

Coherent pluggables

Chalk Talk

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Coherent Pluggables

Outline

1. Industry context
2. Networking Applications and Evolution
3. Details on Ciena Offering

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State of the Industry around coherent optical networking

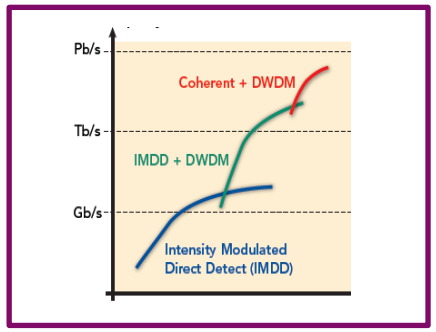


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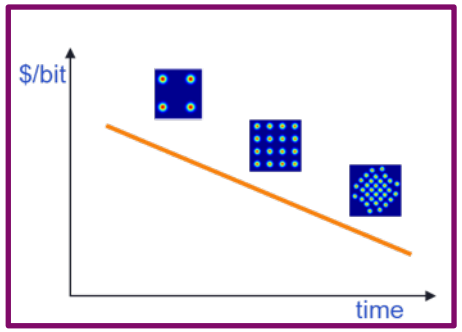
Coherent technology is playing an increasingly critical role in solving networking business challenges

Addressing the need for Massive Scale

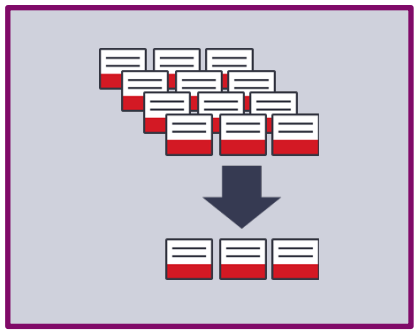
Network capacity



Cost Reduction



Competitiveness



BECOMING PERVASIVE TECHNOLOGY ACROSS APPLICATIONS

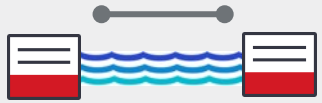
Multi-Haul: Metro and Long Haul

100s to 1000s km



Submarine

10,000km



DCI

10s to 1000s km



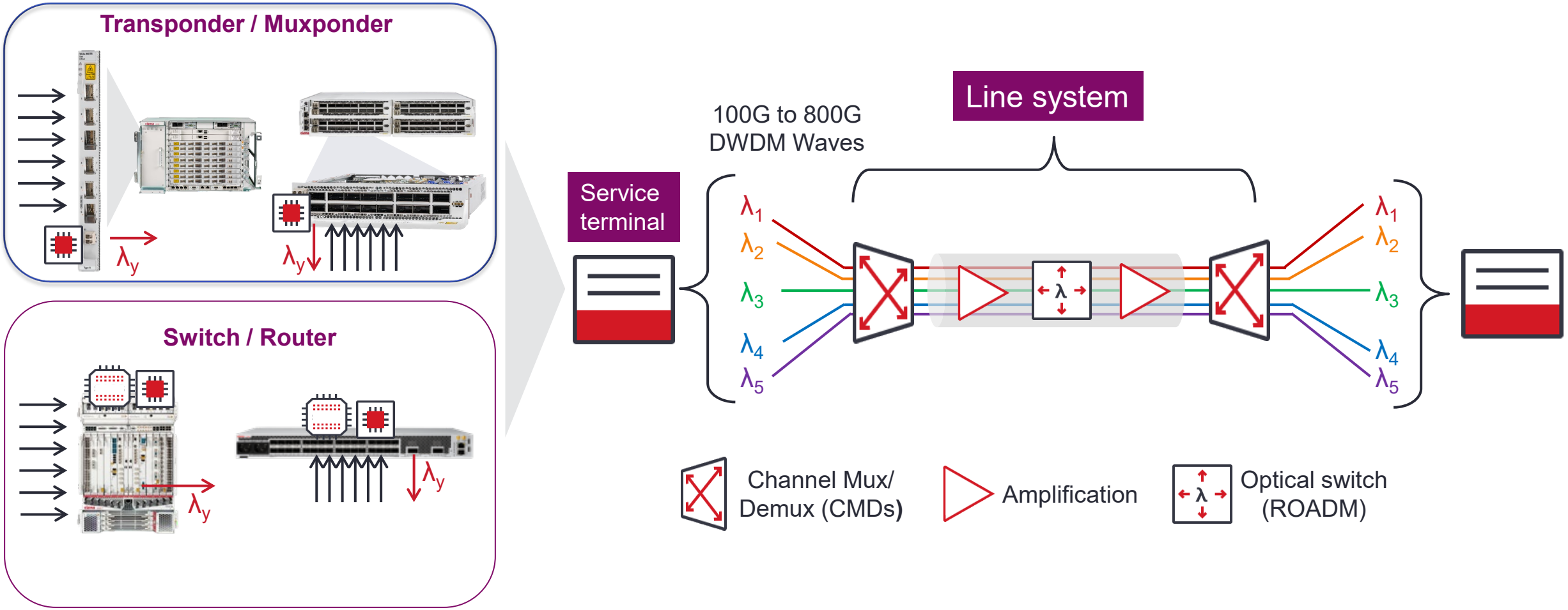
Fiber in Access (Fiber Deep, 5G)

