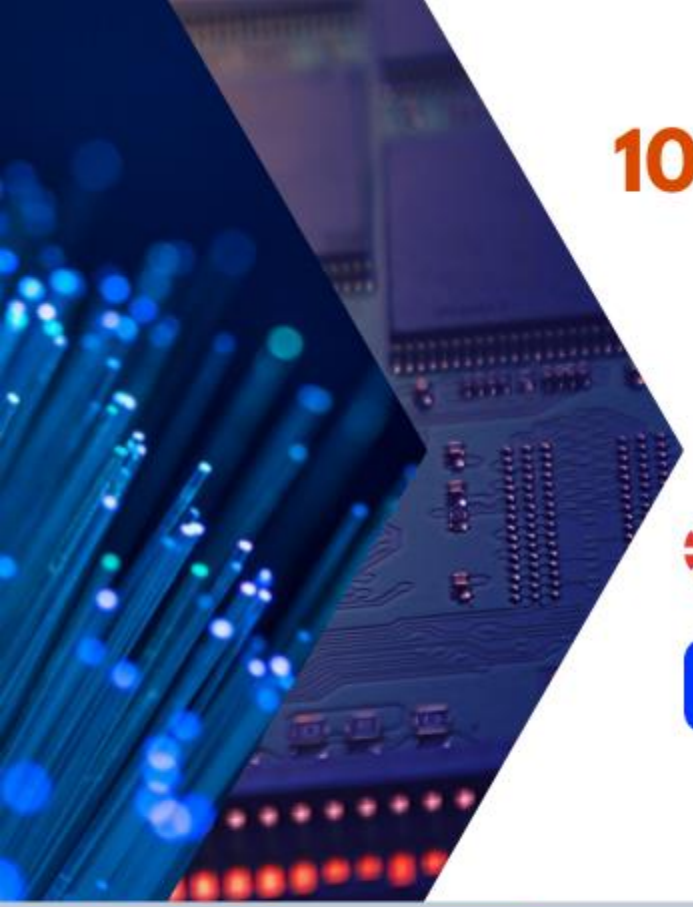

100ZR - COHERENT OPTICS AT THE NETWORK EDGE

ADVA™

windstream wholesale

COHERENT

CableLabs®

Cignal AI
Active Insight

100ZR - COHERENT OPTICS AT THE NETWORK EDGE

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100ZR: Coherent for the Edge of the Network

Scott Wilkinson
Lead Analyst

September 8, 2022

Webinar: 100ZR – Bringing Coherent Optics to the Network Edge

Cignal AI
Active Insight

Technology Migration to the Edge of the Network

History – 10Gbps moves to the edge

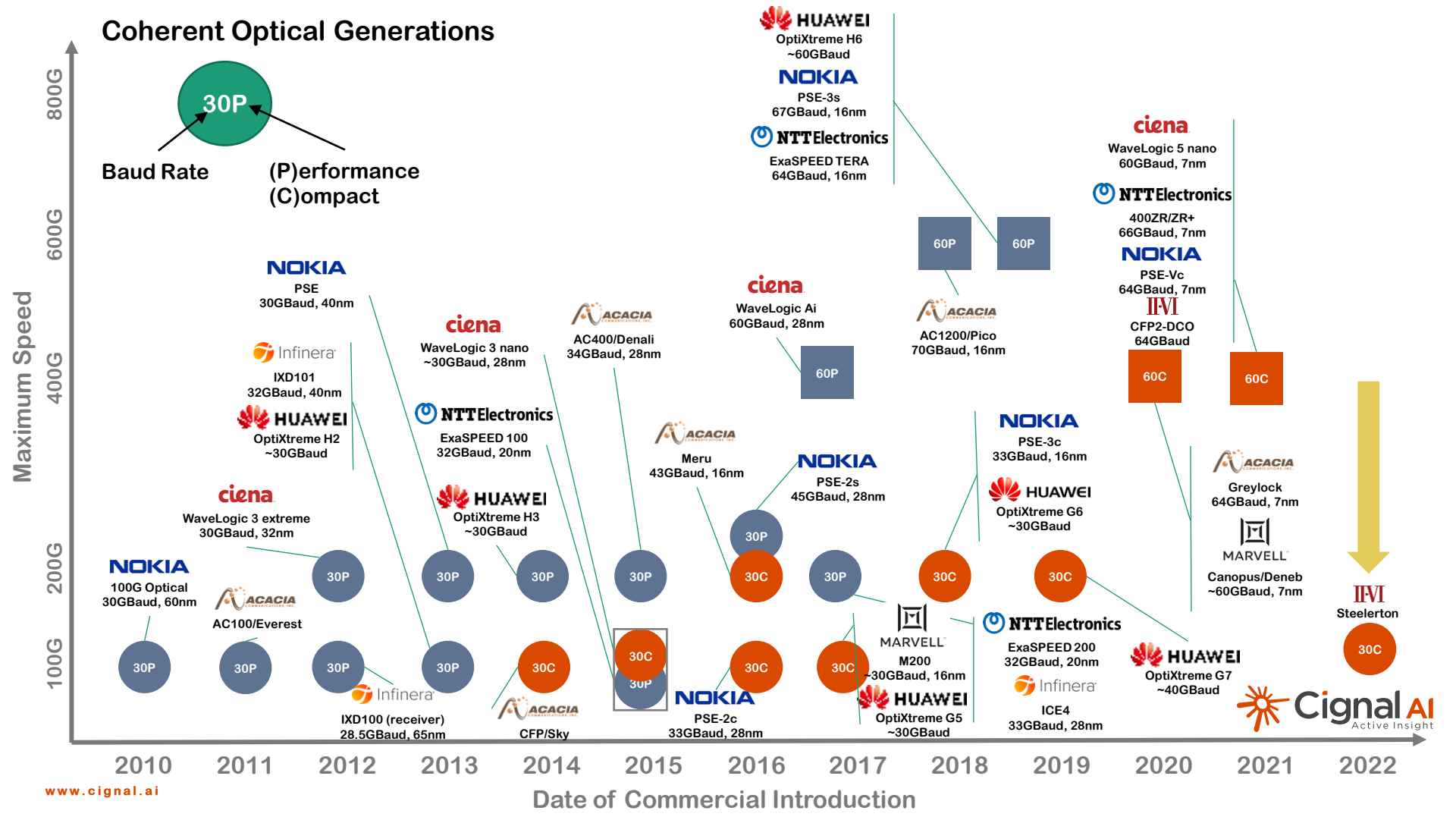
Edge	Metro/DCI	Metro Core	Long Haul
10Gbps	10Gbps	10Gbps	10Gbps
DWDM	DWDM	DWDM	DWDM

Smaller / Cheaper technology → Higher capacity

Coherent migration to the edge

Edge	Metro/DCI	Metro Core	Long Haul
100Gbps	400Gbps	800Gbps	1.2T+
DWDM	DWDM	DWDM	DWDM

Today's Topic

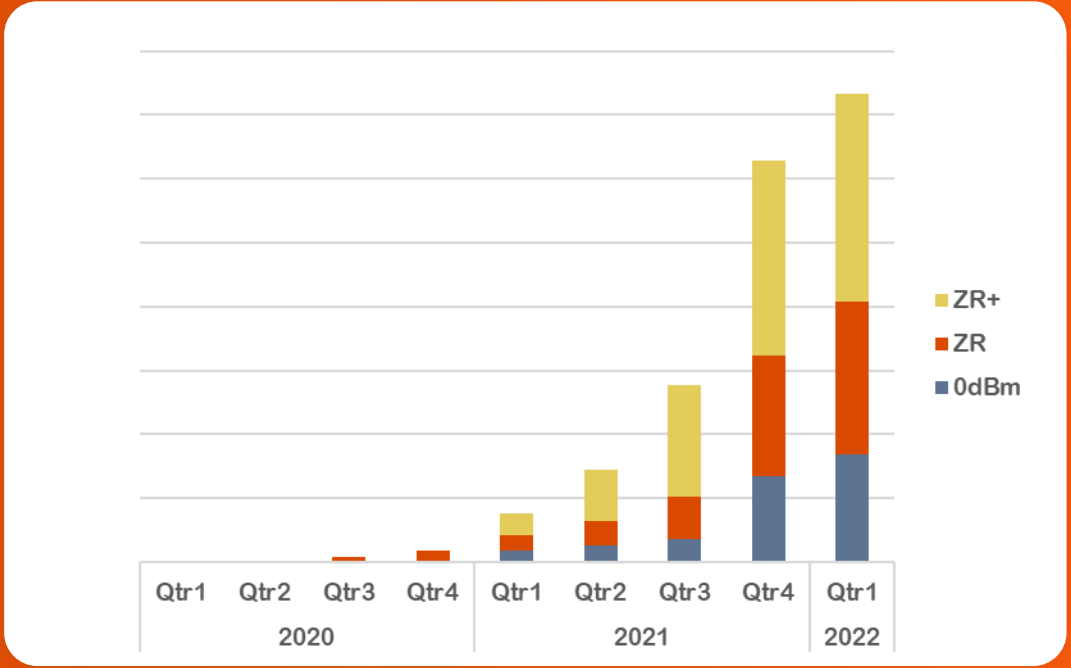

Coherent Optical Generations
30P
Baud Rate
(P)erformance
(C)ompact
Maximum Speed
800G
600G
400G
200G
100G
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
Date of Commercial Introduction
HUAWEI
OptiXtreme H6
~60GBaud
NOKIA
PSE-3s
67GBaud, 16nm
NTT Electronics
ExaSPEED TERA
64GBaud, 16nm
ciena
WaveLogic 5 nano
60GBaud, 7nm
NTT Electronics
400ZR/ZR+
66GBaud, 7nm
NOKIA
PSE-Vc
64GBaud, 7nm
II-VI
CFP2-DCO
64GBaud
NOKIA
PSE
30GBaud, 40nm
Infinera
IXD101
32GBaud, 40nm
HUAWEI
OptiXtreme H2
~30GBaud
ciena
WaveLogic 3 extreme
30GBaud, 32nm
NOKIA
100G Optical
30GBaud, 60nm
ACACIA
AC100/Everest
ciena
WaveLogic 3 nano
~30GBaud, 28nm
NTT Electronics
ExaSPEED 100
32GBaud, 20nm
HUAWEI
OptiXtreme H3
~30GBaud
Infinera
IXD100 (receiver)
28.5GBaud, 65nm
ACACIA
AC400/Denali
34GBaud, 28nm
ACACIA
CFP/Sky
ACACIA
Meru
43GBaud, 16nm
NOKIA
PSE-2c
33GBaud, 28nm
ciena
WaveLogic Ai
60GBaud, 28nm
NOKIA
PSE-2s
45GBaud, 28nm
ACACIA
AC1200/Pico
70GBaud, 16nm
NOKIA
PSE-3c
33GBaud, 16nm
HUAWEI
OptiXtreme G6
~30GBaud
MARVELL
M200
~30GBaud, 16nm
HUAWEI
OptiXtreme G5
~30GBaud
NTT Electronics
ExaSPEED 200
32GBaud, 20nm
Infinera
ICE4
33GBaud, 28nm
ACACIA
Greylock
64GBaud, 7nm
MARVELL
Canopus/Deneb
~60GBaud, 7nm
HUAWEI
OptiXtreme G7
~40GBaud
II-VI
Steelerton
30P
30C
60P
60C
Cignal AI
Active Insight
www.cignal.ai

Gen60C: Pluggable Coherent Success Story

- 400ZR: Designed to meet the need for a low-cost, low-power DCI solution
  - Finally, real IP-over-DWDM
- Extraordinary growth, primarily from webscale operators
  - The right technology at the right time
- Multiple variants now in production to expand the applications space
  - 400ZR, Enhanced FEC, OpenZR+, OpenROADM, 0dBm, QSFP-DD, CFP2, etc.
- Forecast to ship over 190k modules in 2022
  - >50k per quarter by the end of the year

The success of 400ZR has changed the way network operators think about coherent optics.

