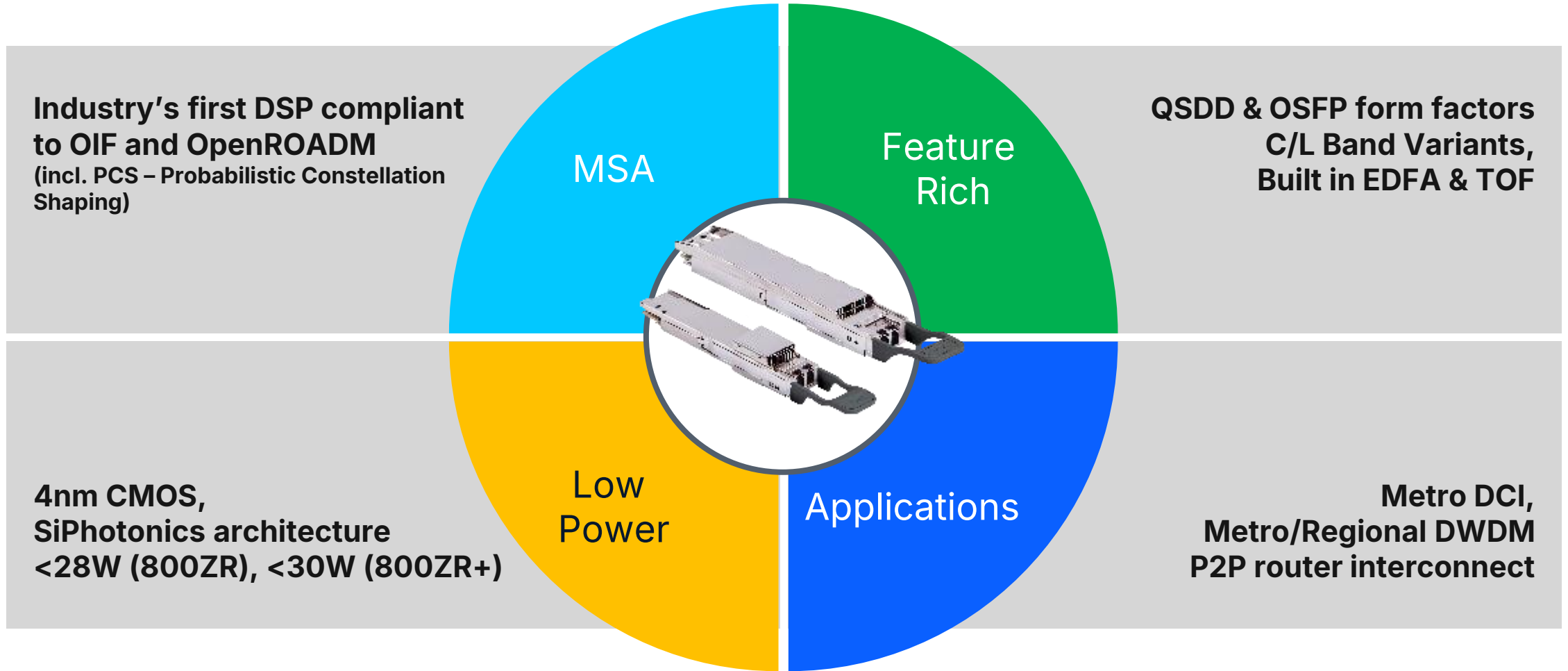
Expanding pluggables to access & long-haul networks



Vertical integration is key to lowest cost and best performance

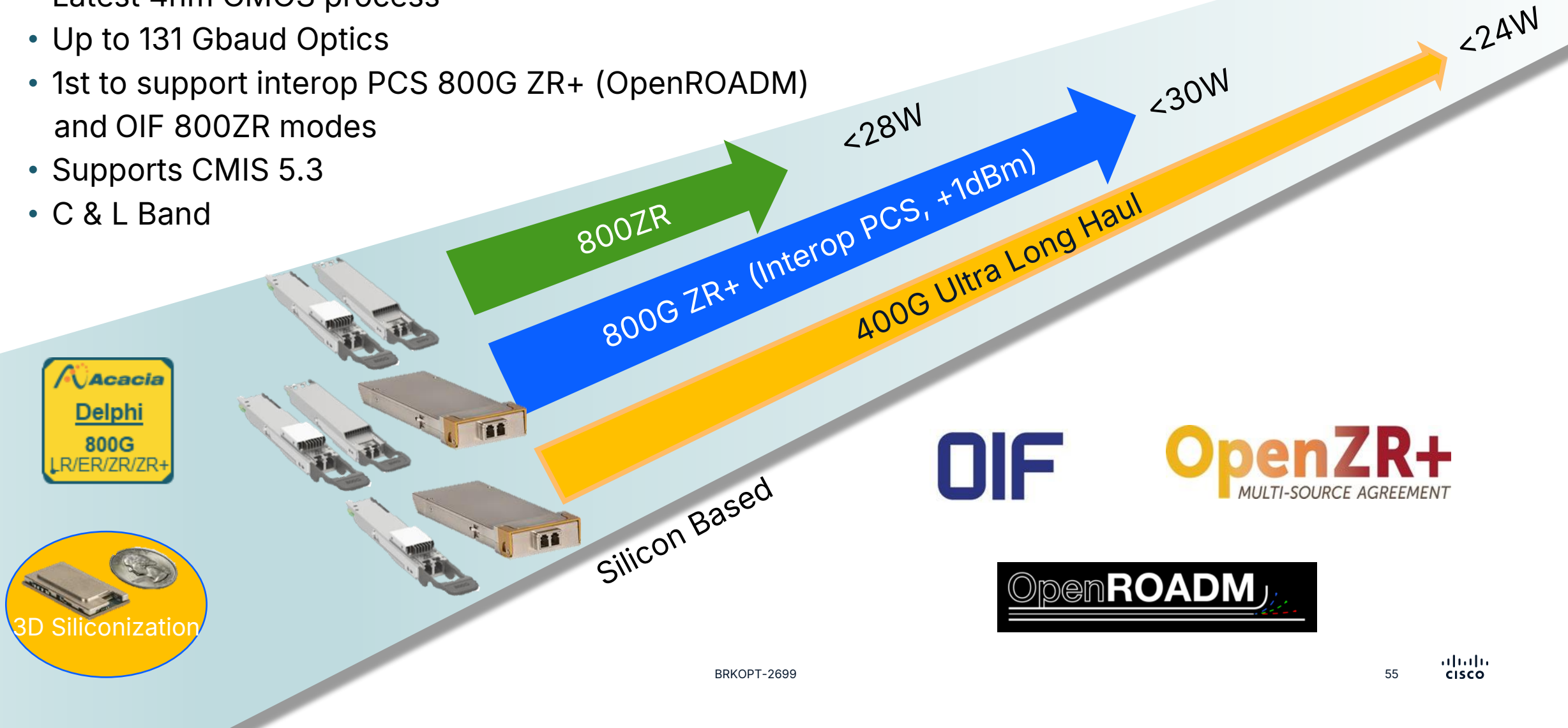


800G Coherent pluggables



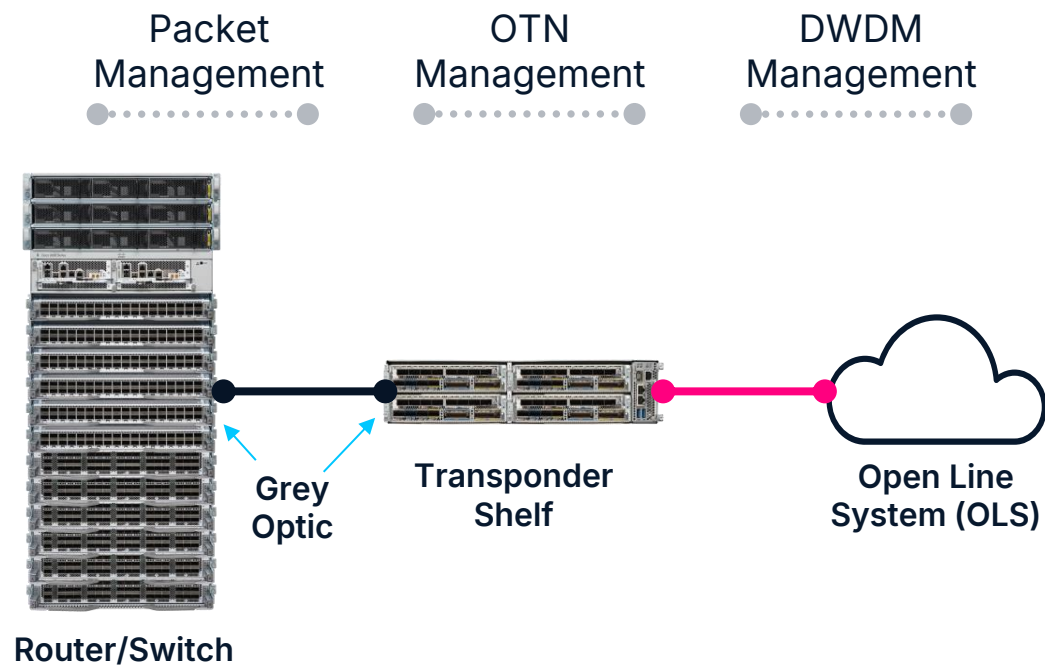
Welcome to the next-gen coherent pluggables !