10s km



Selecting the most suitable optical technology for network applications critical to controlling costs/space/power

Elements of coherent optical solution



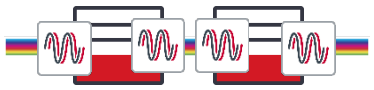
Coherent optics deployed across L1/L2 switch, router, and optical transport equipment

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Optical line system designs evolving towards flexible, programmable systems supporting any-any traffic connectivity

Reduced cost, power, site visits, turn-up time

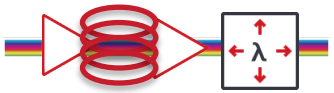
Regen – Regen



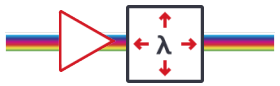
Amp-compensation module (DSCM) – Regen



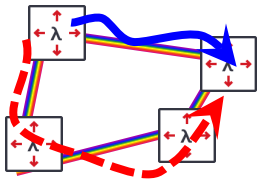
Amp-DSCM–OADM



Amp-ROADM Single direction



Intelligent, flexible photonics



Coherent DSP eliminates DSCM

Embedded instrumentation, flexible service routing, increased availability



Coherent technology enabled move to flexible, programmable, more automated networks

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Pluggable WAN Optics Are Nothing New

Natural Evolution of DWDM technology to Smaller, Lower Power, Modular Solutions

Coherent



10G DWDM

2008



40Gb/s



100G

2012



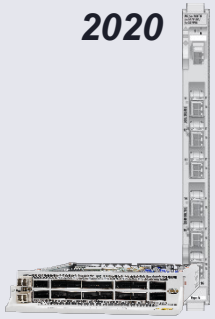
100G

2017



400G

2020



800G



1.2T-1.6T

3-4-year lag

3-4-year lag

2011



10G DWDM XFP



10G DWDM SFP+

2014



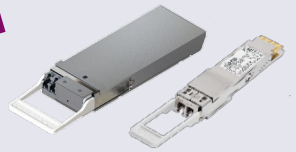
100G
CFP

2017

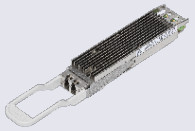


100G/200G
CFP2-DCO

2021



400G



800G

Timeline

Technology lag between form factors driving two divergent solution paths

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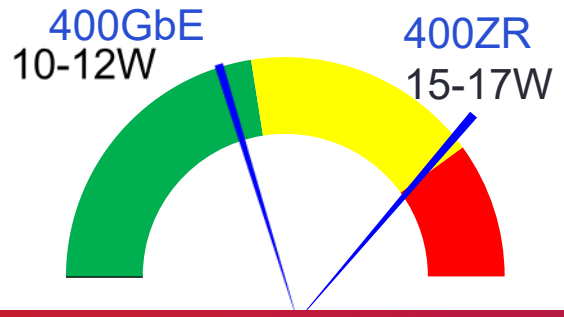
What's different now?

Optics/DSP/Analog Innovation enable Hi-Cap Coherent in very small footprint



Client and Line Optics now available on same form factor (QSFP-DD)

Different network applications,
Different technical requirements



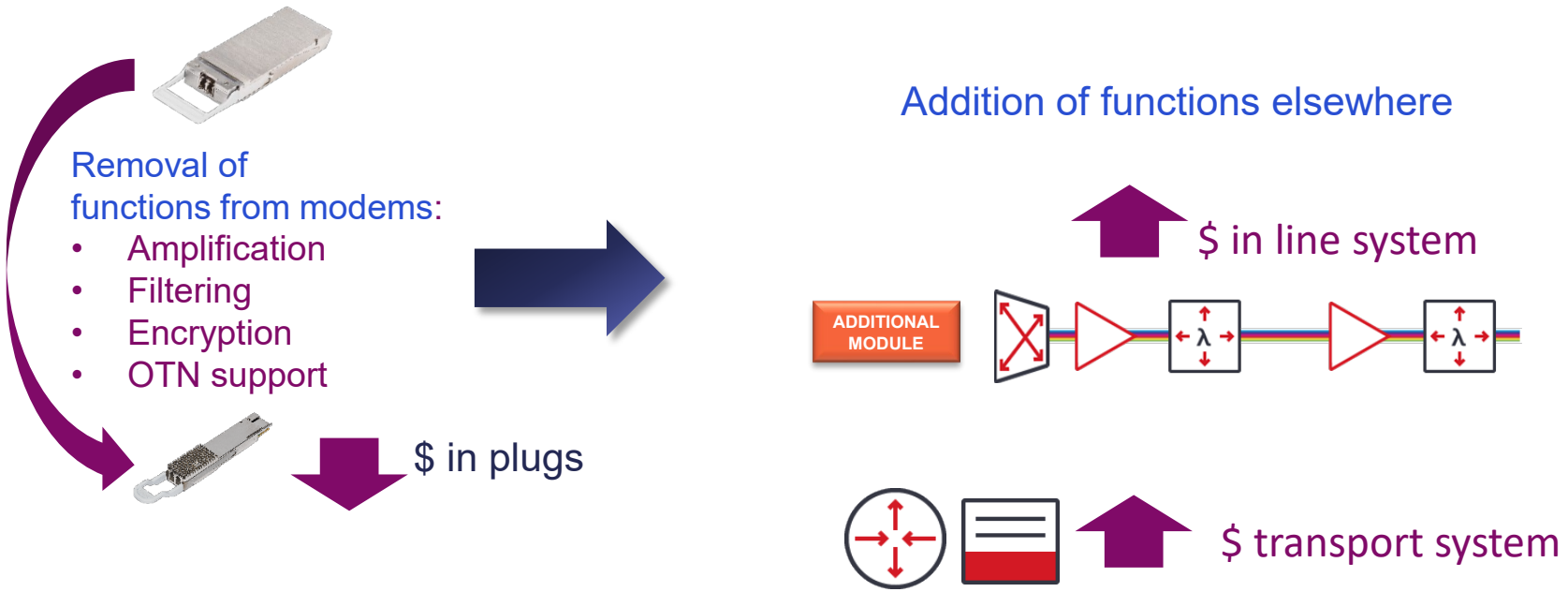
Hi-Cap DWDM and propagation → Coherent requires more complex DSP