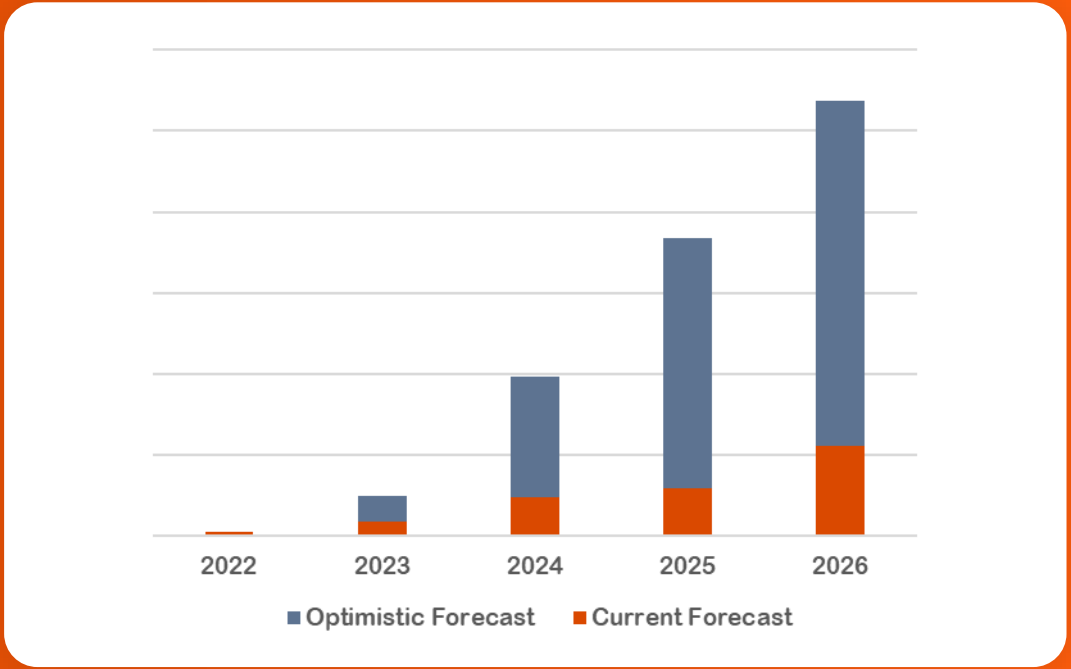
Pluggable 400Gbps Coherent Port Shipments



The Need for 100ZR

- Millions of 10Gbps DWDM modules deployed at the edge of the network
- A simple, low-cost 100Gbps solution is needed
- Current options
  - Direct Detect: Distance limited, not always DWDM compatible, useful for single-wavelength (and some DWDM) short reach
  - Scaled-down 400ZR: Higher power, higher cost, potential applications in enterprise networks
- Cignal AI's current forecast is based on existing solutions
- An optimistic forecast assuming 10Gbps DWDM replacement would be much larger

100ZR Forecast (Modules Shipped)



Cignal AI
Active Insight

Thank You

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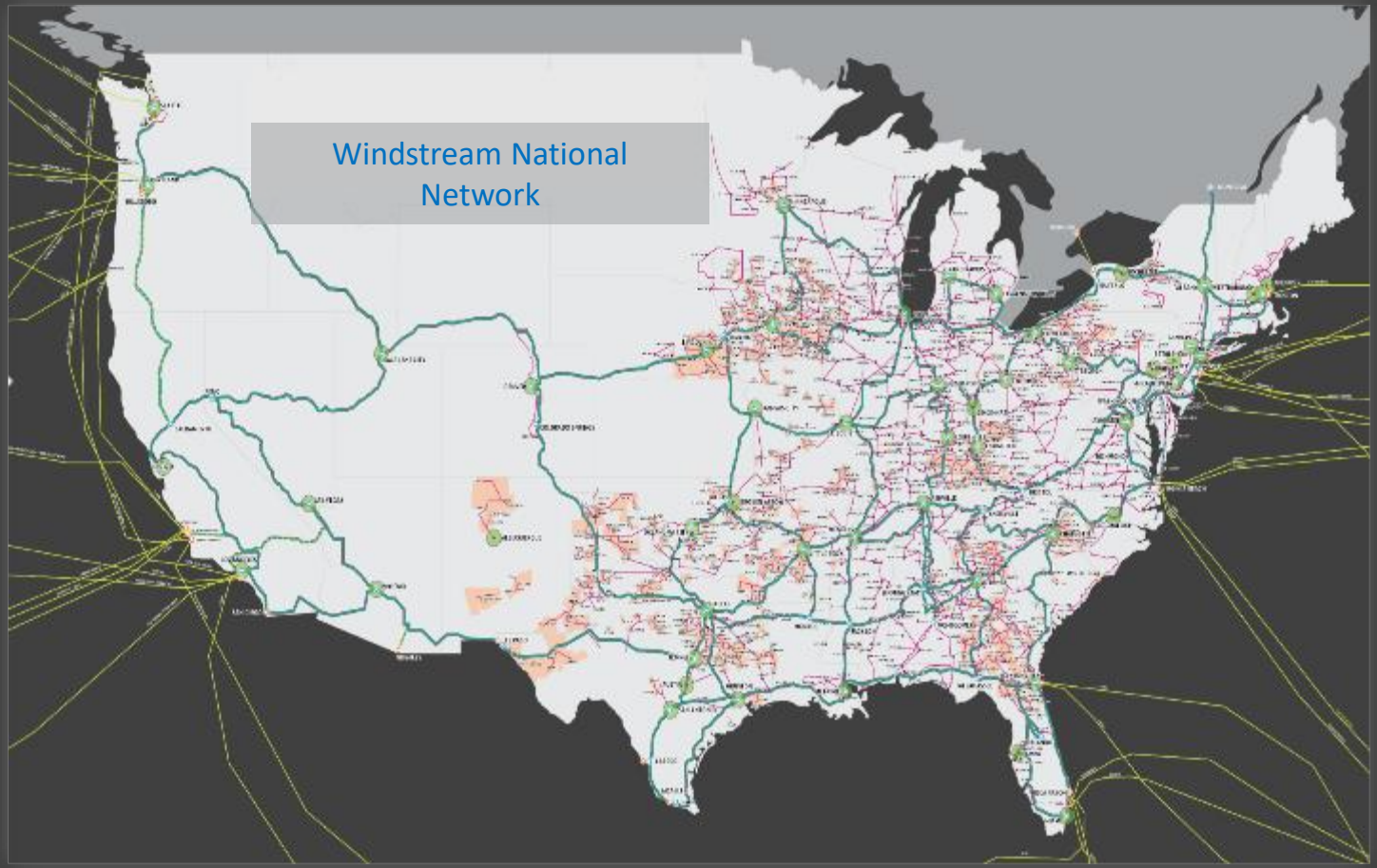
Cignal AI Webinar 2022

100 Gig ZR

Kim Papakos – Principal Optical Strategist

WINDSTREAM

Introduction



National

Terrestrial Network

Large Application Mix

Ultra Long Haul

~150 Sites

Metro / Regional

~5000 Sites

Access / Edge

~2000 Sites

~7000+

Sites and Growing

Windstream's Network presents a large opportunity for Open and Interoperable Coherent Transceivers

ICON by WINDSTREAM + ICONedge by WINDSTREAM

Disaggregated (Layer 1/2/3)

Alien Wavelength Services (Single Wavelength)

Bulk Spectrum Services (Multi-Wavelengths)

Integrated Layer 0 Analytics (Coherent probe, OSA, OTDR)