- 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



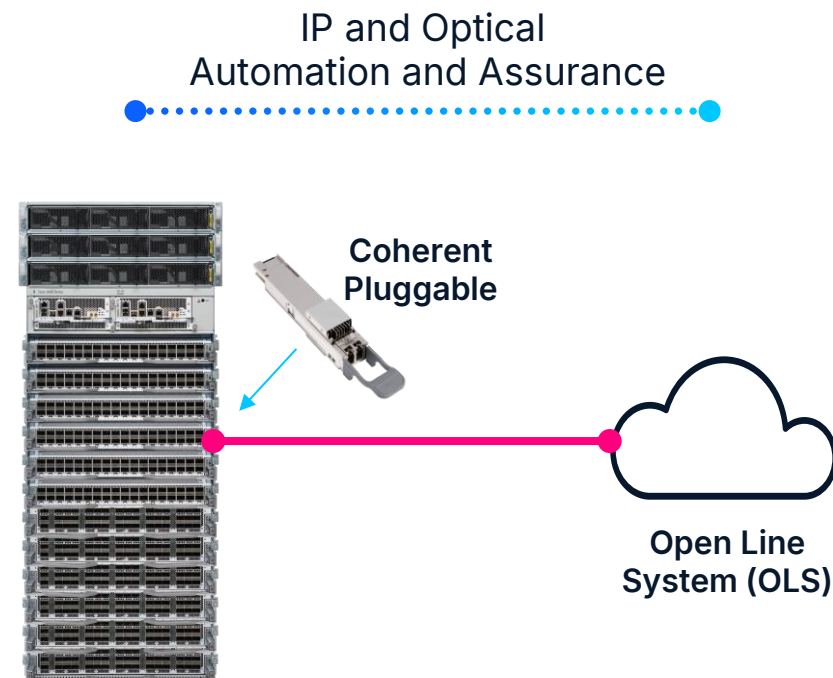
Coherent optics enables IP-optical convergence

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

Routed Optical Network (RON)

Supporting different use cases (access to ULH) and different deployment models



TCO* 46%
CapEx* 35%
OpEx* 57%

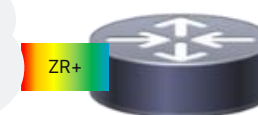
1

QDD-ZR/ZR+
over third-party OLS



Cisco Router

Third-party
OLS



Cisco Router

2

QDD-ZR over dark fiber
or passive DWDM



Cisco Router



Cisco Router

3

QDD-ZR+
over Cisco OLS



Cisco Router

Cisco
OLS



Cisco Router

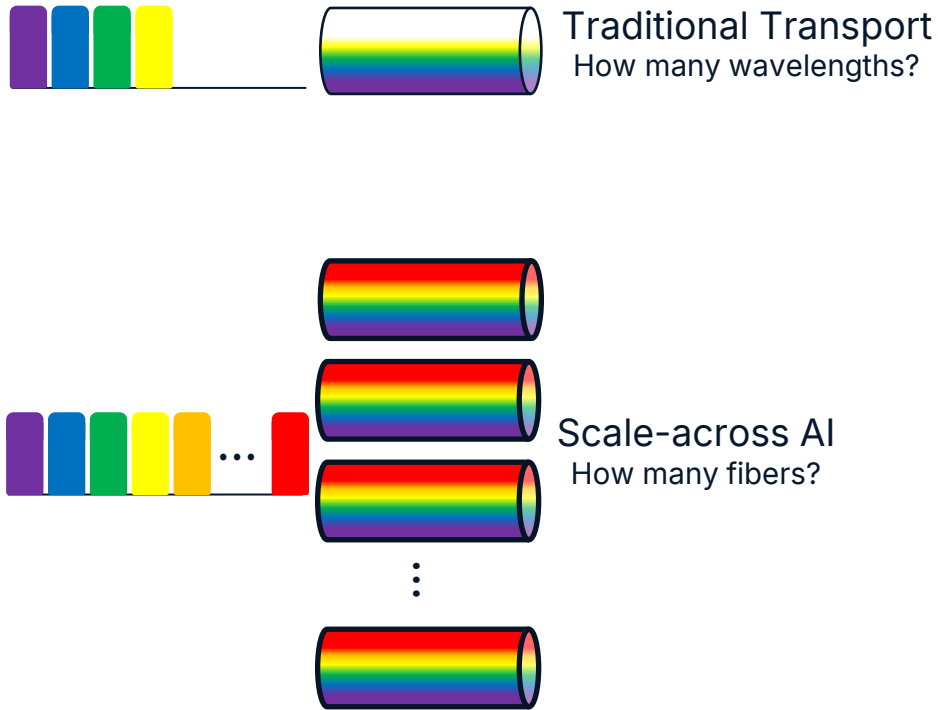
>75% of the RON deployments are over third-party line system! OLS: Open Line System

* ACG Research 2023

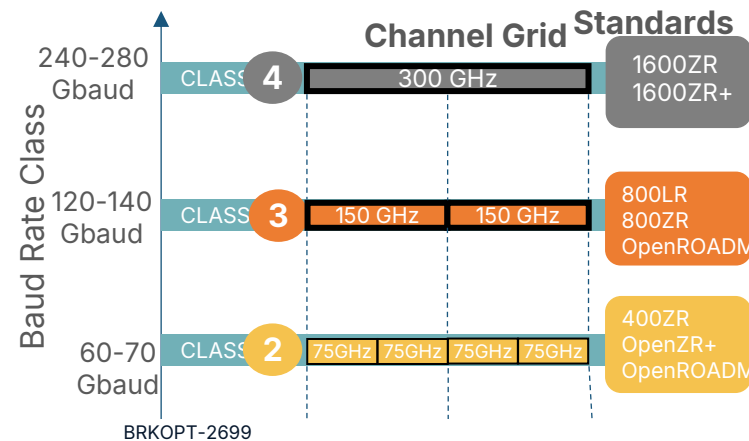
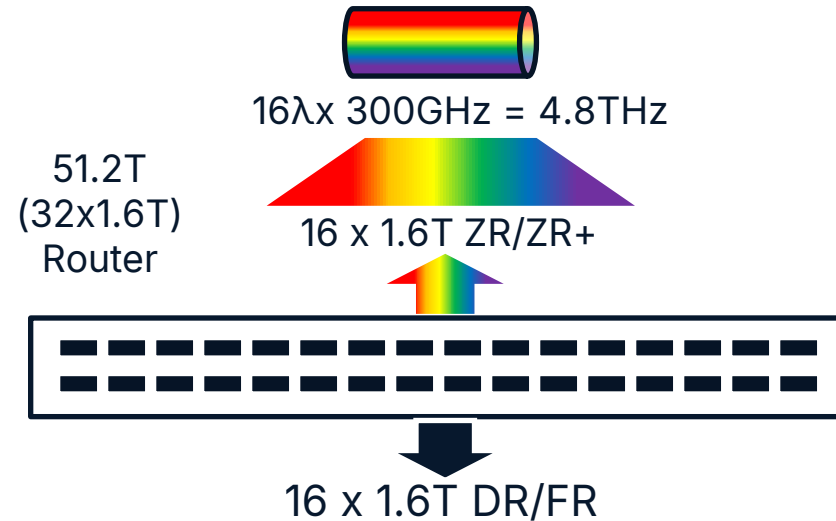
Scale across architectures

Considerations for Coherent optical interfaces → What's next

AI Driving New Traffic Granularity



Alignment of C-band and Router Capacity

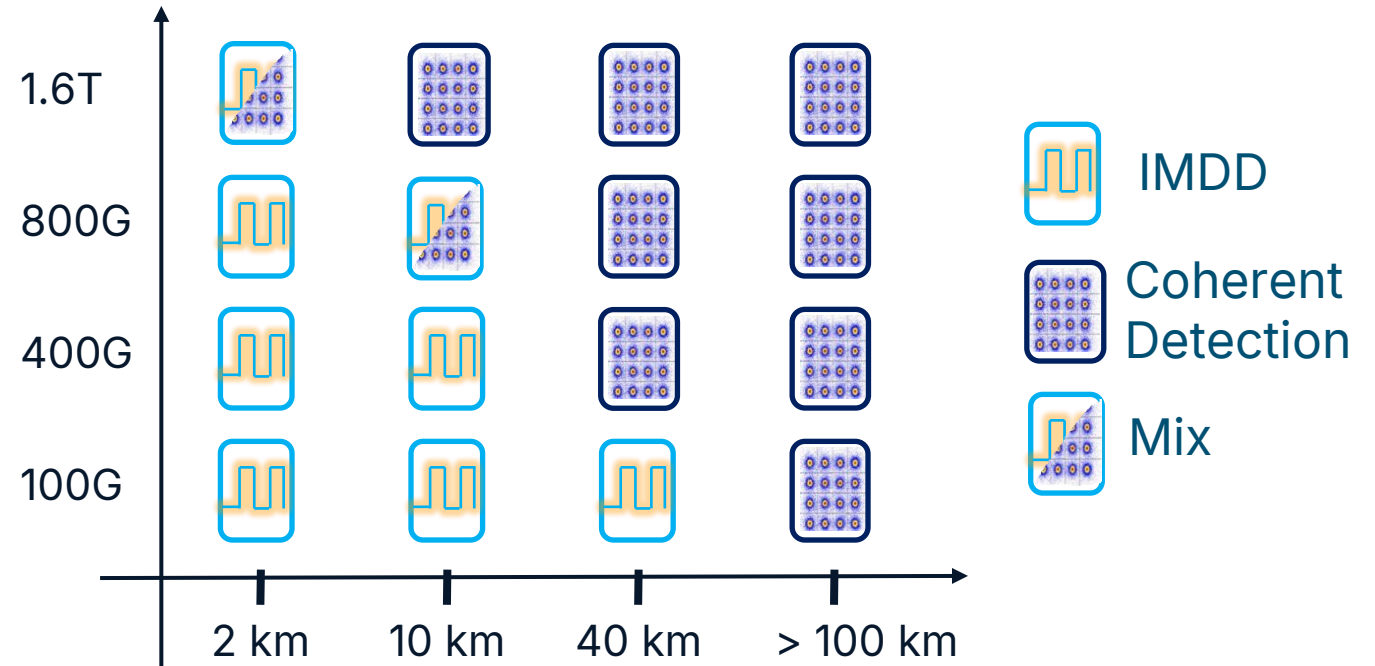


Coherent Pluggable

- 1.6T ZR/ZR+ being defined by OIF
- 240Gbd+
- Digital subcarriers for 1.6ZR+
- oFEC 16QAM, <40W, 3nm/2nm

Coherent optics addresses higher reaches (and speeds)

- IMDD and Coherent technology will continue to be used
 - 800G, 1.6T and beyond
 - Coherent pushing towards shorter reaches. Not only in DWDM but also Grey applications
 - Focus shifting from performance enhancements (\$\$\$) to interoperable interfaces and pluggables
- Coherent multivendor Interop more and more prevalent
 - 100ZR, 400ZR/ZR+, 800ZR/ZR+, 1600ZR



As speed increases, the crossover distance between IMDD & coherent decreases

Key takeaways – coherent interfaces



Pluggable solutions are leading option for coherent interfaces – including 100G now

400G coherent solutions (and standards) are mature with lots of deployment options

800G coherent solutions (and standards) available – interoperable PCS standardization improves performance

Routed optical networking: improved performance, operational efficiency & cost efficiency