Coherent requires router/host platform designed for higher power & thermals

Important differences drive new platforms and photonic layer considerations in the coherent plug design

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Deployment considerations with coherent pluggables – not always plug and play



Functions/cost that are removed from the optics get added elsewhere in the network

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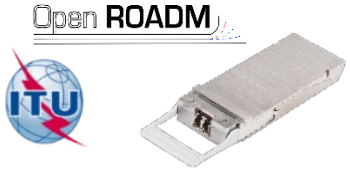
Numerous, application-specific coherent pluggable products will be offered



400ZR



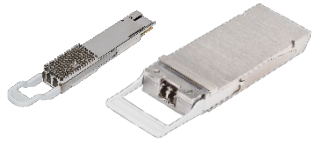
100G-400G
Interoperable
Metro



100G-200G
50GHz
compliant



200G
Extended
Temp



High Perf.
Proprietary
Implementation



100G
Access



“Right” solution dependent on application and operational requirements



QSFP-DD



CFP2-DCO

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Two Types of Solutions for continued transport cost reduction

Latest CMOS technology, and photonic integration with Indium Phosphide, Silicon Photonics key technology

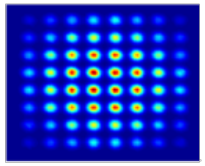
PERFORMANCE - OPTIMIZED

- Lowest $/bit per km
- Maximum fiber capacity using least # of modems
- Ability to maximize optical layer automation



Requires:

- Sophisticated DSP algorithms
- High bandwidth electro-optics with photonic integration



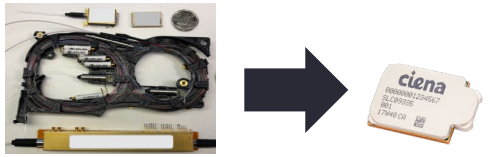
FOOTPRINT - OPTIMIZED

- Designed to fit within specific power envelope
- Opportunity for packet-optical integration efficiencies
- Brings coherent to access applications



Requires:

- Small footprint, low power DSP
- Silicon photonics integration



Very few have the competencies / financial strength to offer both, complete solutions

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Networking Applications and How Pluggables Fit



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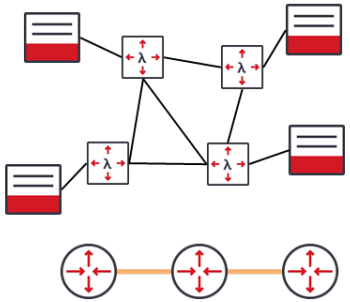
Different Applications Dictate Different Technical Requirements

Campus / Metro DCI



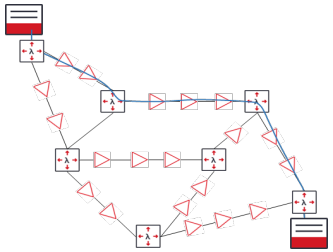
- Simple point-point
- Controlled environment
- 80-120km
- High volumes from few hyperscalers → multi-vendor interop desired

Multi-span Metro



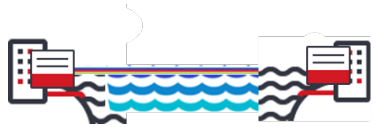
- Reach & S.E. key requirements
- Highly meshed
- Protection & restoration key design requirement
- CDC ROADMs design consideration
- C&L-band for max fiber ROI

Regional / Long haul



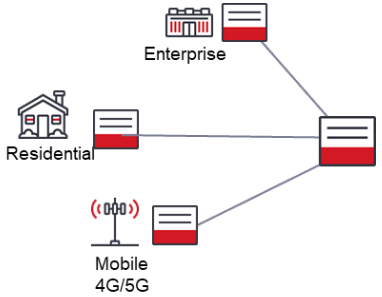
- Reach & spectral efficiency key requirements
- Lightly meshed networks
- Protection & restoration key design requirement
- C&L-band for max fiber ROI

Submarine



- Reach & maximum spectral efficiency paramount
- Extreme propagation lengths
- Non-linear compensation
- Interoperability with terrestrial backhaul

High-Capacity Access

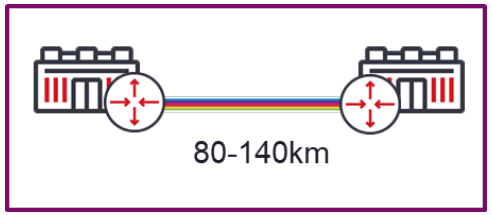


- Transition 10G → 100G
- Longer term transition to 200G & 400G
- Linear or hub & spoke architectures
- High loss, challenging spans
- Outside plant required