CDC-F with Alien Degree capability

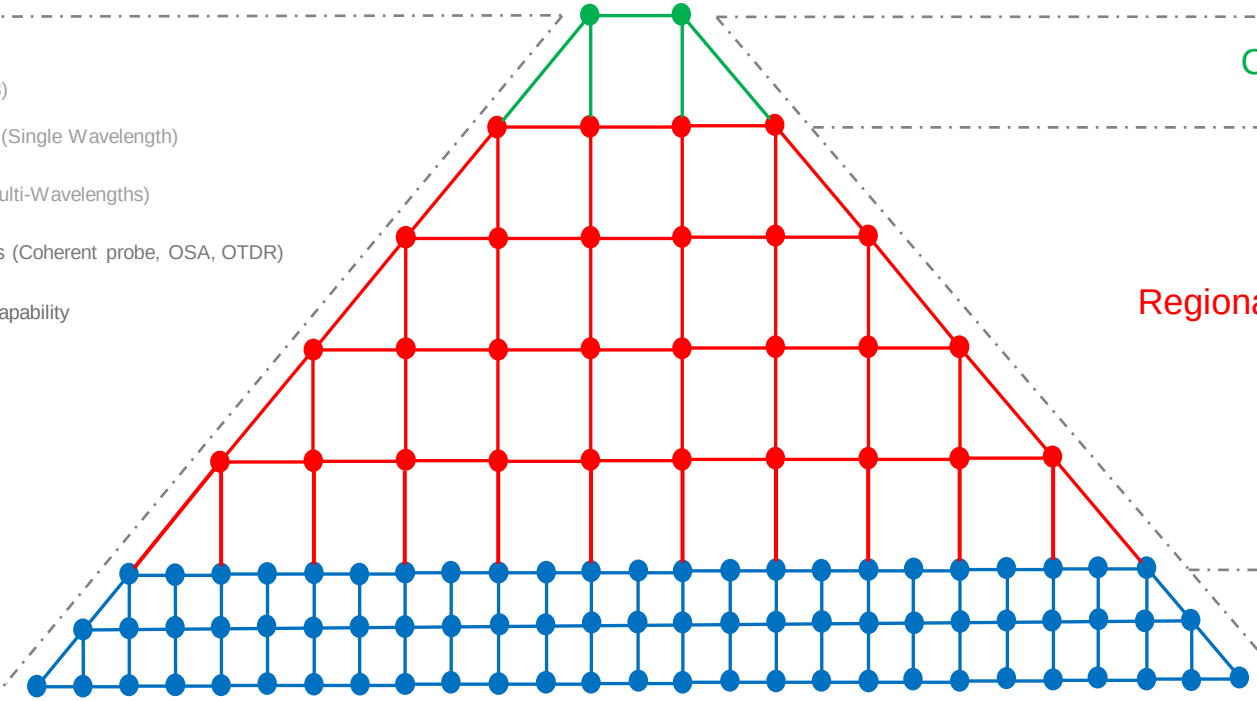
C+L band support

DCI / Cloud Services

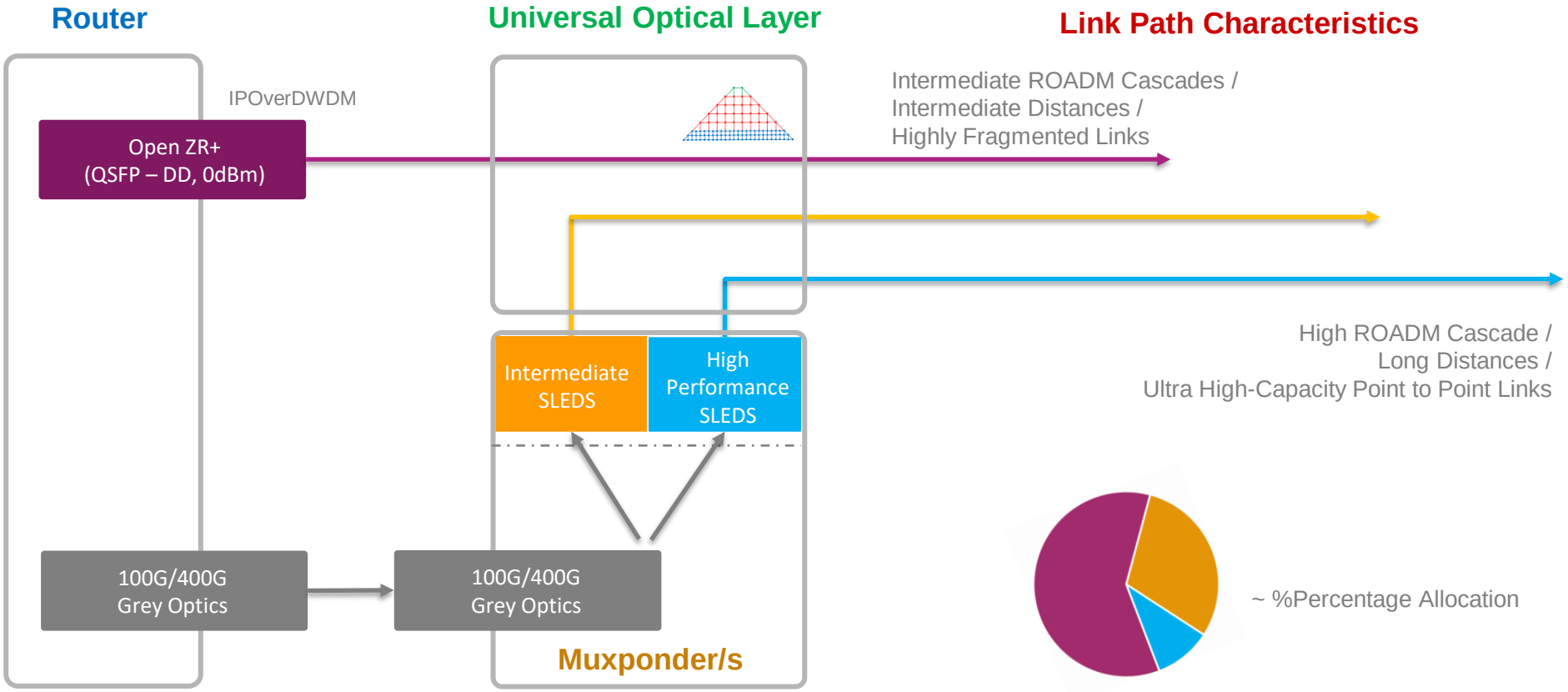
OTN

X-Haul

Future



Operator's perspective of Coherent Transceiver Applications



Desire: Extend IPOverDWDM Architecture to deep edge

100 Gig Coherent has been around for many years ….. So why is this time different?

100 Gig ZR – Application specific, focused coherent transceiver, utilizing latest technology base significantly improves key metrics ……..

Metric	Form	Power	Interface	Cost
Current / Previous 100 Gig Coherent	Open ZR+ (CFP-2, QSFP – DD)	Power ~ 20 – 25 Watts	Interface Standards Various	$$$
Modern focused 100 Gig Coherent	Open ZR (QSFP – 28)	Power ~ 5 Watts	CMIS Standard	$

which become critical in unlocking edge networking where …….

Edge Networking Characteristics			
	Capacity is Medium	Large Number of Sites	Small to Medium Sized IP switch fabrics

medium sized traffic, large number of sites, small to medium sized switch fabrics ARE key defining characteristics.

Building Blocks - Relationship between Capacity, Host Devices and PHY interface support

IP Routers

Modern
High Capacity
IP Routers

Modern
Small to Medium
IP Routers

Legacy
Small to Medium
IP Routers

Pluggable Modules

400G Coh

100G Coh

400G Grey

100G Grey

10G Grey

1G Grey

Shelf / Modules

QSFP Mux / Regen
DCI / Grey Box

ICON – Edge Platform

Optical Layer
ROADM CDC Flex
(Layer 0)

Transponders /
Muxponders
(Layer 1)

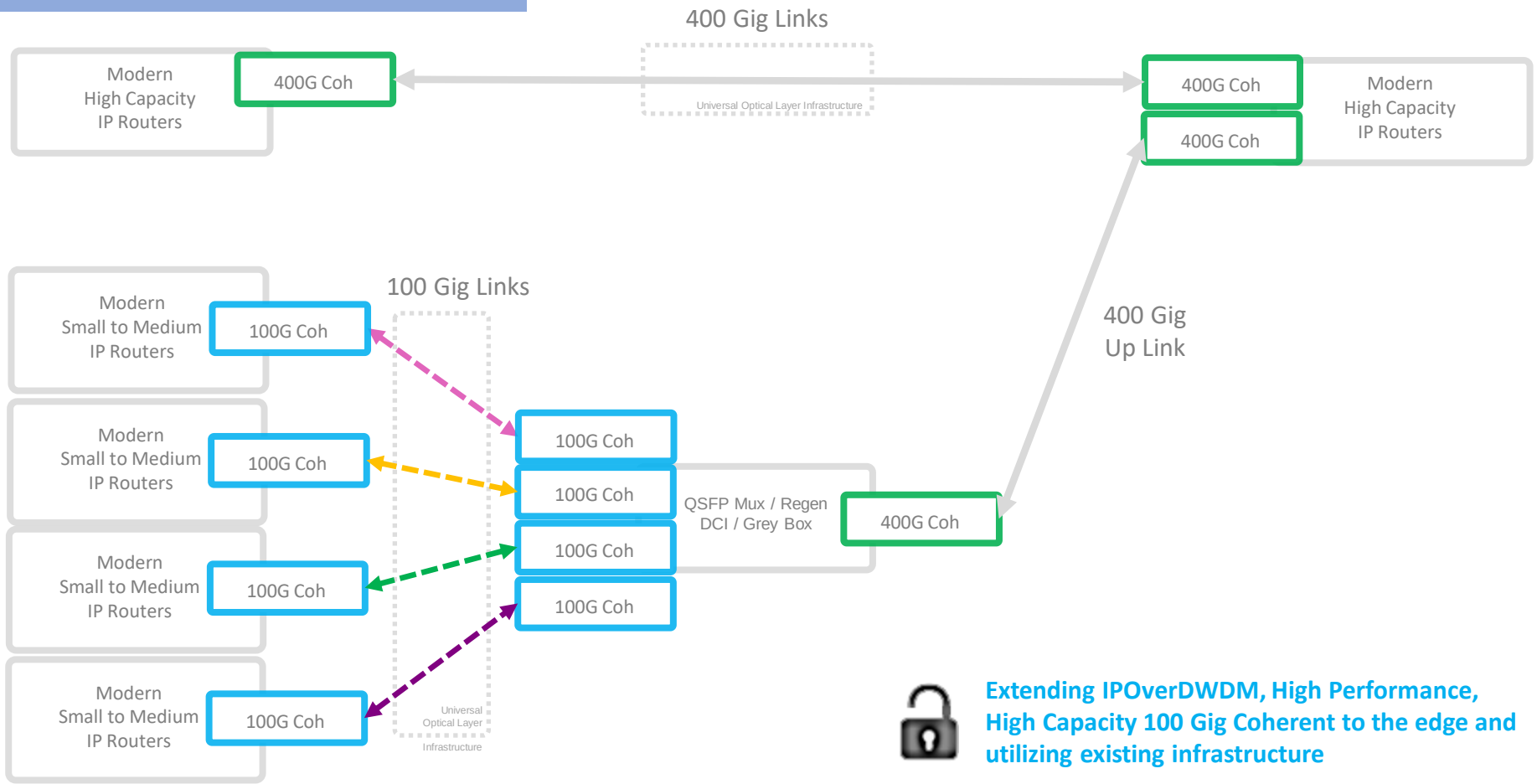
Adding application specific 100 Gig ZR Coherent with modern technology base to portfolio of building blocks – unlocks many possibilities!