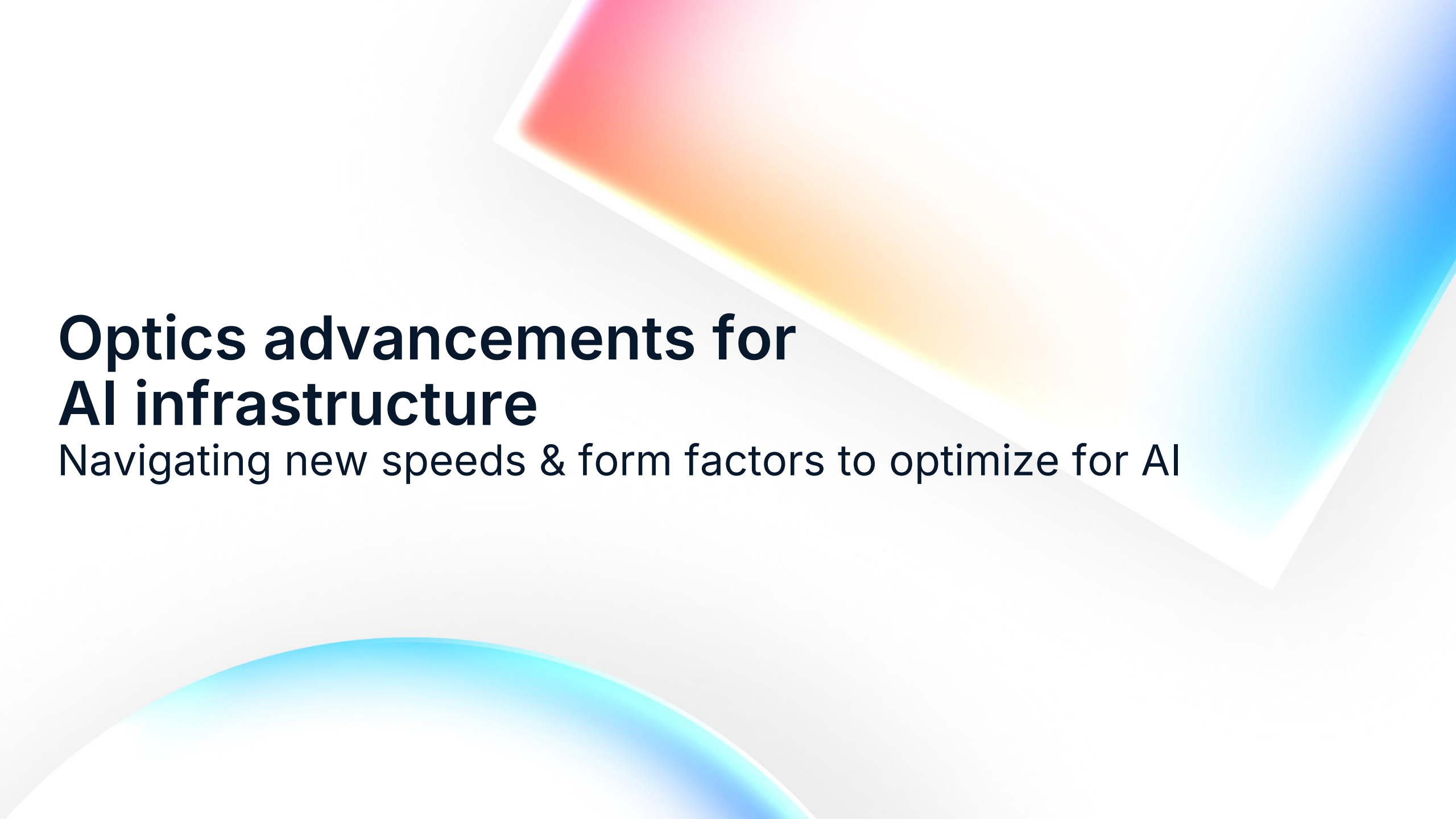
Increasingly relevant for AI Infrastructure

Operational checklist

Separate deployment readiness from optics shorthand.

Operational checklist

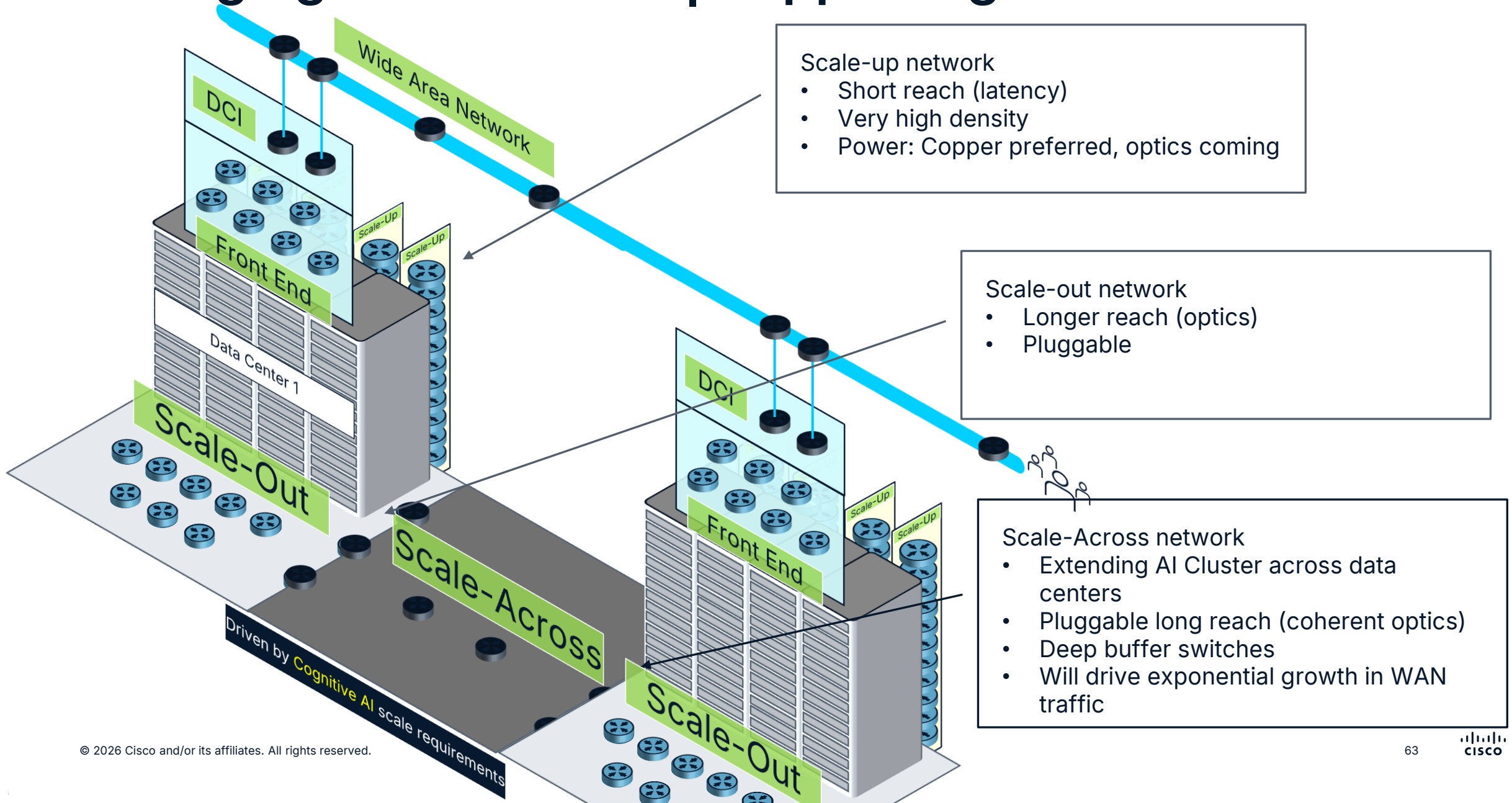
- 1 Validate the full link**
Host, module, fiber plant, reach, temperature, and FEC profile.
- 2 Instrument before scale**
CMIS/VDM baselines, alarms, error counters, and trend thresholds.
- 3 Plan lifecycle control**
Firmware, optics qualification matrix, sparing.
- 4 Model power and cooling**
Watts per port, cage thermal margin, fan curves, and rack power.
- 5 Document breakout behavior**
Lane mapping, polarity, cabling, support boundaries, and rollback

The background features abstract, overlapping geometric shapes in shades of red, orange, yellow, and blue, creating a modern and dynamic visual effect.

Optics advancements for AI infrastructure

Navigating new speeds & form factors to optimize for AI

Changing architectures | Supporting AI infrastructure



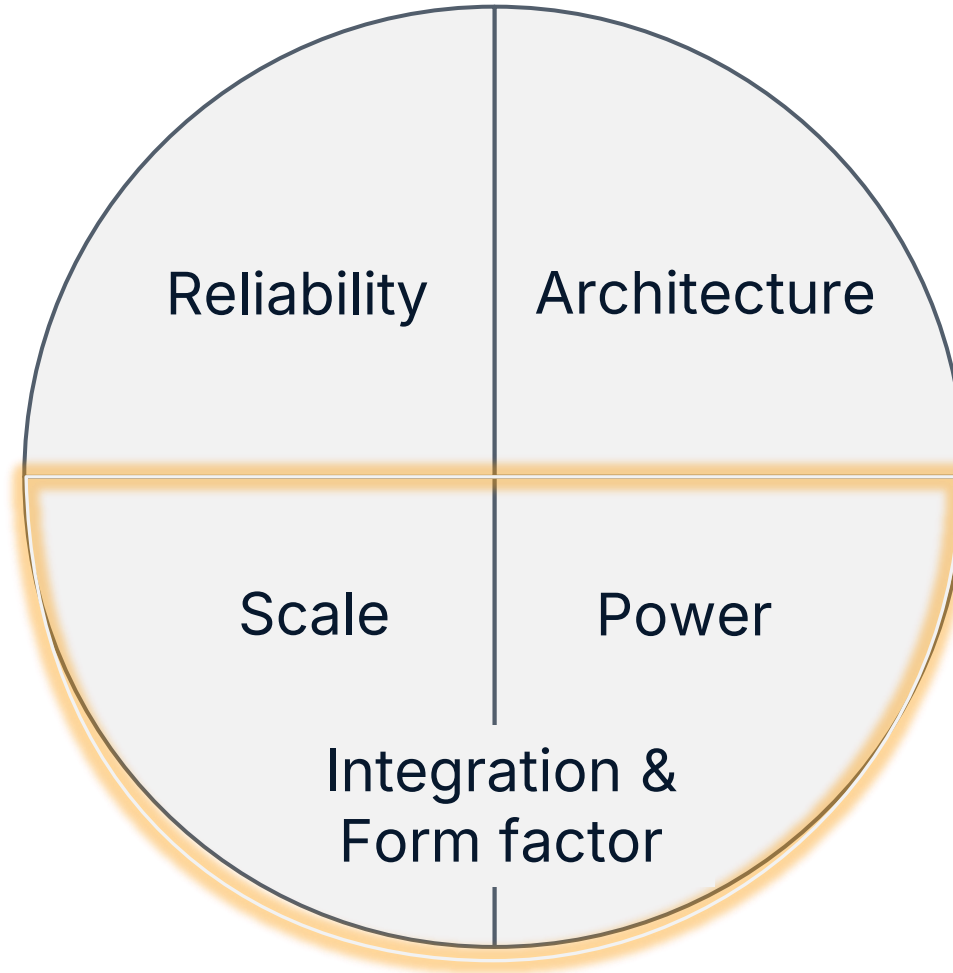
Priorities for interconnect in an AI world