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Metro DCI – highly competitive, fast evolving market

Consumption model: best-in-breed disaggregated components



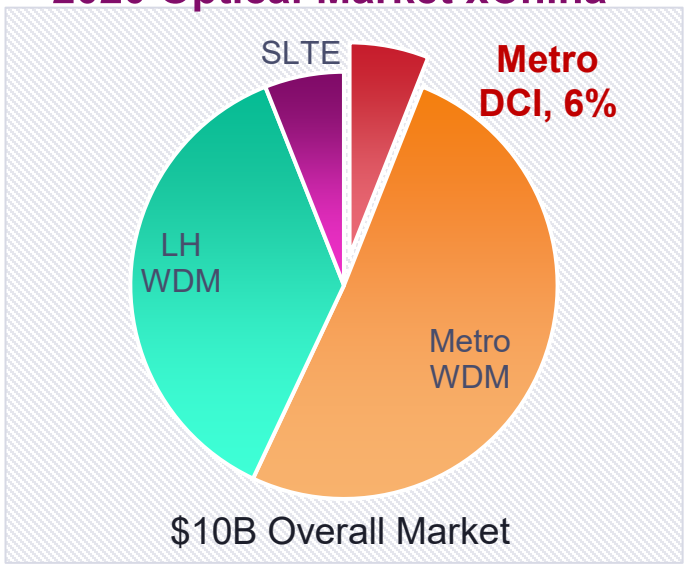
Campus, Metro DCI Today

Coherent transport (ex. Waveserver)

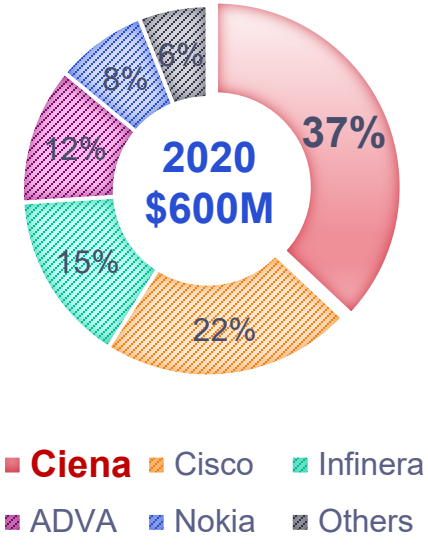
Direct Detect PAM4 (ex. ColorZ)

Optical

2020 Optical Market xChina*



2020 Metro DCI Share*



400ZR ecosystem being built

- 400ZR IA published
- Samples available, testing ongoing
- Initial volume deployments starting 2H'21

*Ciena analysis based on Cignal AI and Omdia 4Q20 market share data

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Metro DCI – highly competitive, fast evolving market

Consumption model: best-in-breed disaggregated components

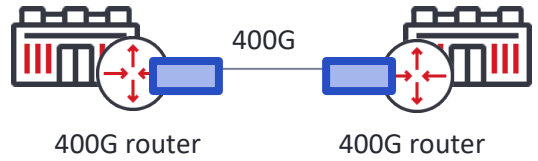
Metro DCI opportunity 2022+

- Overall opportunity increases (coherent + PAM4)
- A few hyperscalers will continue to dominate consumption
- Will continue evolving with new innovations in datapath and optics (~2 yr cycle)

Winning hand only Ciena can deliver:

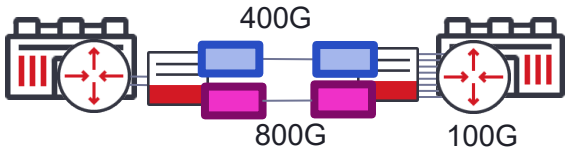
- Deep understanding of networking requirements and link engineering, enabling simple deployments at scale
- Leading in performance (embedded + pluggables), vertical integration and supply chain
- Best-in-class stand-alone modules, transponder platforms, line systems
- Sustained forward innovation

400ZR direct on router



- Lowest power solution
- Smallest footprint
- Eliminates interconnect
- Multi-vendor interop ecosystem

Optical transport



- Mix generation router connect
- Demarcation
- 800G for spectral efficiency or pluggable for lowest power
- Encryption
- Operate in challenging conditions

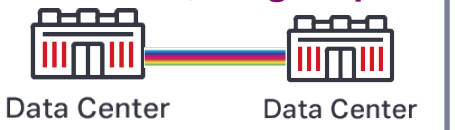
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DCI evolution

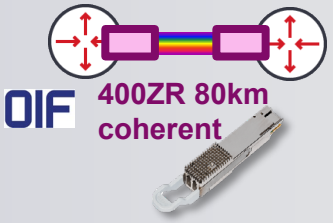
2021/22	2023-25	2025-2030
100G/400G	800G	1.6T?