Today's Problems

Modern High-Capacity Routers are overkill and expensive for widespread edge deployment

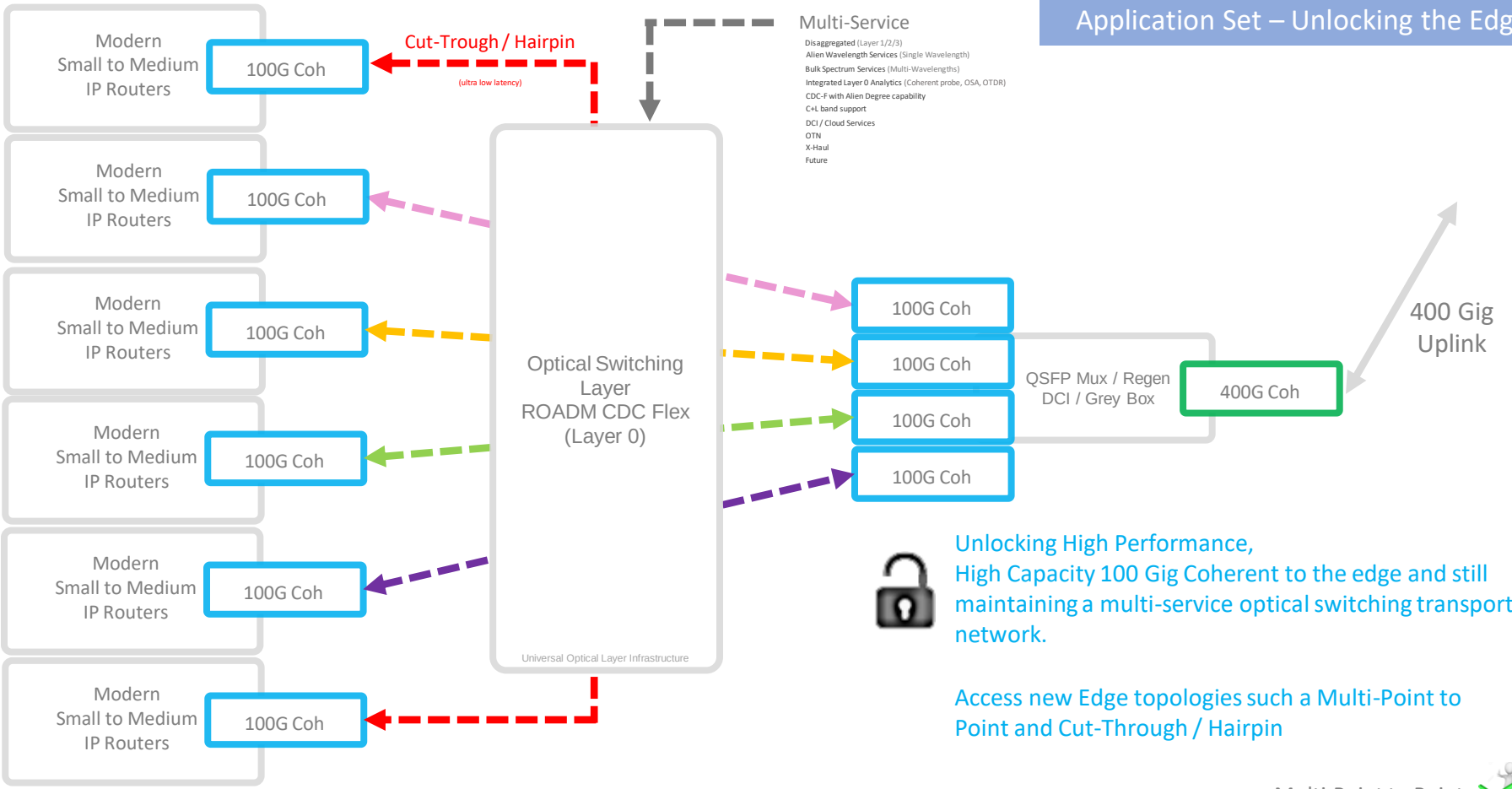
Smaller to Medium sized IP routers do not support 400 Gig DD pluggable ports / modules - Capacity per port, power, thermals etc.....

Application Set – Unlocking the Edge



Extending IPOverDWDM, High Performance, High Capacity 100 Gig Coherent to the edge and utilizing existing infrastructure

Application Set – Unlocking the Edge



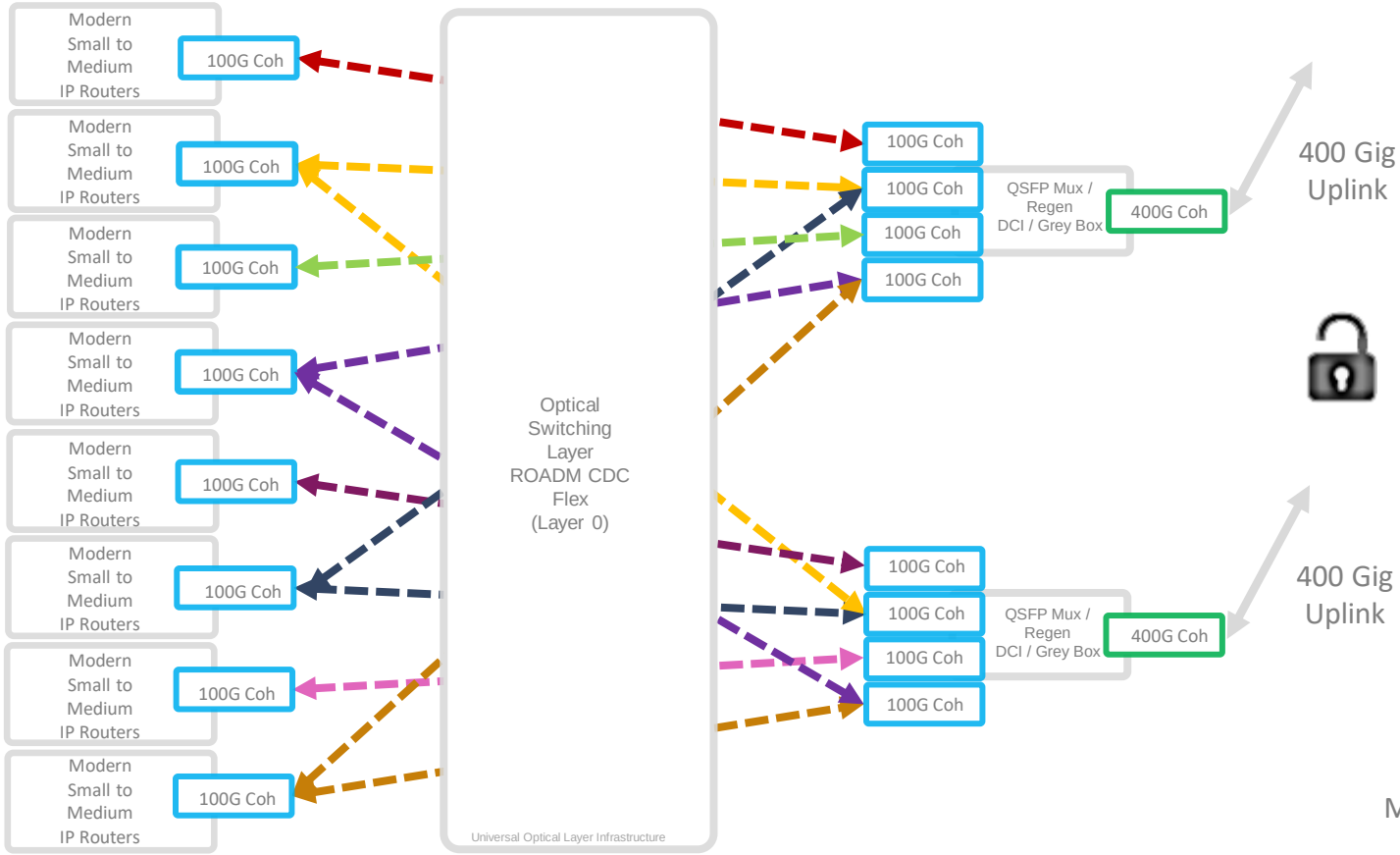
Unlocking High Performance,
High Capacity 100 Gig Coherent to the edge and still maintaining a multi-service optical switching transport network.

Access new Edge topologies such a Multi-Point to Point and Cut-Through / Hairpin

Multi-Point to Point ✓

Point to Point ✓ Long Distances ✓ ROADM Compatible ✓ Simplified Host Software ✓ Low Power Solution ✓ Cut-Through / Hairpin ✓ Multi-Service ✓

Application Set – Unlocking the Edge



Access new Edge topologies such a Multi-Point to Point, Multi-Point to Multi-Point and Cut-Through / Hairpin

Multi-Point to Multi-Point

Multi-Point to Point

Point to Point | Long Distances | ROADM Compatible | Simplified Host Software | Low Power Solution | Cut-Through / Hairpin | Multi-Service

Open and Interoperable Standards – Learn from the past and do it a little bit better next

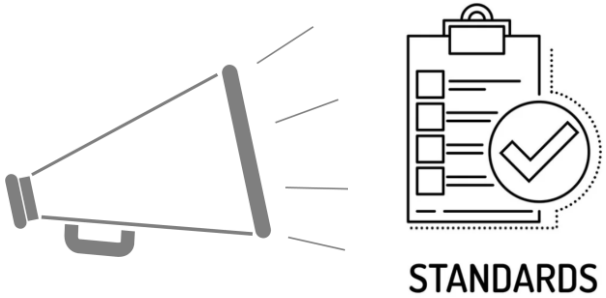
400 Gig ZR+ – First real attempt at Open and Interoperable Standards – (Thank you to the collaborative efforts of various standards bodies)

Open and Interoperable can be deemed a success with various field trials results reported, however many things were learned throughout the process

Application specific 100 Gig ZR category class will greatly benefit from "Holistic" Open and Interoperable Standards

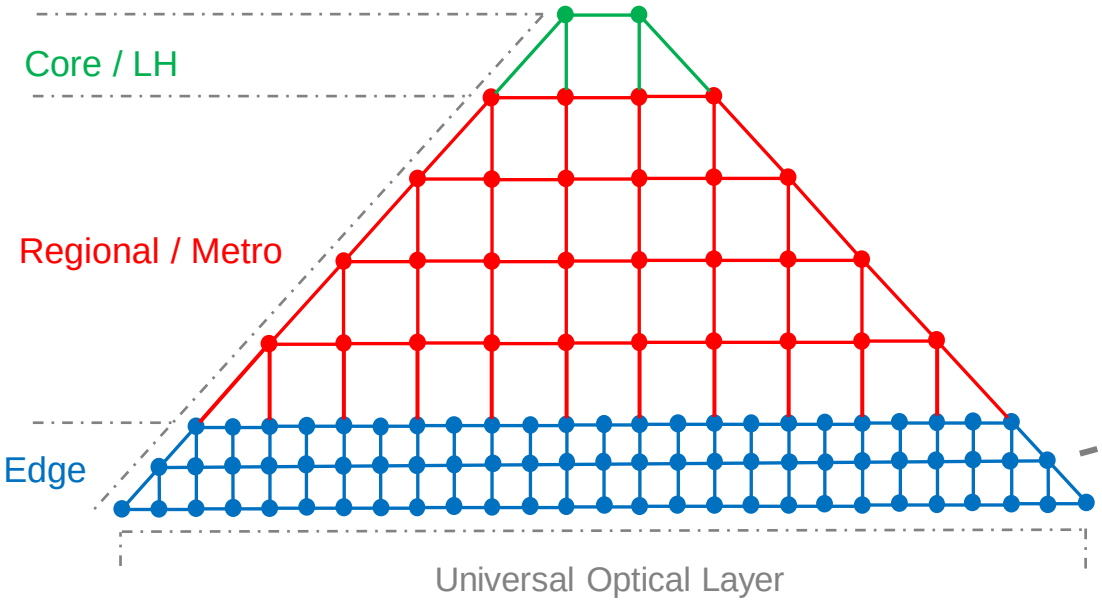
Holistic = more than just FEC and modulations scheme. Holistic means the standardization and agreement on additional items such as the following items:

- Host Interface Standards
- Application code Standards
- Mechanics
- Power
- Thermals
- Diagnostics
- Optimized Interoperability



Optimize for Edge Deployment

ICON by WINDSTREAM + ICONedge by WINDSTREAM



Edge

Edge represents largest number of nodes and physical locations

Many Edge nodes are not easily accessible / limited hours of access

Many more field personal required to cover Edge all with varying knowledge of DSP / Coherent Transceivers

Zero Touch Provisioning

Remote Coherent Transceiver management

Remote provisioning, (Wavelength, launch Power etc.)