Minimize workload impacts

- Physical reliability
- Link Performance

Interfaces:

- Ethernet
800 GbE → 1.6 TbE → 3.2 TbE
- Speeds: SERDES and λ
100 Gb/s → 200 Gb/s → 400 Gb/s



New architectures to support the necessary scale

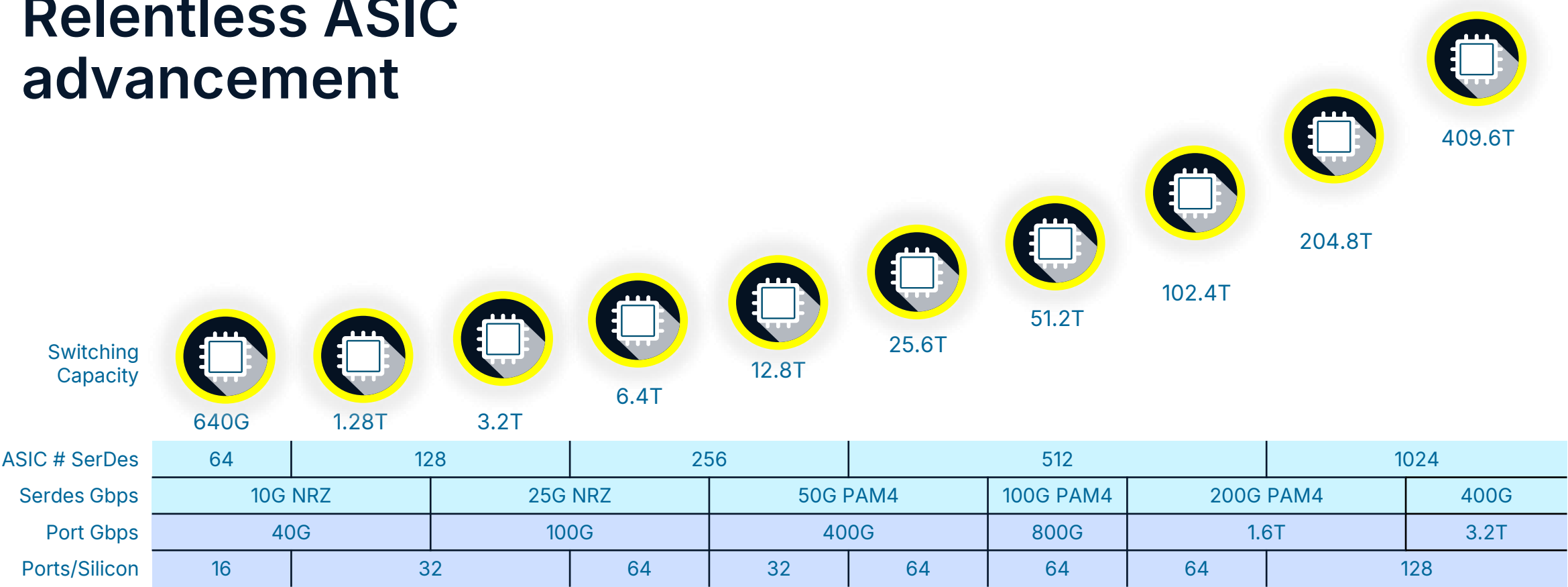
Power Efficiency

- Copper cables
- Linear Optics
- New approaches



Scale: Port & lane speed

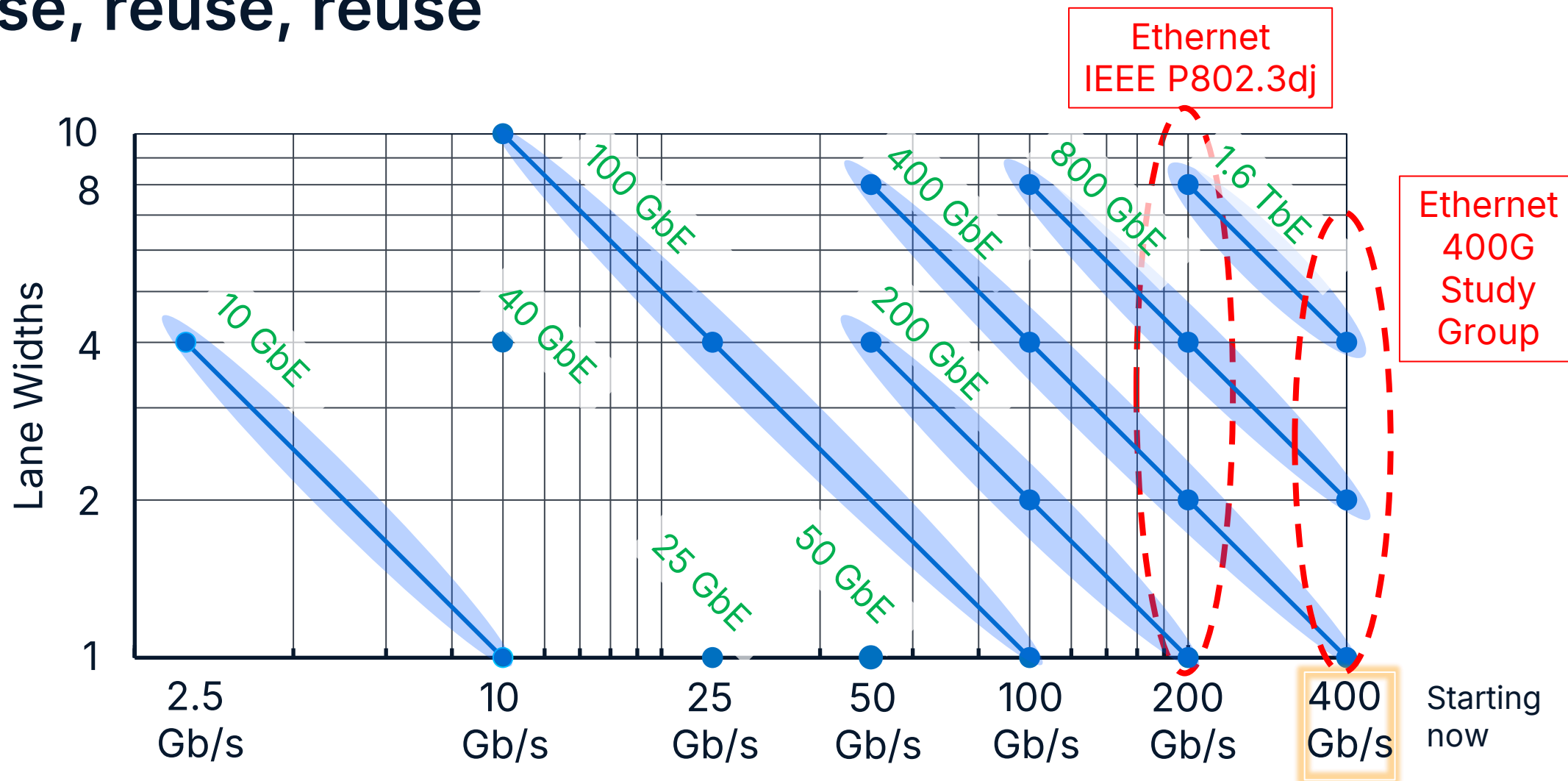
Relentless ASIC advancement



ASIC density continues to redefine how products are built.
SerDes & Interconnect. Optics & wavelengths.

Credit: adapted from slide by Rakesh Chopra & John Chapman
<https://blogs.cisco.com/sp/co-packaged-optics-and-an-open-ecosystem>

Next generation Ethernet's high-speed solutions – reuse, reuse, reuse



Ethernet's next generation: IEEE 802.3 P802.3dj

200 Gb/s per lane for 1.6 TbE, 800 GbE, 400 GbE and 200 GbE

Key themes :

- 200 GbE, 400GbE, 800GbE and 1.6TbE Ethernet interfaces (N x 200Gb/s)
 - Consideration of Breakout use-case
- Electrical interfaces based on 200 Gb/s
 - Copper Cables
 - Backplanes
 - Chip to module (AUI) interfaces and Chip to chip interfaces
- Optical Interfaces
 - Only single mode fiber (Duplex and Parallel)
 - 500m to 10km using 200 Gb/s per lane IMDD technology
 - 10km to 40 km using 800 Gb/s per lane (16QAM) coherent technology

Current status:

Spec in final review cycle

Products are in labs and demos

Publication expected CY26

What will 1.6T Ethernet pluggable modules provide?