"Metro" DCI

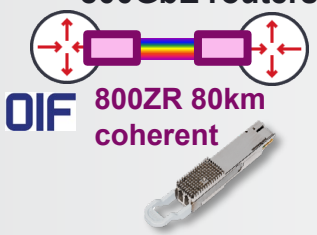
40 - 80 km, Single-span



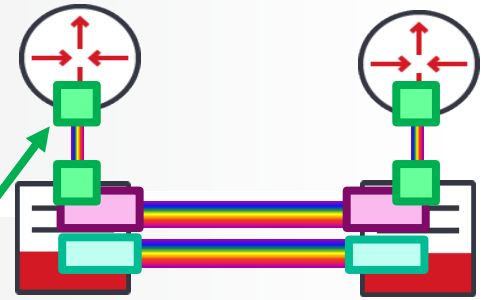
400GbE routers



800GbE routers



3.2T switch CPO interface



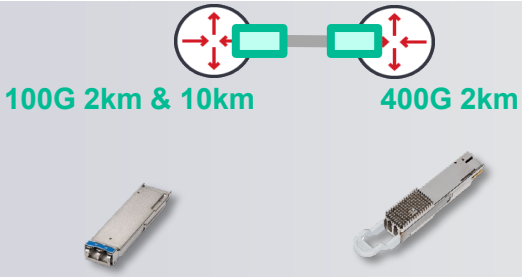
OIF
CPO 3.2Tbps

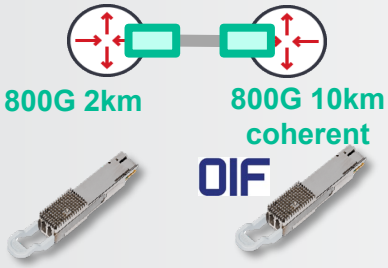
3.2T coherent
(4 x 800G?)
(2 x 1.6T?)

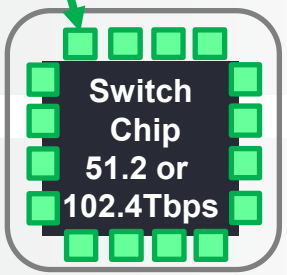
Campus DCI

2 – 10 km, Single-span









CPO interfaces for 2km:
- 8 x 400G

CPO interfaces for 500m:
- 8 x 400G
- 32 x 100G

Intra-DCI

<2km



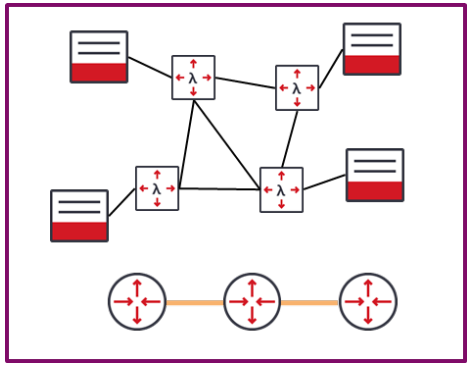


Coherent Increasing in Importance: Metro → Campus → Inside DC?
CPO Disruption on the Horizon… Timing TBD … Impact on pluggables

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Multi-span metro network evolution – one size will NOT fit all

Consumption model: system vendor



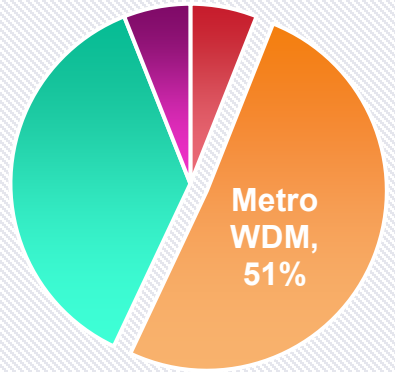
Multi-span Metro opportunity

- Dominated by service providers, wholesale providers, MSO
- Different network architectures
- Performance-optimized optics ideal for:
  - Max spectral efficiency, high BW flows
- Pluggables ideal for:
  - Moderate capacity, shorter links
  - Legacy network evolution
  - CFP2-DCOs on transport will dominate for ease of ROADM deployment

Winning hand only Ciena can deliver:

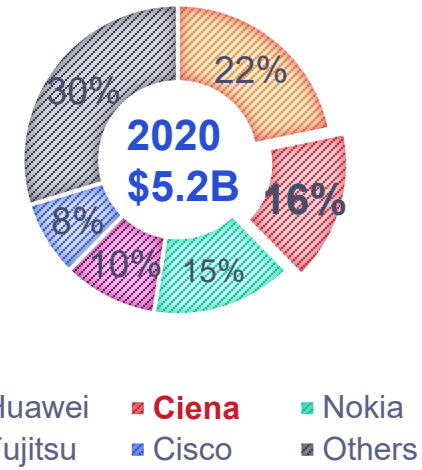
- Full solution provider
- Vertical integration
- Heavy dose of intelligent photonics, right service terminal, SW domain controller to address diverse requirements
- Unmatched networking expertise – realistic architecture pros/cons analysis