Remote diagnostics, (Temp, CD, PMD, SNR, OSNR, PDL, etc.)

Simplicity and next level automation are highly desirable from both the pluggable and host platform vendors

Thank you

from Windstream

Coherent in Cable Access
Enabling a Multi-Service Converged Network

CableLabs

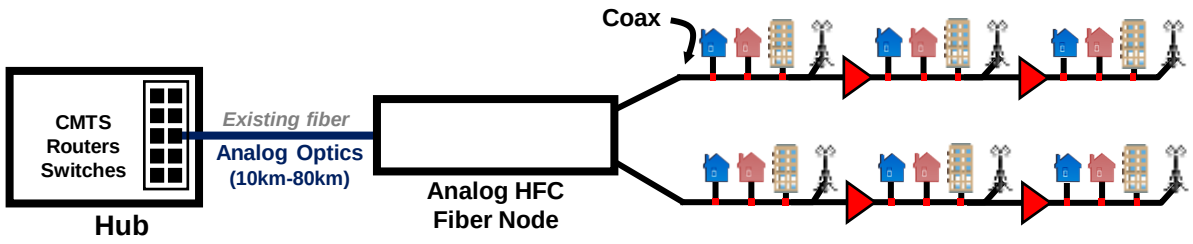
Matt Schmitt

m.schmitt@cablelabs.com

Today's Cable Access Network

- Electrical RF signals generated at Hub facility (analog or digital video, data via DOCSIS® technology) and carried via coax
- Converted from electrical to optical and transmitted over fiber (analog optics)
- At Fiber Node, converted back to electrical signal over coax
- Tree and branch architecture with taps to connect to homes and amplifiers to extend signal as needed
- Same happens in reverse for return path
- Enables a variety of IP based services via DOCSIS technology

Today's Analog HFC Architecture



Residential Services via
- DOCSIS (HFC)

Business Services via
- DOCSIS (HFC)

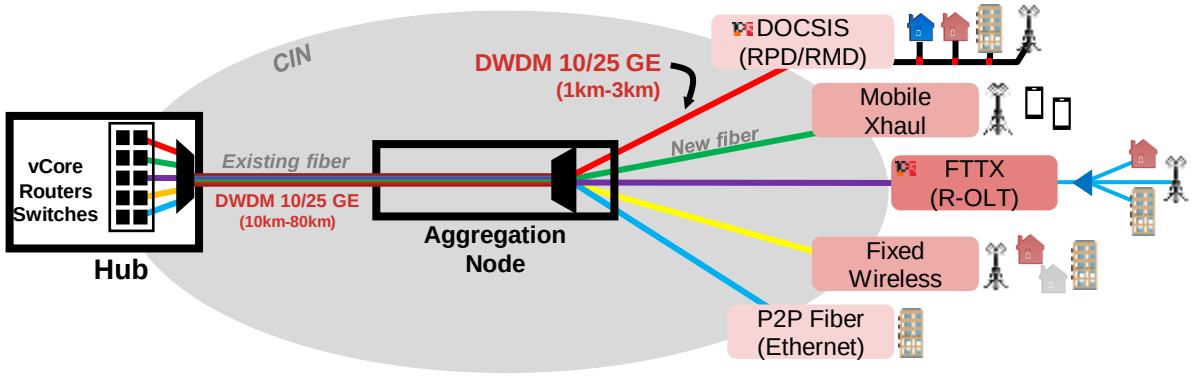
Xhaul Services via
- DOCSIS (HFC)

Transition to Distributed Access Architecture

CableLabs

- Many operators are transitioning to a Distributed Access Architecture (DAA)
  - Often in combination with pushing fiber deeper by splitting existing Fiber Node into smaller serving groups
- With DAA, RF generation is moved into the field (Remote PHY or Remote MAC/PHY Device), which is connected to Hub via Ethernet
  - 10G colored optics with DWDM using existing fiber and short extensions
  - Each end device (child node) gets a separate 10G wavelength

In Progress Distributed Access Architecture (DAA) Deployments



Residential Services via
- DOCSIS (HFC), FTTX, Fixed Wireless

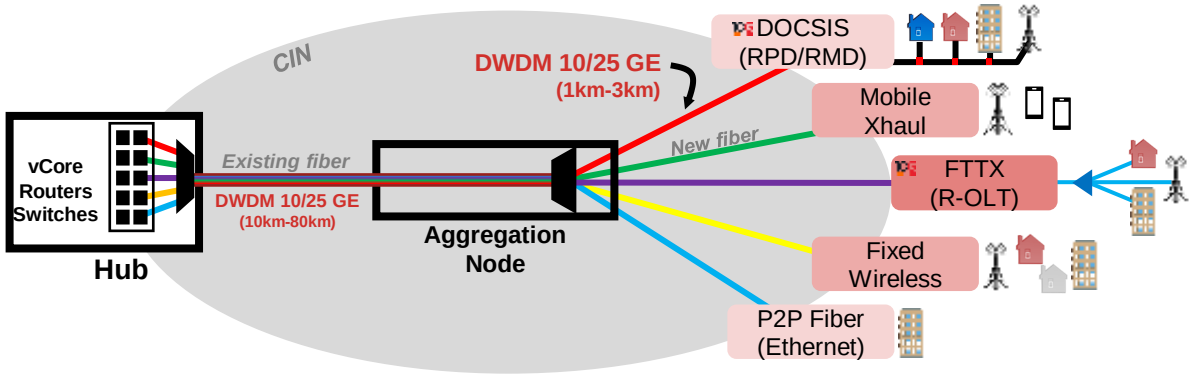
Business Services via
- DOCSIS (HFC), FTTB, Fixed Wireless, P2P Fiber (Ethernet)

Xhaul Services via
- DOCSIS (HFC), FTTX, P2P Fiber (Ethernet)

Drivers for DAA

- Significantly reduces equipment required at Hub facility
  - Better ability to scale services, add new equipment for new services, and/or consolidate facilities
- Improves SNR over coax network via digital optics and reduced noise and signal loss
- Ability to use lower-cost digital optics with reduced maintenance
- Ability to support other devices and services directly via fiber network

In Progress Distributed Access Architecture (DAA) Deployments



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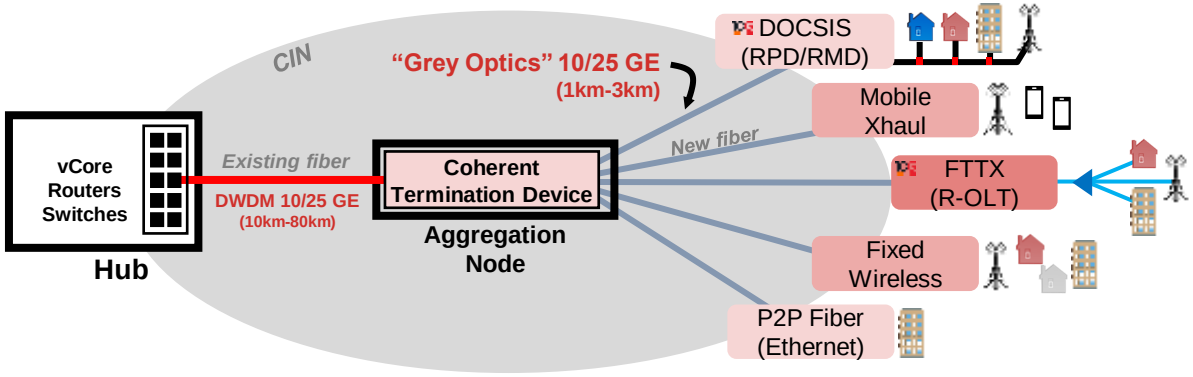
The Case for Coherent

CableLabs

- Alternate to 10G DWDM: P2P Coherent Optics
  - P2P coherent optics at 100G or 200G per wavelength from Hub to Coherent Termination Device (CTD) at Aggregation Node
  - CTD connected to child nodes via low-cost grey optics at 10G or 25G
  - CTD forwards using Layer-2 (switching) or Layer-3 (routing)
- Anticipated advantages:
  - Reduced cost with larger numbers of child nodes
  - Increased capacity/scalability/flexibility to support wider range of services

Future DAA Deployments using P2P Coherent Optics – Reducing cost and improving capacity/scalability/flexibility



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Xhaul Services via
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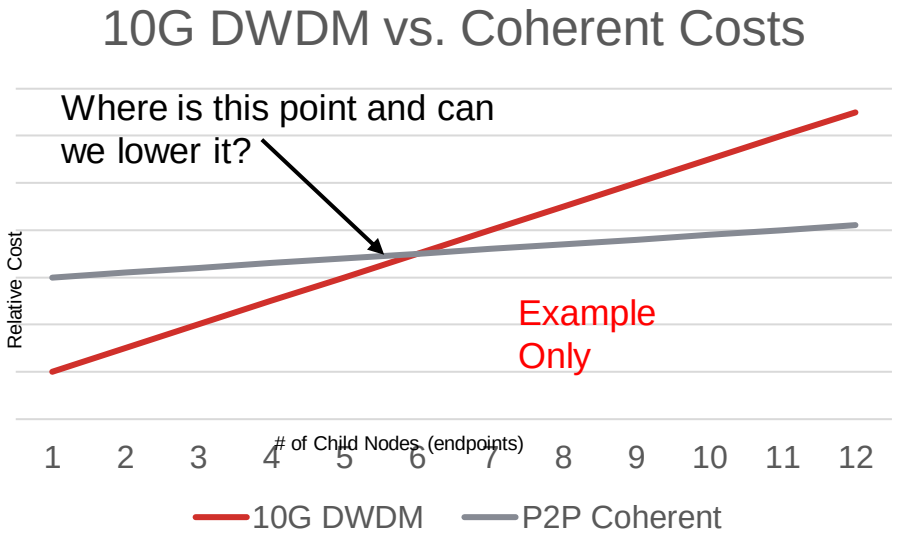
Economic Case