Continued flexibility of implementations

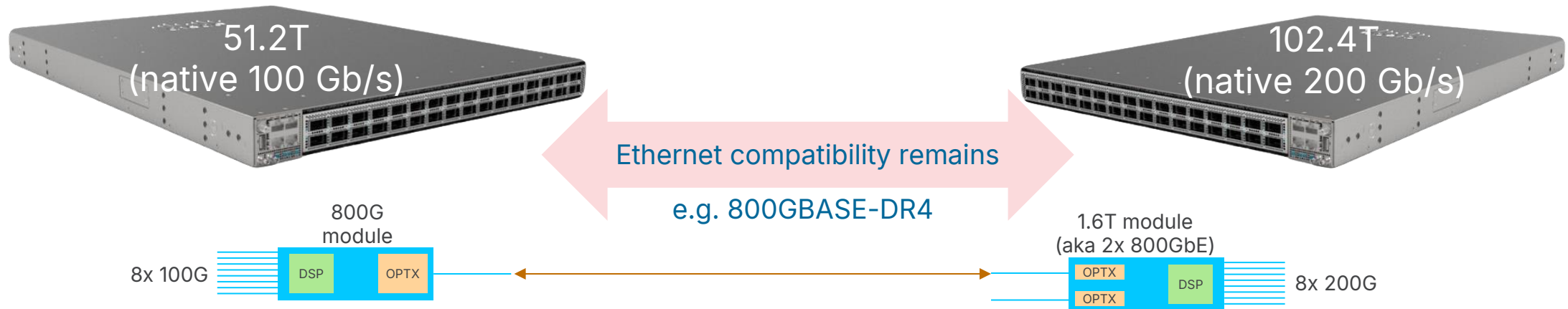
- Copper cables
- Multimode Fiber – 30/50 m (**just started in P802.3ds**)
- Single Mode Fiber inside DC – 500m & 2km
- Single Mode Fiber Campus – 10 km
- Outside plant, DCI – up to 40 km

Compatibility with known implementations was a strong factor in the Ethernet project's decisions

- Compatible with current CMOS
- Compatible with popular system configs or pluggable modules



1.6T Ethernet will maintain Ethernet's backwards compatibility



IEEE 802.3 P802.3dj's logic and architecture ensures compatibility with "legacy" systems and implementations.

Any 800 GbE capable port will operate with any other 800 GbE capable port:

- As long as the same PMD interface is used
- For example, 800GBASE-FR4 in both ports

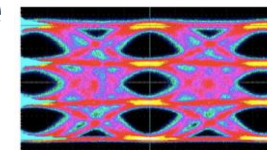
Key elements of 1.6 TbE using 200 Gb/s technology

Compatible with current CMOS, SiPhotonics, EML, Cable, Fiber technology

**200 Gb/s
Electrical and
Optical
technology
(PAM4)**

**New FECs and
compatible FEC
architectures**

Multiple FEC schemes for different reaches. Common architecture to enable compatible implementations



Implementations can use same technology for 8x, 4x, 2x or 1x variants

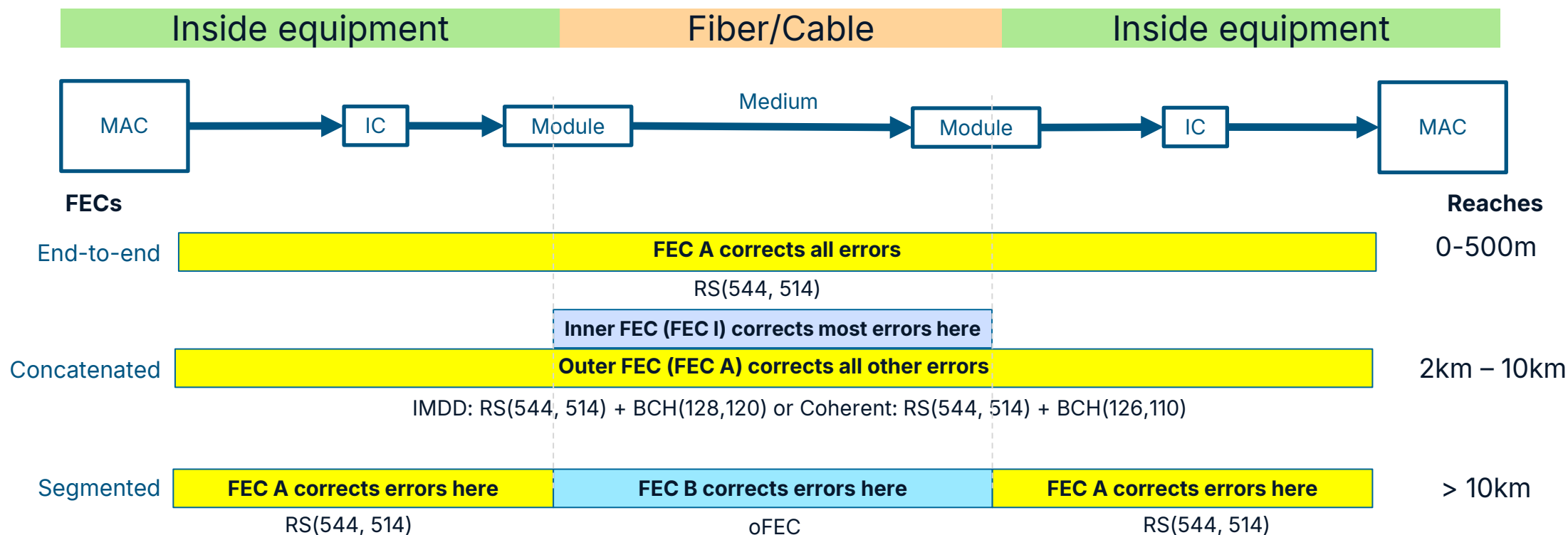
**Re-use
compatible
technology**

**Advanced link
operation**

New (optional) Optical Link Training and Automatic Path Startup (APSU)

Each speed step is more challenging!

Different reaches need different FECs



They key point:

- The switch platform will always have integrated FEC
- Modules may have additional FEC to reach a longer distance

Reliable connectivity for AI data centers

Cisco OSFP 1.6T pluggable optics

Powered by **Cisco Silicon Photonics**

High-performance and reliability
Advanced DSP-based diagnostics and monitoring



High bandwidth AI scale-out

1.6T switch-to-NIC connectivity and high-density fabrics for massive AI cluster builds (2x800G, 4x400G, and 8x200G links)

Diversified supply chain

Seamless AI cluster scaling with diversified supply chain and interoperability across Cisco and 3rd party DSPs

Efficiency and flexibility

Optics for power-efficiency and deployment flexibility in liquid cooled and air-cooled platforms

Ethernet starts its work on 400G per lane

400 Gbps per lane PHYs and Interfaces

Call for Interest (CFI) Consensus Building

Kent Lusted, Synopsys
Mark Nowell, Cisco

IEEE 802.3 400G per Lane Signaling CFI, March 2026

1

Started in March 2026

Focused on Scale-up market req'ts:

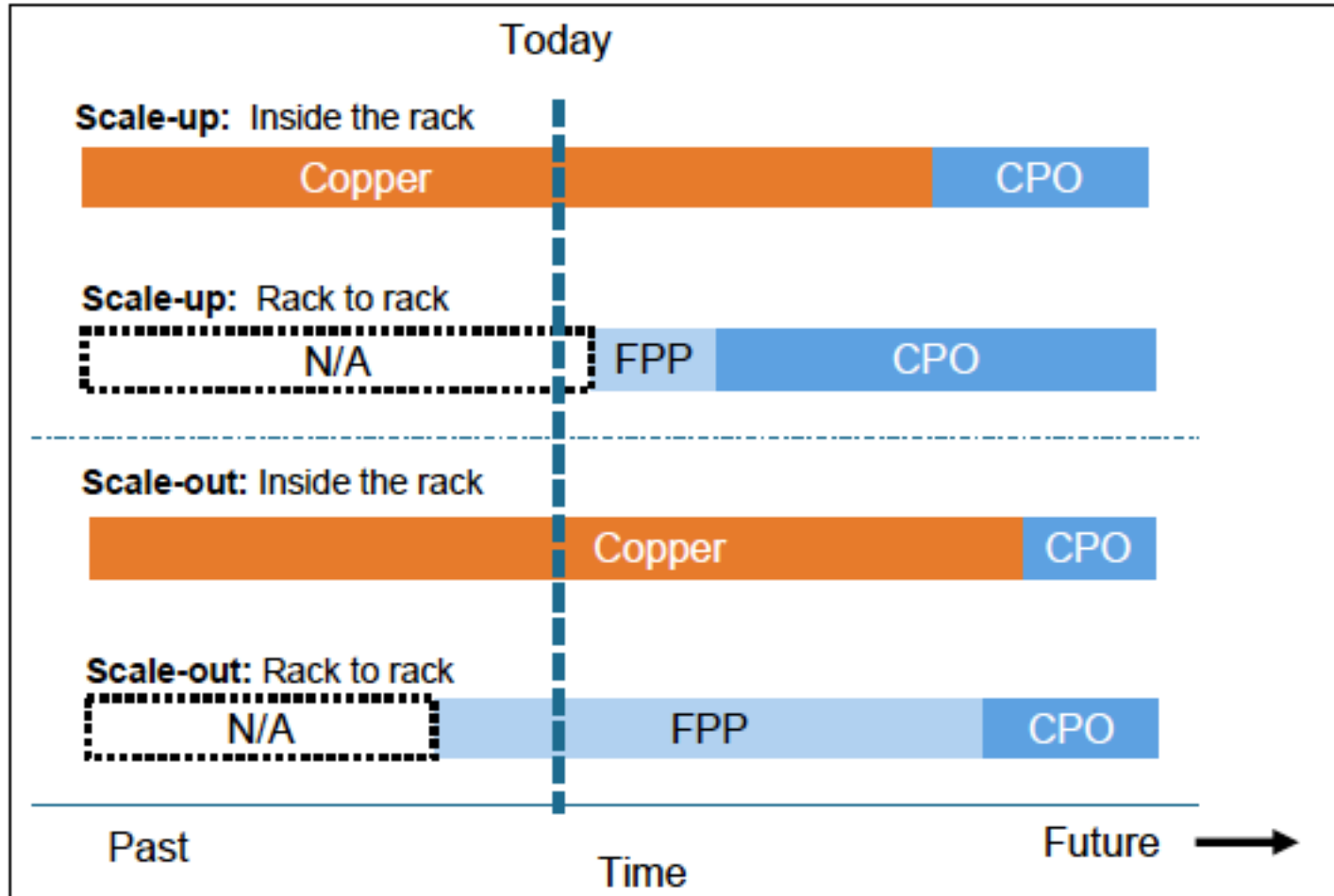
- Higher lane data rates (400G)
- Focused on the scale-up market needs
 - Electrical
 - 1m cable
 - Chip-to-Module interfaces
 - Optics
 - Single λ , 500m max

https://www.ieee802.org/3/cfi/0326_1/CFI_01_0326.pdf

Not included, but expected to be incorporated in fast-following projects:

- 3.2 TbE MAC rate
- Longer reaches

Ethernet 400G per lane Study Group scope



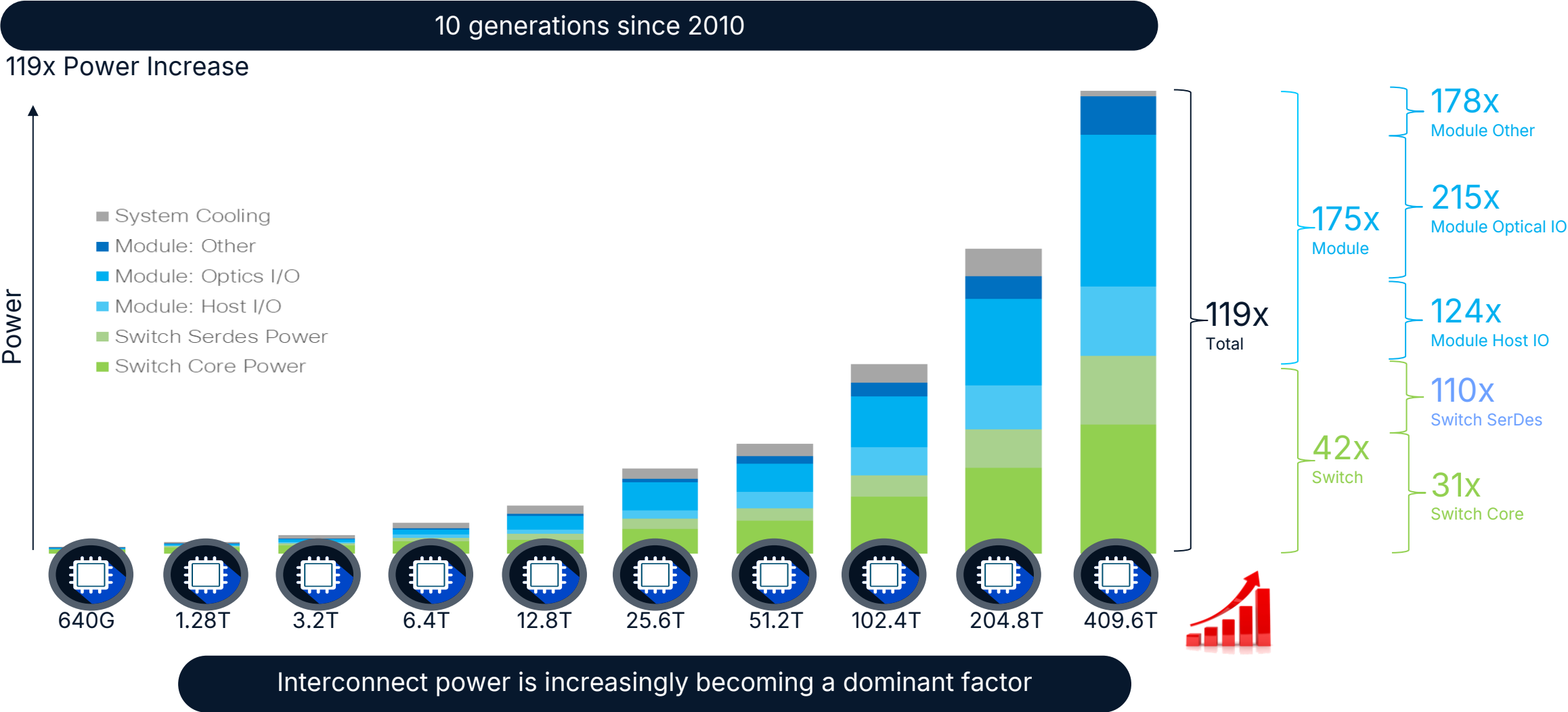
Evolution of optical and electrical interfaces within AI infrastructure

https://www.ieee802.org/3/cfi/0326_1/CFI_01_0326.pdf Based on AI Networking: What do scaleup and scaleout really mean for networking demand, Alan Weckel (650 Group),
https://www.ieee802.org/3/ad_hoc/E4AI/public/25_0327/weckel_e4ai_01_250327.pdf

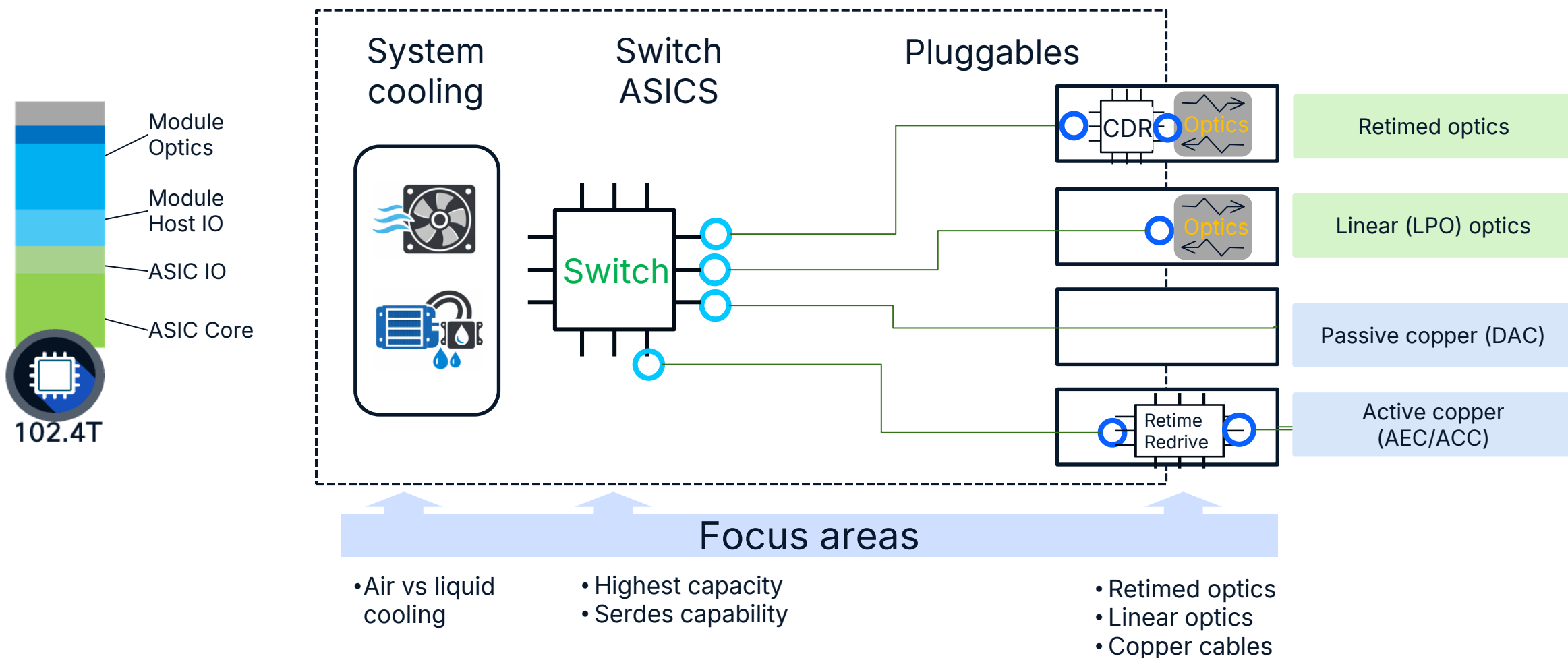
Power & Integration (Form Factors)



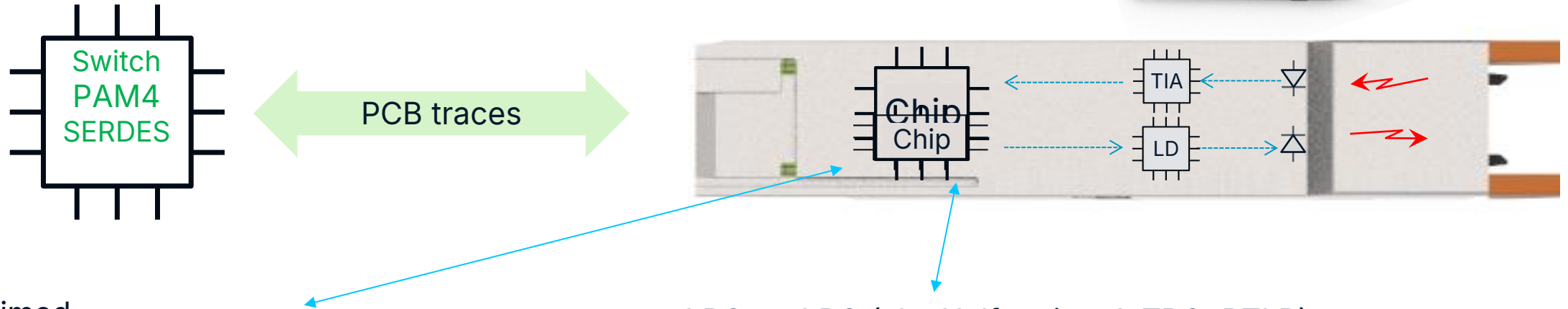
Systems and power scaling | 640x BW, 119x power



Lowering the power for pluggable interconnect



Linear pluggable (LPO) and Linear receive optics (LRO)



Retimed

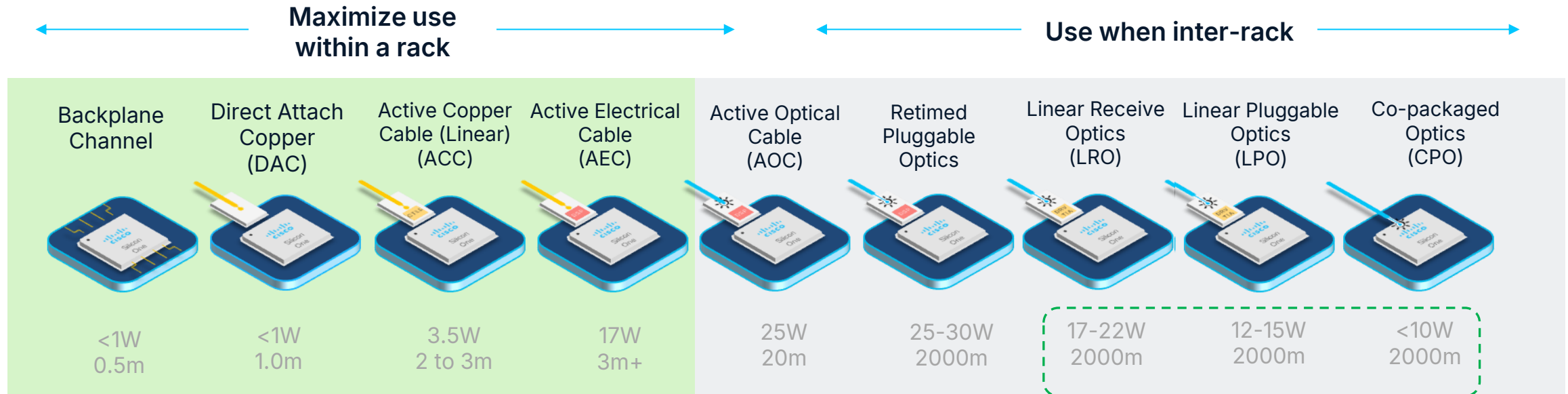
- DSP has full digital equalization for both electrical & optical signals
- Enables broad interoperability
 - Host/Port/Module
- Full telemetry & loopbacks possible
- FEC Monitoring or Partitioning possible
- But this adds power