Optical Market xChina*



$10B Overall Market

2020 Metro WDM Share*

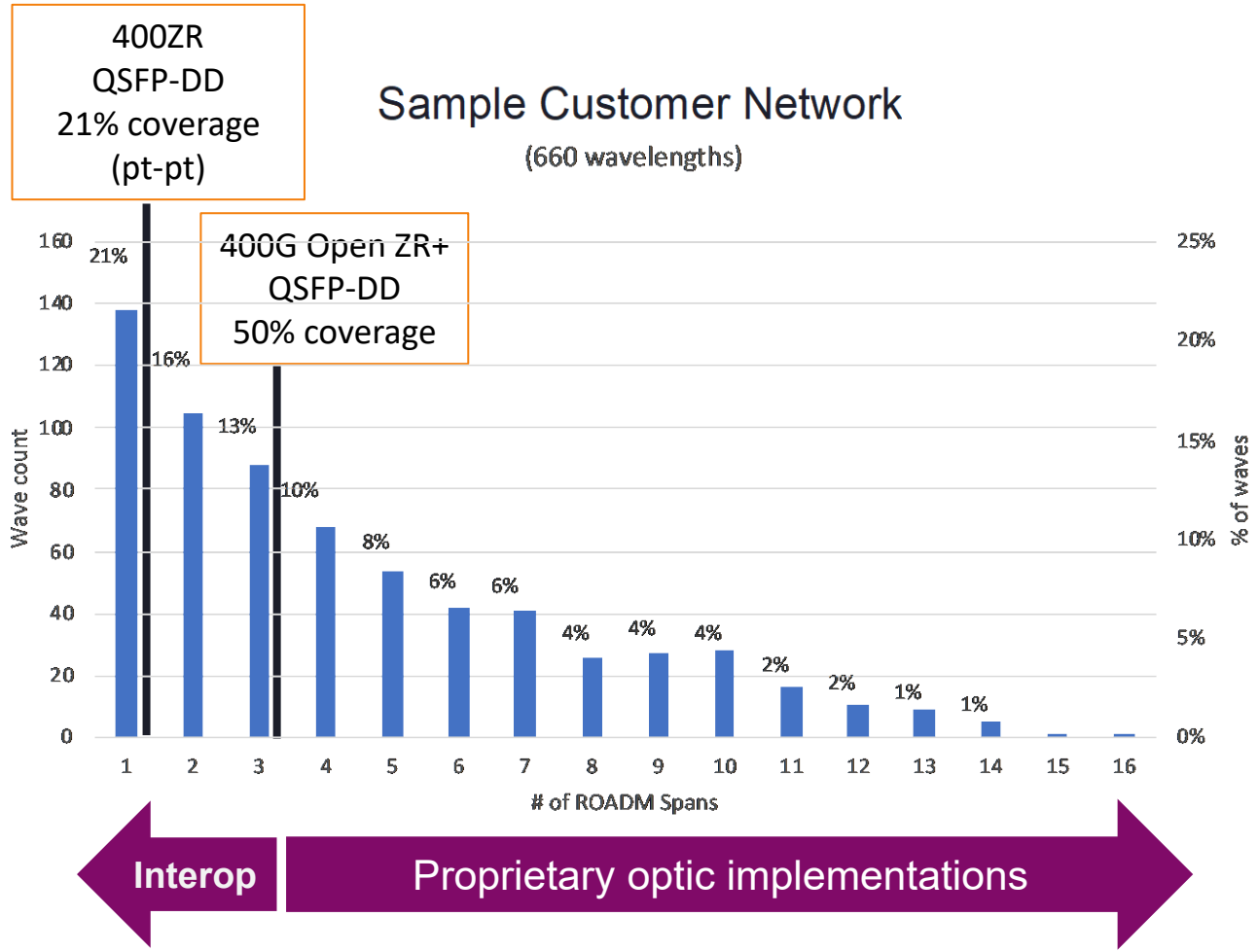


*Ciena analysis based on Cignal AI and Omdia 4Q20 market share data

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Example NA telco metro network analysis – predominantly mesh connectivity

Fraction of demands supported using interoperable pluggables



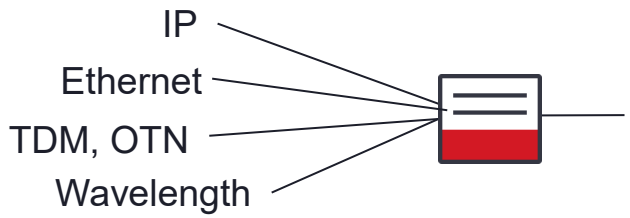
- Interoperable QSFP-DD addresses only 50% of requirements
- CFP2-DCO on transport equipment expected to be most popular choice for pluggable deployments
  - Most suited for existing ROADM networks

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Promise of IP/Optical convergence combined with open and disaggregation

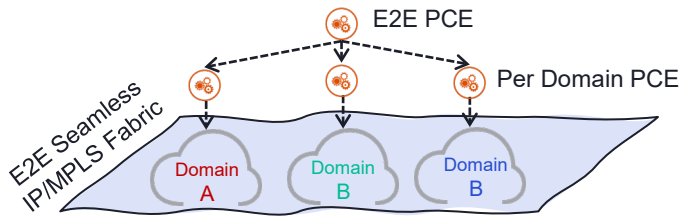
Opportunity to simplify and de-cost the network through new technologies and software

Service Convergence



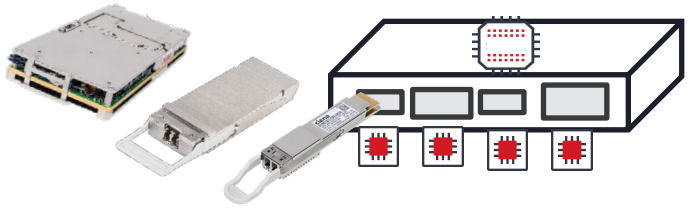
Optimized routing

Centralized Path Computation Engine (PCE)