- 10G DWDM has low initial cost but scales linearly
- P2P Coherent has higher initial cost, but scales more slowly
  - Initial cost for coherent modules and CTD
  - Small incremental cost for low-cost grey optics
- Crossover point location critical to viability and scale of coherent deployments in this application
  - If too high, only suitable for very dense deployments
  - As crossover drops, becomes more interesting for wider range of deployments
  - Driven by cost of optics and CTD
- CableLabs key objective: lower crossover point by promoting interoperability, scale, competition

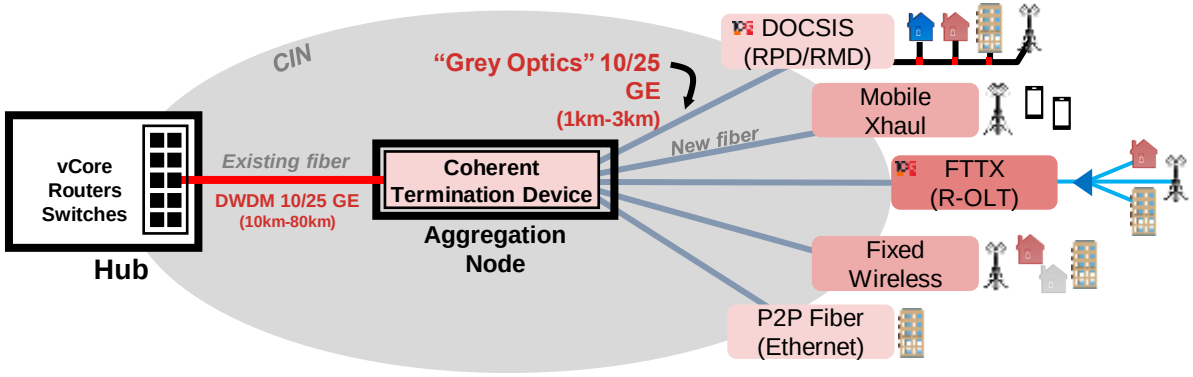


Unique Aspects of Cable Access Deployments

CableLabs

- One coherent endpoint is outdoors, introducing unique device requirements
  - I-Temp, weather hardened devices
  - No optical amplifiers in field (impacts OSNR and therefore reach)
  - CTD only needs 1-2 coherent links with 12-16 10/25G links
- Coherent signals need to coexist with other wavelengths
  - 10G DWDM signals, other coherent wavelengths, even analog signals

Future DAA Deployments using P2P Coherent Optics – Reducing cost and improving capacity/scalability/flexibility



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CableLabs Activities Promoting Interoperability and Adoption

CableLabs

- Developed specifications promote interoperability, scale, and competition in order to enable this market
  - Architecture Specification
  - Physical Layer Specifications (PHYv1.0 for 100G, PHYv2.0 for 200G)
  - CTD Requirements Specification
  - CTD OSSI Specification
- Hosted multiple interoperability events
  - Opportunity for manufacturers to meet on neutral ground
  - Validated multi-vendor (and multi-chipset) interoperability at 100G and 200G per wavelength
- Deployed coherent optics technology in our 10G multi-service lab
- Excited to see and support new developments in this space

Coherent in Cable Access

CableLabs

Matt Schmitt

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The coherent optical edge

A paradigm shift for scaling aggregation networks

September 2022

Unprecedented market dynamics at the edge

- Digital transformation accelerated by pandemic
- U.S. federal stimulus legislation
- FCC's rural digital opportunity fund (RDOF)
- 5G rollouts and deployments
- Upgrade cycle driven by hybrid working environments

Dramatic bandwidth growth at the converged edge

Investment cycle drives new requirements and convergence

Line speeds at the optical edge

Network element evolution

Broadband access DSL or PON	Broadband access Cable	Mobile access LTE or 5G	Business access and wholesale
MSAN OLT	RPD-HUB	BBU or DU CSG	PE aggregator
today +3years 10G 100G 400G	today +3years 10G 100G 400G	today +3years 10G 100G 400G	today +3years 10G 100G 400G
Adtran TA5000 SDX series	DAA architecture with coherent termination device	E.g. Nokia's AirScale radio access	ADVA™ FSP 150 series G.metro solutions

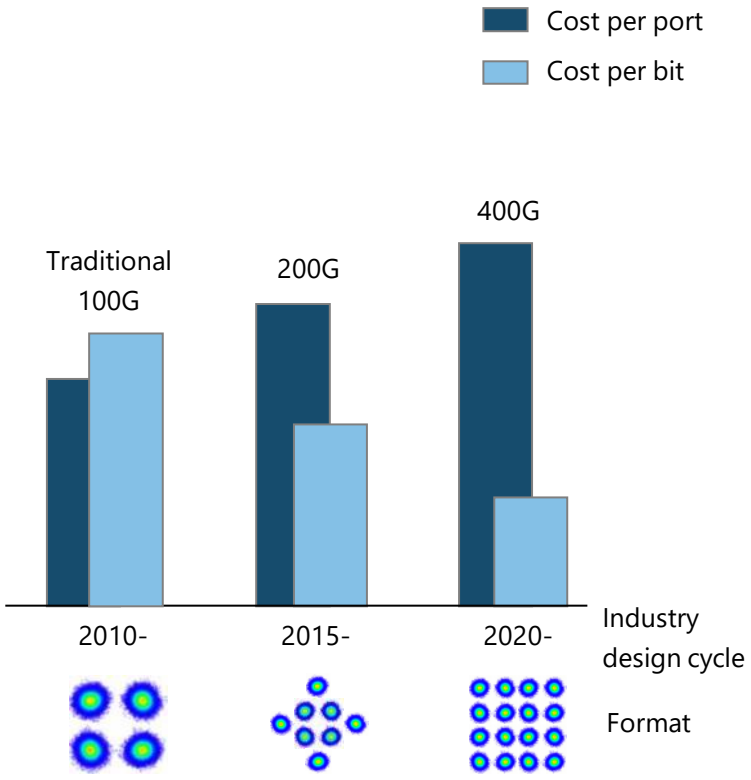
100G (QSFP28) is going to be the dominant feeder port at the optical edge

Coherent optical interface evolution

Economics of coherent WDM interfaces

- During the last decade every new generation of coherent interface came with an increased data rate
- Assuming a 100% utilization of the interface bandwidth this results in a strong reduction of cost per bit

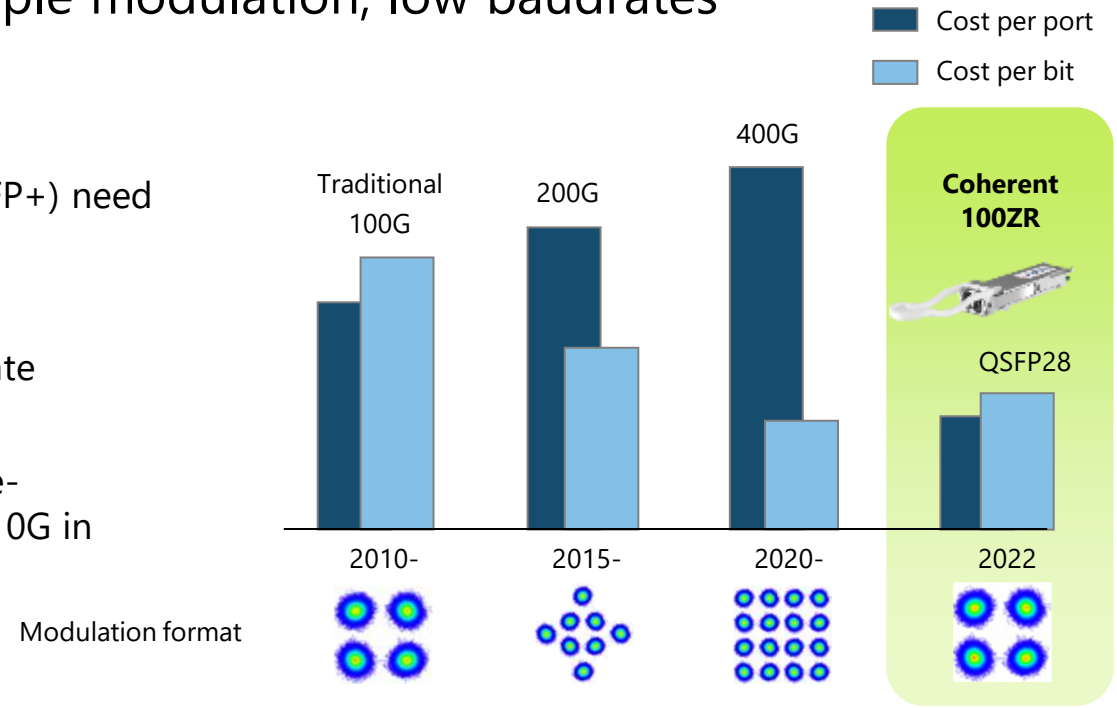
Edge applications do not benefit from further increase of interface bandwidth



A new breed of coherent optics for the edge

7nm DSP technology, simple modulation, low baudrates

- Millions of access tails at 10GE (SFP+) need high-speed upgrades
- 100GE (QSFP28) ports will dominate
- 100ZR plug needs optimized price-performance to substitute WDM 10G in volume deployments



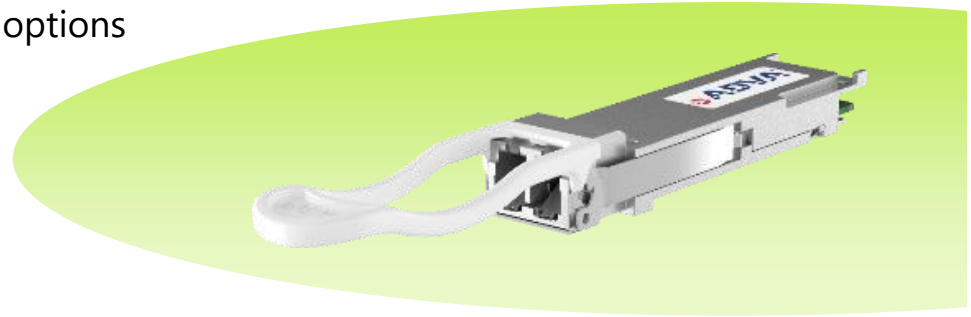
State of the art technologies to reduce power and cost