LPO or LRO (aka Half-retimed, TRO, RTLRL)

- Power reduction due to absence of digital equalization
- Performance is based on quality of every component in link since they are concatenated
 - Optics, Serdes, PCB, connectors
 - Varies port to port
 - Some linear gain and equalization in module
- Interoperability becomes more challenging
- Loss of some telemetry, monitoring or loopback

High-density interconnect options: Power vs. reach tradeoff

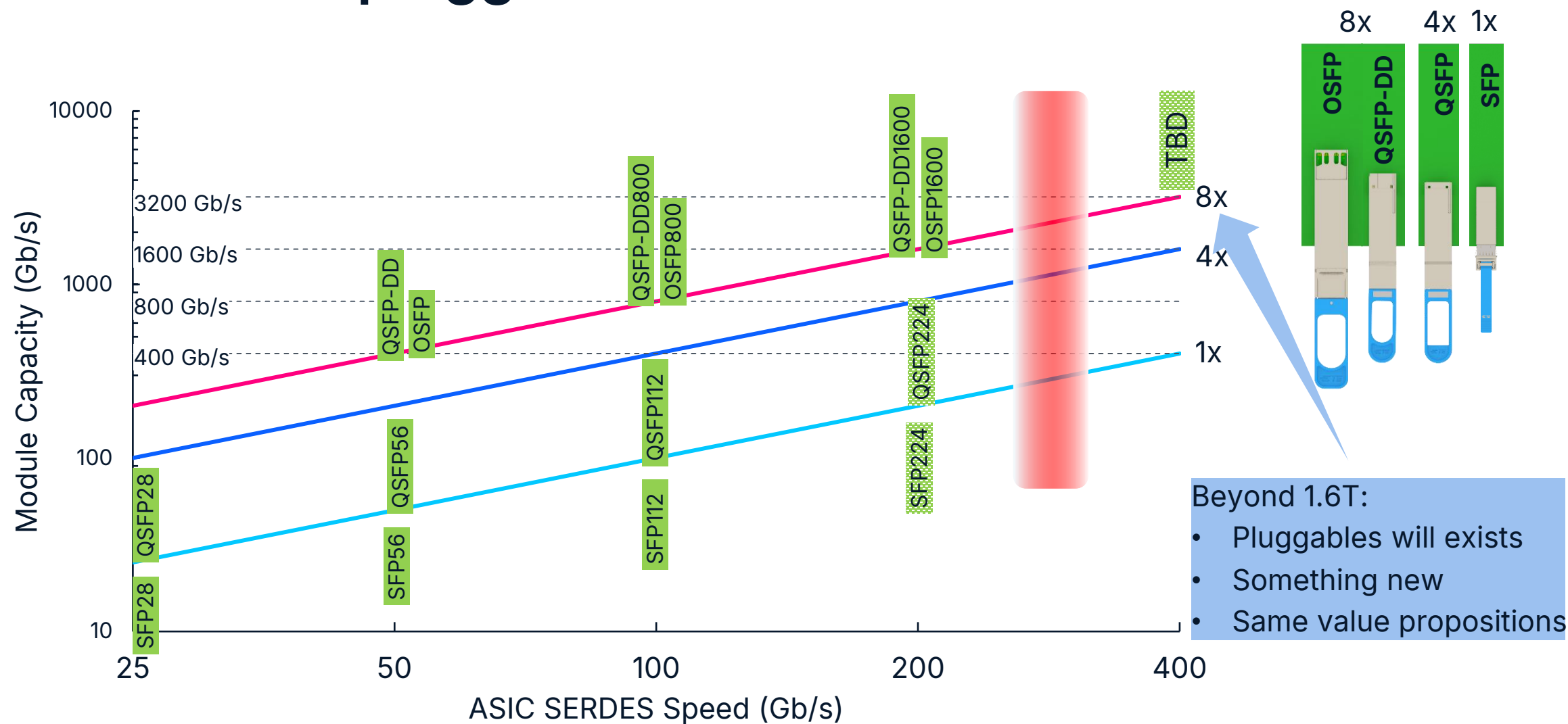
Power and Reach @ 1.6T



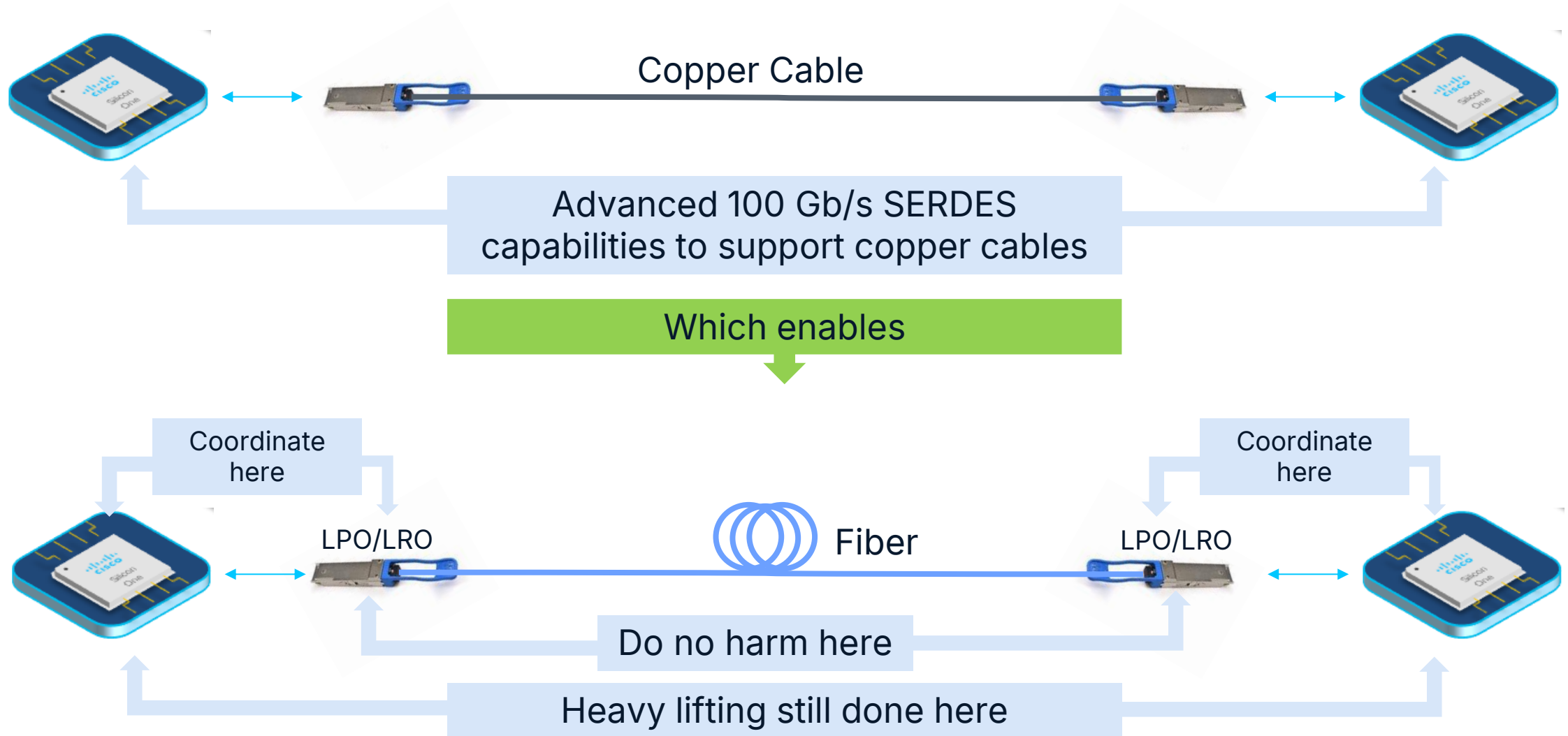
Copper cables and interfaces still look attractive from power perspective

Longer reach = increased power
Power reduction opportunities coming from CPO, LPO & LRO

Evolution of pluggables

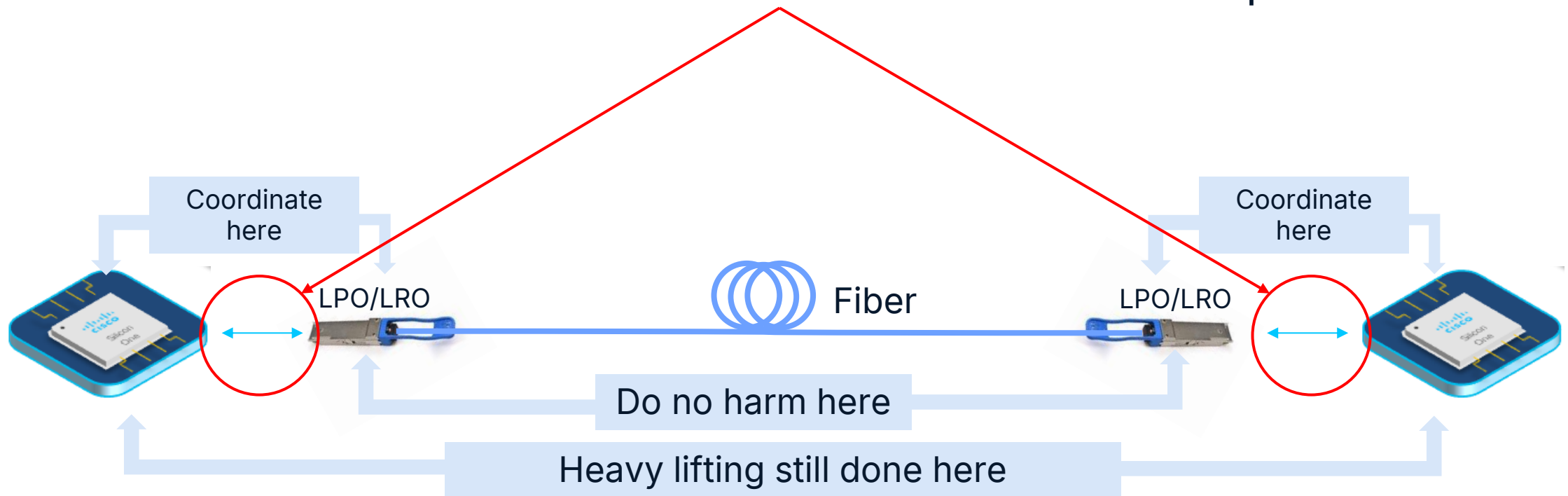


Why does linear optics work?



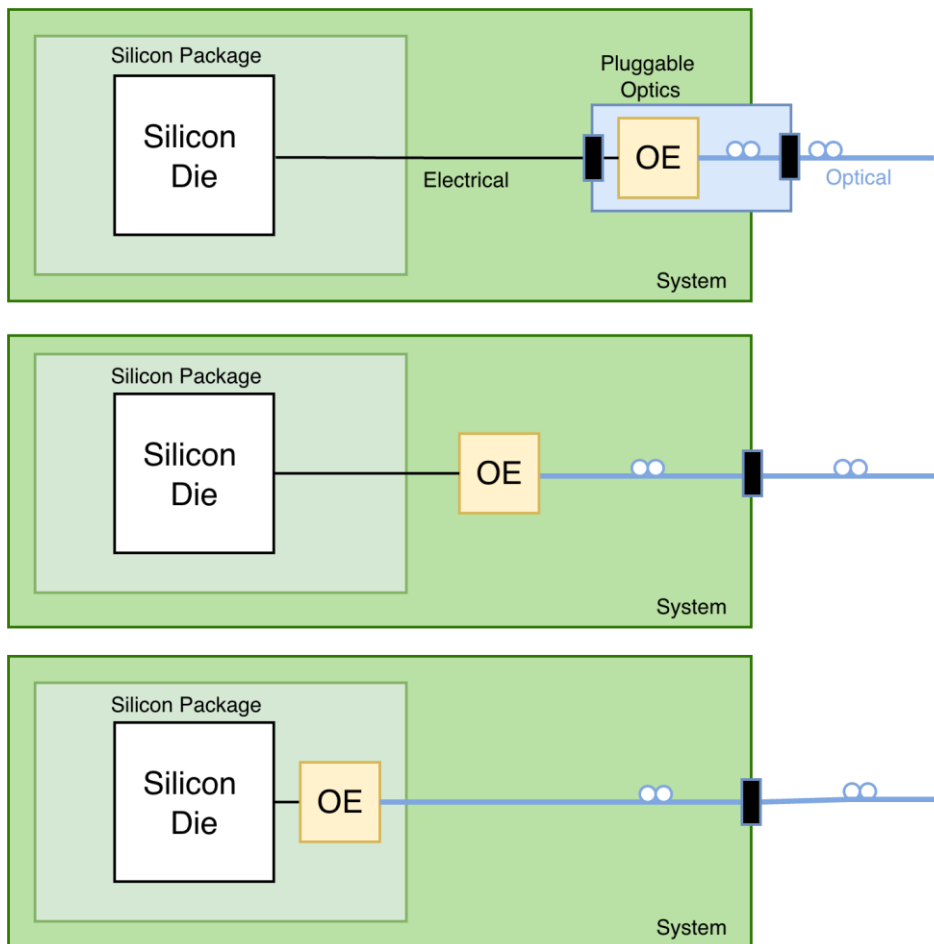
The challenges of linear optics

The performance of the link is highly dependent on the speed and loss of the electrical link between ASIC and optics.



Lowering the power beyond pluggable interconnect

Optical Engine Location



Front Panel Pluggable

The Optical Engine is in a module which is plugged into the system

Proven at scale | Pay-as-you-grow | Serviceable |
Wide Ecosystem | Lowest Efficiency

Near Package Optics (NPO)

The Optical Engine is inside of the system

Improved Efficiency | Limited Flexibility |
Non-field serviceable

Co-Package Optics (CPO)

The Optical Engine is inside of the silicon package

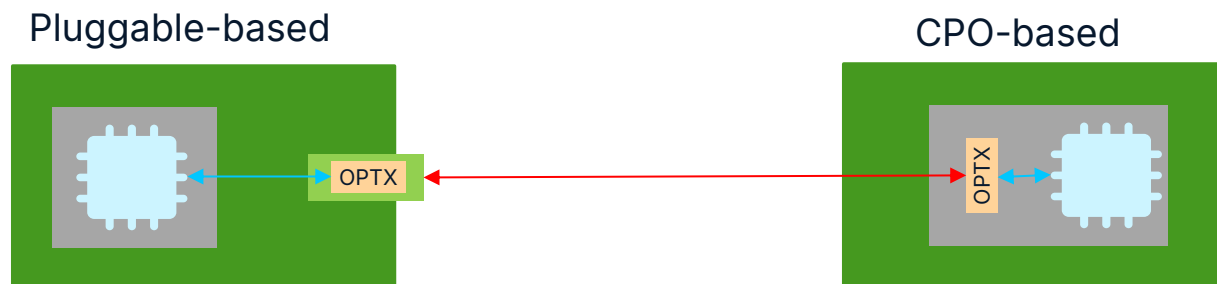
Best Efficiency | Scalable | Lack of flexibility |
Non-field serviceable

Flexibility

Scalability, Power Efficiency

What about interop? CPO, LPO, LRO, retimed

Link interoperability is independent of implementation



As long as the interface type matches (e.g. 800GBASE-DR8 or 800G-LPO-DR8) the link will interoperate.

- Relevant for pluggable (OSFP, OSFP-RHS, QSFP-DD) and non-pluggable (CPO, NPO)

The one caveat: LRO optics (half-retimed) is intended to be able to interop with the retimed variant.

- @ 100G/lane, LPO works great and is lower power so little LRO
- @ 200G/lane, LRO is more likely to be deployed initially and should interoperate with retimed modules (but those specs aren't done yet)

Explosion of Solutions | We're been here before

Circa 2010-12

10 GbE

- **Mature ecosystem:** 10G SerDes, SFP+
- **Massive growth:** Front-end networking
- **Difficult Future:** Path to 40 GbE & 100 GbE (25 G SerDes)

Today

1.6 TbE

- **Solid ecosystem:** 200G SerDes, OSFP1600
- **Massive growth:** AI networking
- **Difficult Future:** Path to 400G SerDes

Unclear path creates a proliferation of **interface types**



Unclear path creates a proliferation of **form factors**



Eventually the field narrows to a **small subset**

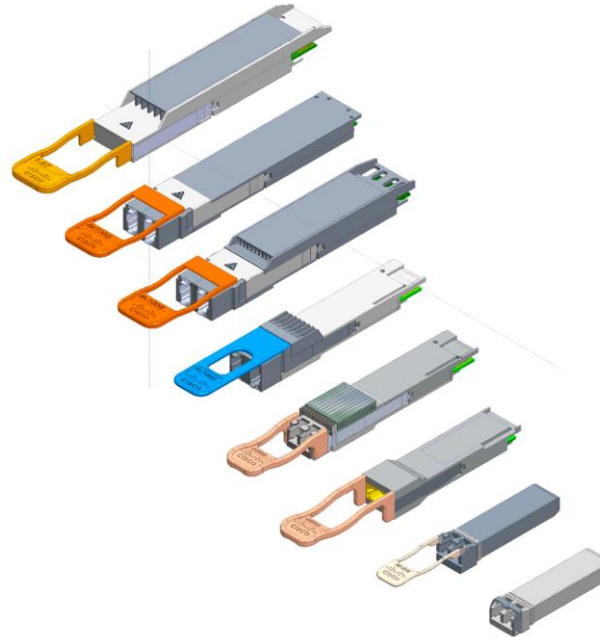


What will be the dominant **interface(s)** and **form factor(s)**?

2028 Trajectory



CPO provides lowest optical power solution



Pluggables dominate for a reason.
400G per lane version will emerge

Passive Copper



400G IMDD
Optics

Is there a new solution to fill
this gap?

Wrap up

Deploy now / Plan next / Watch

Turn the technology update into a practical planning model.

Deploy now

400G and 800G pluggables where power, reach, and switch support are validated

Breakout modes for mixed-speed refreshes

400ZR / ZR+ for router-hosted DCI where the span and operational model fit

CMIS, VDM, alarms, and firmware lifecycle as part of standard turn-up

Plan next

1.6T optics and 200G/lane Ethernet readiness

LPO / LRO qualification against host ASIC

800ZR / ZR+ coherent expansion

Rack power, airflow, faceplate density, and fiber path assumptions

Watch

CPO and near-package optics maturity

3.2T and 400G/lane roadmap signals

Optical link training and new FEC operating models

Operational tooling, sparing, and failure-domain changes

Decision rule

Preserve pluggable flexibility where refresh cycles are uncertain; optimize power and integration where the architecture is stable and validated.

Revisiting: Myth vs. reality

Myth

800G is just two 400G links.

CPO replaces everything

LPO/LRO removes operational complexity.

Coherent belongs only in transport.

Reality

→ Supports 800 GbE. Breakout is possible to 100 GbE, 200 GbE and 400 GbE

→ CPO solves specific density and power problems, while pluggables remain a deployment workhorse.

→ LPO/LRO shifts more responsibility into host/channel validation and monitoring.

→ ZR/ZR+ pluggables make coherent part of DCI, Scale-Across and RON design choices.

Takeaway: the best optics choice is the one your platform, telemetry, operations team, and physical plant can support at scale.

Simplify AI with Cisco optics tools

Optics Selector	https://optsel.cisco.com
Optics-to-Device Compatibility	https://tmgmatrix.cisco.com/
Optics-to-Optics Interoperability	https://tmgmatrix.cisco.com/io
Product Information (Dynamic Datasheet)	https://copi.cisco.com/

Complete your session evaluations



Complete a minimum of 4 session surveys and the Overall Event Survey to be entered in a drawing to win 1 of 5 full conference passes to Cisco Live 2027.



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