100ZR closes the gap between traditional direct-detect (10G) and coherent

Just imagine what you could do with …

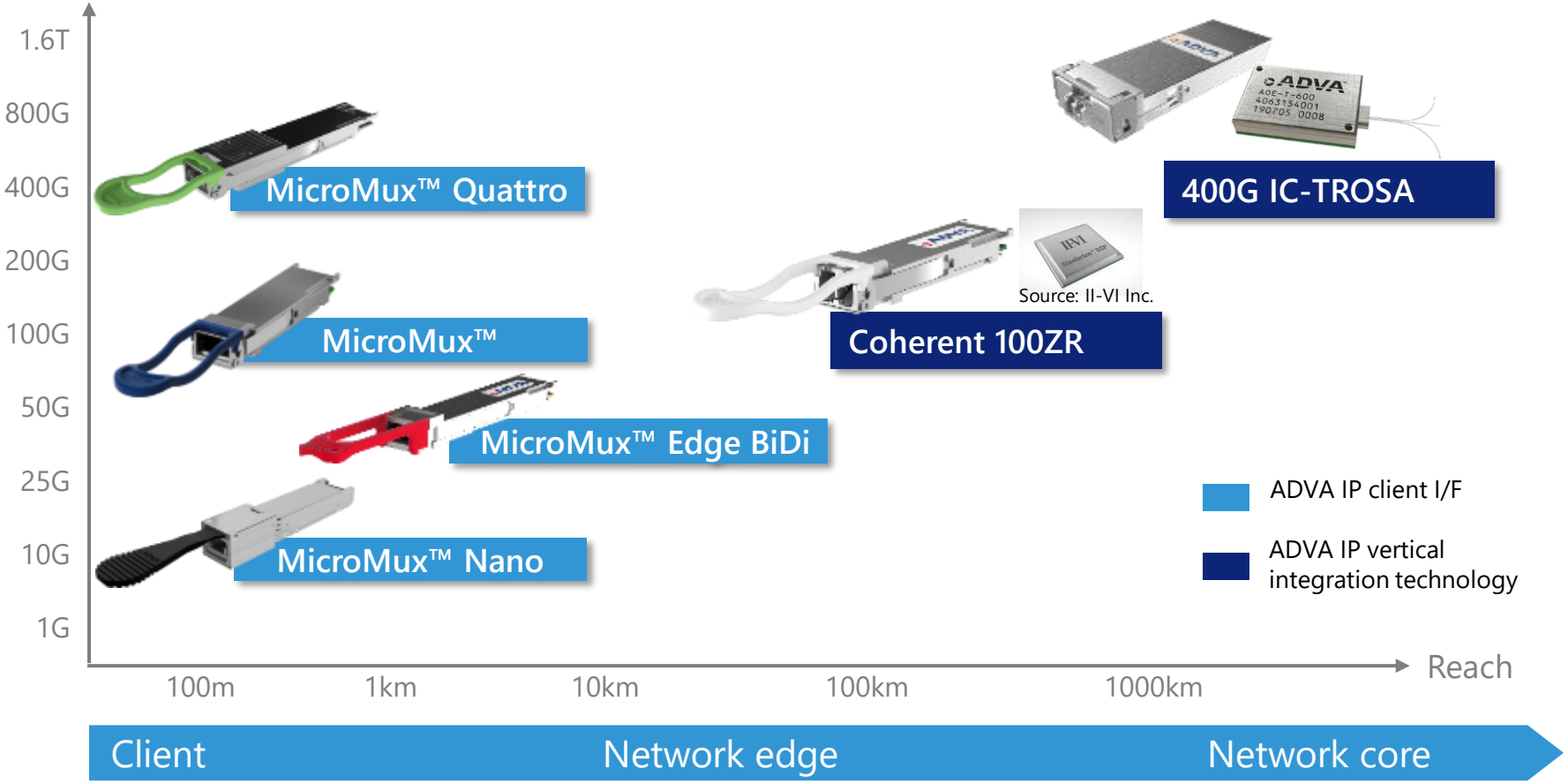
100ZR coherent technology in a 5 Watts power envelope

- 100GBASE-ZR compliant with IEEE Std 802.3ct™-2021
- QSFP28 form factor and power envelope
- OTN OTU4 and Ethernet 100GE host interface options
- 300km amplified reach (chromatic dispersion)
- 100GHz/50GHz/Flexgrid resolution
- Fully tunable (remote tuning)
- Versions for cTEMP and iTEMP



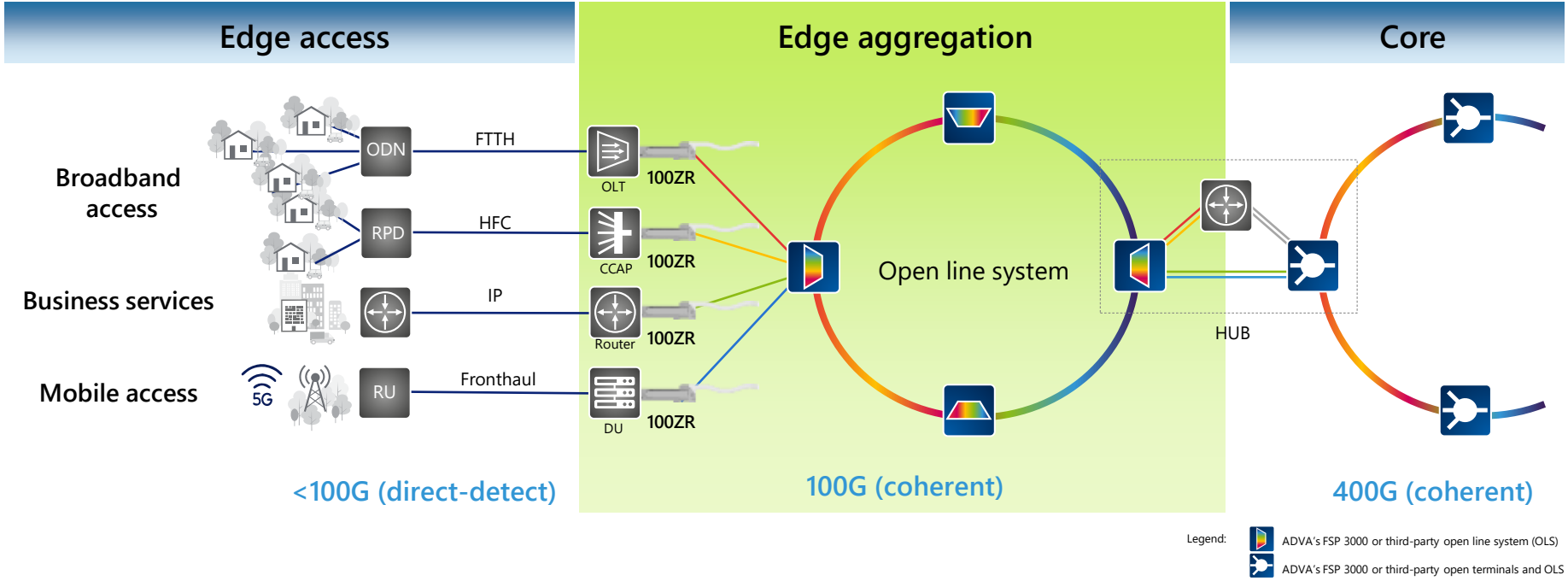
Radically new DSP innovation creates industry's lowest-power coherent 100ZR plug

ADVA – open edge networking transceivers



Coherent 100ZR

A paradigm shift for the optical edge



100ZR QSFP28 enables seamless introduction of 100G coherent waves at the edge

Thank you

srettenberger@adva.com

100GBASE-ZR QSFP28-DCO

Time for coherent at the edge of the network

September 8th, 2022

Matthias Berger
VP Coherent Product Line

COHERENT

100G coherent ZR QSFP28 – What is it?

- Digital Coherent Optics module, QSFP28 form factor
- IEEE 100G Ethernet (CAUI-4) or ITU-T 100G OTN (OTL4.4) compliant host interface
- 100G DP-DQPSK line side modulation with:
  - Standardized FEC's according to IEEE 802.3ct and ITU-T G.709.2
  - Additionally very low latency FEC per ITU-T G.709
- Transmission reach up to 80km unamplified, 120km amplified
  - >22 dB loss budget (unamplified)
  - Optional extended reach up to 300km amplified
- Full C-band tunable
  - Optional Flextune™® automatic wavelength configuration, as well as remote digital diagnostics
- Versions for standard and hardened environment
- Typical module power dissipation < 5W
- Controlled latency through module to support IEEE 1588v2 Precision Time Protocol applications – Class C
- Management interfaces:
  - CMIS 5.1 / OIF-C-CMIS-01.2 to enable rich feature set
  - SFF-8636 to support legacy hosts, with reduced feature set

Low cost, low power, small form factor standardized coherent pluggable for Access and Metro applications

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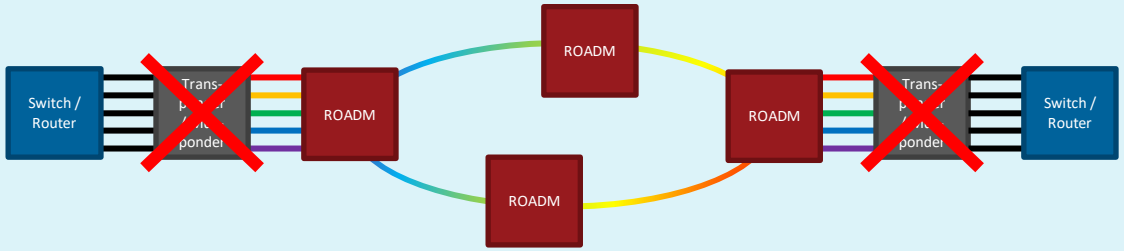
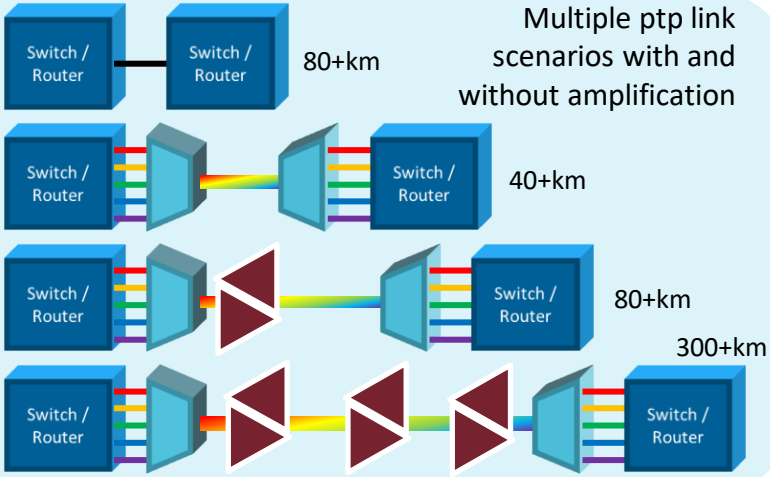
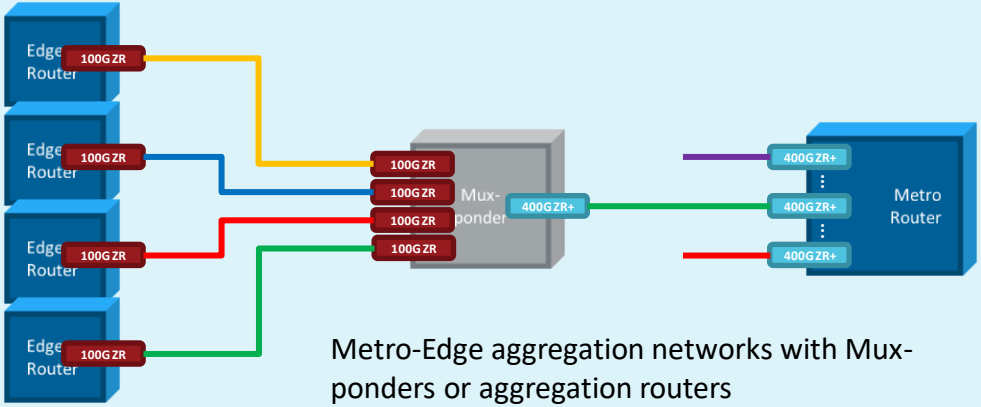
Application scenarios for 100G coherent



Metro-WDM rings without transponders using high power version



Multiple ptp link scenarios with and without amplification



Metro-Edge aggregation networks with Mux-ponders or aggregation routers

Application space aligned with network operators needs, ease of use engineering due to coherent detection

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Comparison of tunable WDM pluggables

Power / Size

10G/25G tunables

Form factor: SFP+
Power dissipation: ~2 W
Cost: $

- Limited to Access applications only
- Too low data rate for cost efficient Metro-WDM
- 25G direct detect limited to ~15km (chromatic dispersion)

100G coherent ZR

Form factor: QSFP28
Power dissipation: ~5 W
Cost: $$ - $$$

- High loss budget due to coherent detection
- Chromatic dispersion limit only dependent on DSP build-in filters
- High enough data rate for efficient use in Metro-WDM applications

400G coherent ZR

Form factor: QSFP-DD
Power dissipation: ~18 W
Cost: $$$$ - $$$$$$

- Optimized for larger capacity
- Power dissipation requires QSFP-DD (or larger) form factor (even if used at lower data rates)
- Cost structure / capacity not always matching needs in network access

Cost / Data Rate

A commercially attractive product solution covering a wide application range

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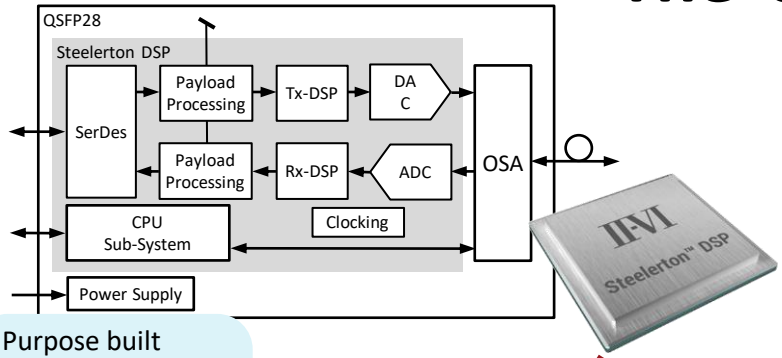
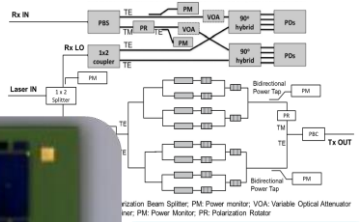
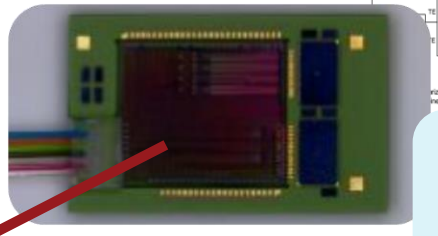
The ‘secret sauce’

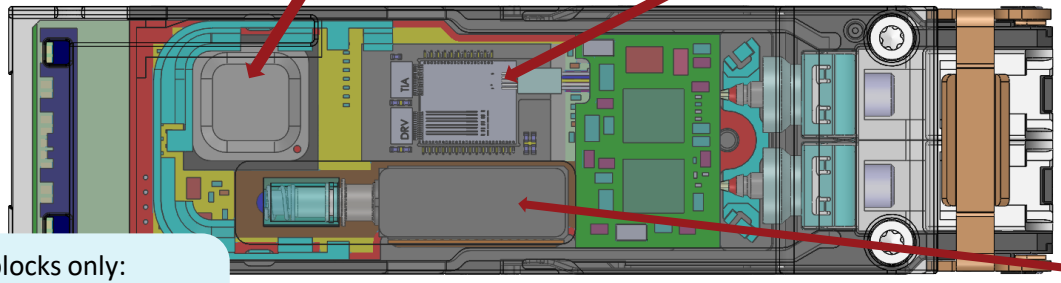


Purpose built **low power DSP** with embedded control functionality



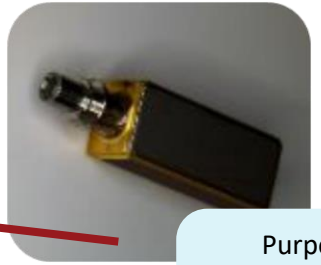


Highly integrated **SiP** transceiver **PIC** with ‘simple’ low cost packaging



Three main building blocks only:

- DSP
- Tunable laser
- SiP transceiver chip



Purpose built **tunable laser**, size and power optimized

All main building blocks designed in II-VI with common targets: low cost, low power and small form factor

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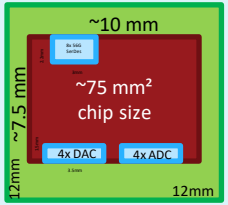
Design for QSFP28 form factor

item	400G based HW*			II-VI QSFP28
Data rate	400G mode	100G mode		100G
DSP	8.0 W	4.5 W		2.0 W
Tunable laser	2.5 W	2.0 W		1.2 W
Optics	0.2 W	0.2 W		0.1 W
RF IC's	5.5 W	2.0 W		1.2 W
misc	2.0 W	1.0 W		0.5 W
total	~18 W	~10 W		~5 W

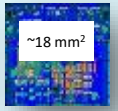
- 400G numbers estimated*
- 100G mode in 400G HW already assumes power optimization of optics and RF IC's

- Low power enabler for QSFP28
  - DSP
    - Power optimized ADC/DAC
    - Innovative DSP architecture
    - Simpler arithmetic with HD-FEC
  - Purpose build driver and TIA (aligned with optics)
  - Power optimized in-house tunable laser

Commercial 400G DSP*



II-VI 100G DSP



4x smaller chip size is not only reducing cost but allows for a small package

Purpose build components utilizing leading edge technology addressing lowest possible power and size enabling QSFP28

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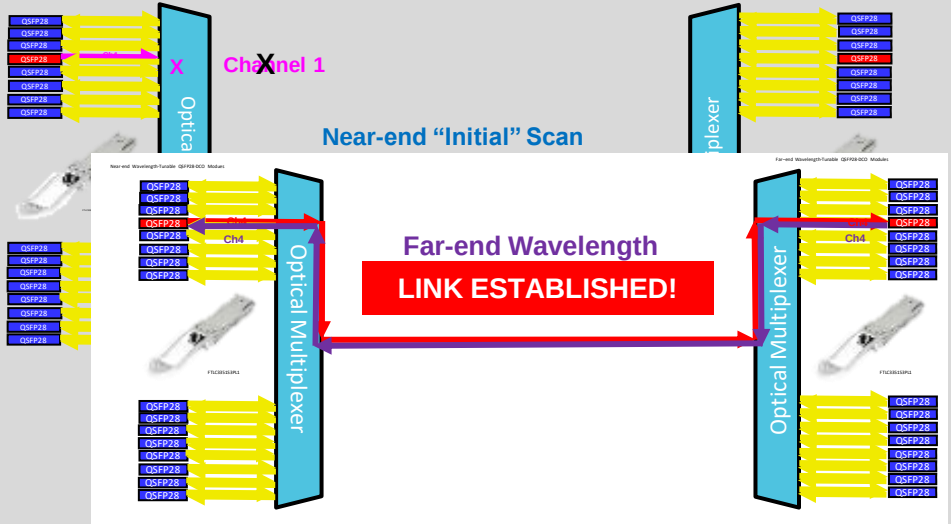
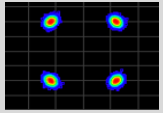
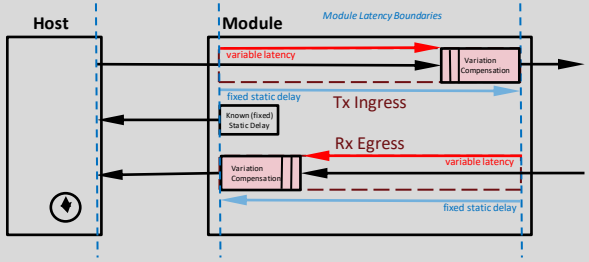
Smart functionality for ease of use (examples only)



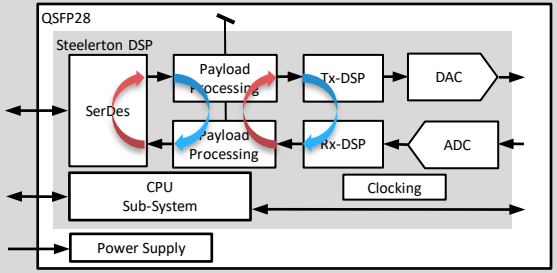
Wavelength auto-tune for reduced provisioning effort



In-situ fiber and performance monitoring accessible through standardized CMIS management interface



Built-in latency management



Multiple loop back functions for installation and fault isolation

Build-in intelligence simplifying operational effort and cost

Summary & outlook

- **WDM architectures in network access** are widely used with hundreds of thousands of ports installed per year
- To date **10G and 25G tunable modules** using direct detection techniques are state of the art but **can't cope with increasing demand** in capacity and in addition **face engineering challenges**
- **Transitioning to coherent** detection schemes remove those engineering challenges and enable growth for many years
- Cost, power and size challenges of coherent detection schemes can be overcome by **purpose build, co-developed building blocks** – specifically the DSP itself plays the most important role
- Combining the DSP with **different optical assets** allows for extending the application space even further (grey, Metro-WDM, …)
- The **evolution of e.g. CMOS** technologies will help driving power / size further down while enabling even higher data rates in the future

What technologies and architectures and how much time is needed to move this into a SFP112?

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