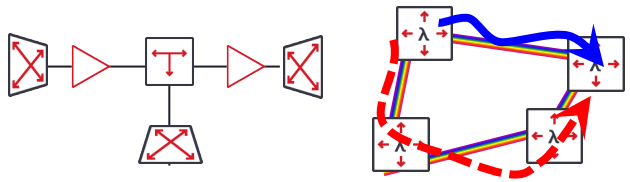


IP/MPLS/SR domains

IP/Optical Integration – with the right optics per application



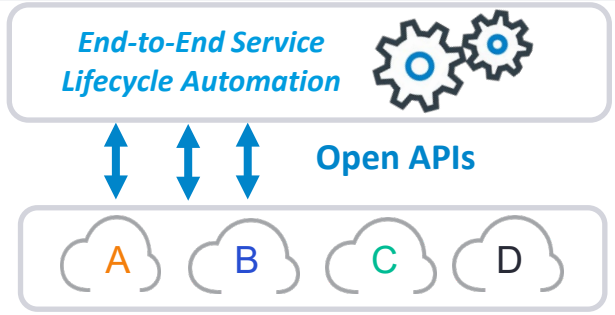
Intelligent, Automated Photonics, flexibility as per application need



Multi-layer Automation, Correlation, Optimization



Common data models for ease of multi-vendor networking

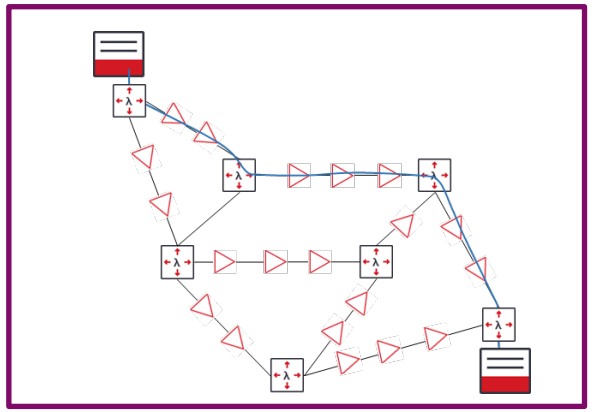


All elements required and being delivered by Ciena – supporting all consumption models
Many vendors delivering subset and claiming IP/Optical convergence

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Long haul networks - maximize fiber capacity key requirement

Consumption model: system vendor

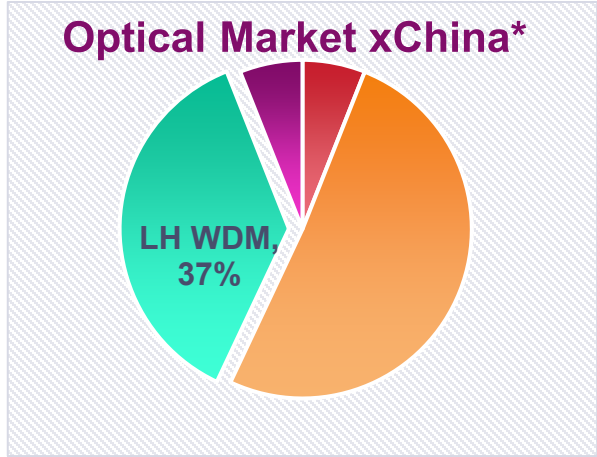


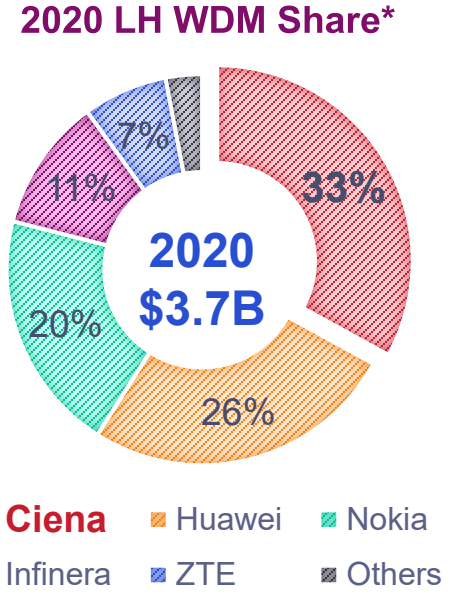
Long Haul network opportunity:

- CSPs and Webscale
- Buy separate service terminals and line system, need network performance guarantees
- High performance, embedded optics will continue to dominate
- Niche pluggables opportunity:
  - Evolution of fixed grid networks to lower cost/power 100G/200G

Winning hand only Ciena can deliver:

- Full system vendor with range of performance optics and line system offerings to address diverse requirements
- Link engineering, open, programmable and automated solutions, C&L, complete range of coherent optics
- Recognized industry leader





*Ciena analysis based on Cignal AI and Omdia 4Q20 market share data

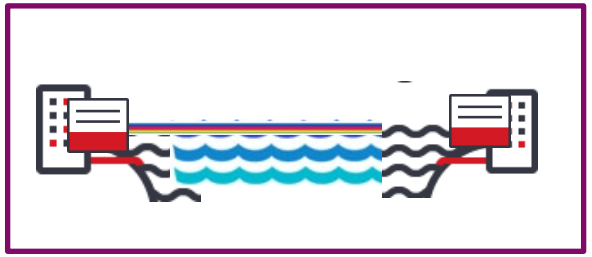
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Submarine networking – maximize sunk cable investment

Consumption model: solution provider

Submarine opportunity:

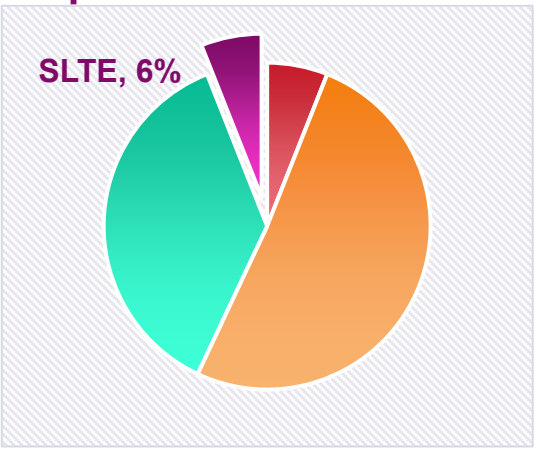
- Consumer: consortia, webscale, CSPs
- Reach and spectral efficiency all that matters
- Looking for highest performance optics from solution provider, link engineering, turn-up services



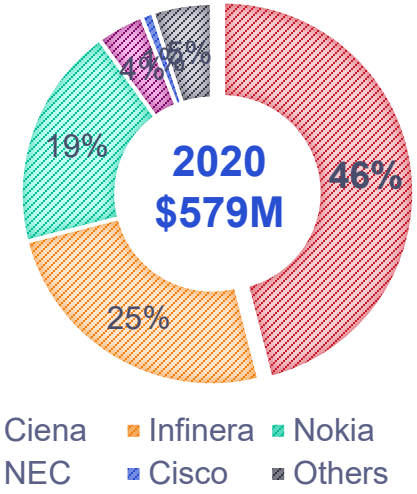
Winning hand only Ciena can deliver:

- Recognized industry leader
- Financial strength to continue to invest and deliver best-in-class innovative solutions
- High performance optics and intelligent, automated turn-up and system optimization

Optical Market xChina*



2020 SLTE Share*



*Ciena analysis based on Cignal AI and Omdia 4Q20 market share data

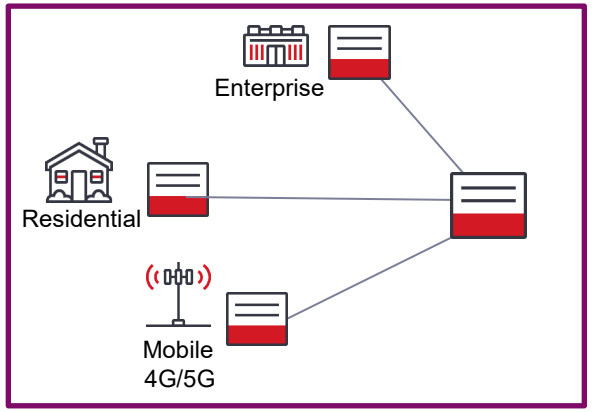
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Access Opening up Brand New Market Opportunity for Coherent Solutions

Consumption model: system vendor

New market for coherent

- 5G, Edge Computing key drivers
- Increasing bandwidth demands and space constraints driving need for coherent plugs, with different technical specs than metro DCI



$0 Market Today

$600M (USD) Market 2025

Winning hand only Ciena can deliver:

- Recognized coherent optical industry leader
- Vertically integrated, component and solution provider
- Full solution provider with access-optimized Adaptive IP™ solutions
- Ability to supply pluggables for 3rd party devices / China market further expands opportunity for Ciena

*Ciena analysis based on Cignal AI and OMDIA reports

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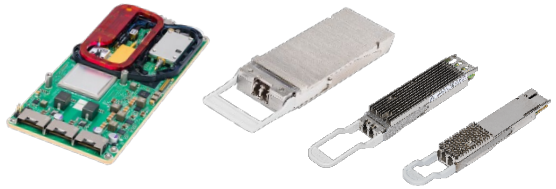
Details on Ciena Offering



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Ciena Holistic Coherent Optical Solution Offering

Coherent Modems



WaveLogic 5

- Modules or solutions
- Performance or footprint
- Products optimized for specific applications
- Ciena vertical integration leads to co-optimized design / cost efficiencies

Packet-Optical Platforms



Waveserver 5



6500 L0 -L3



51xx/81xx switch/routers

- High density, modular interconnect platform
- Converged L0-L3 platform
- Switch/router portfolio

- All support both integrated as well as pluggable coherent optics, tight integration with photonic layer

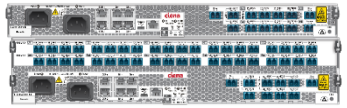
Photonic Line Systems



6500 RLS



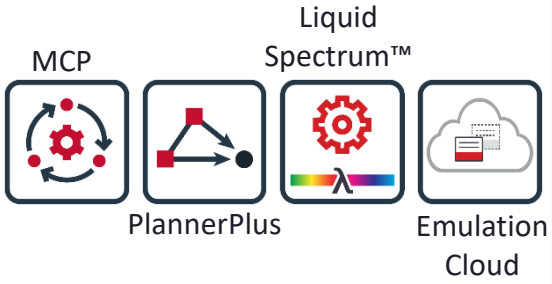
6500



Coherent ELS

- Fully flexible, instrumented photonic line systems
- Designs optimized for specific applications
  - Coherent-optimized, hardened access line
  - Metro DCI
  - Flexible ROADM

Software & Network Design



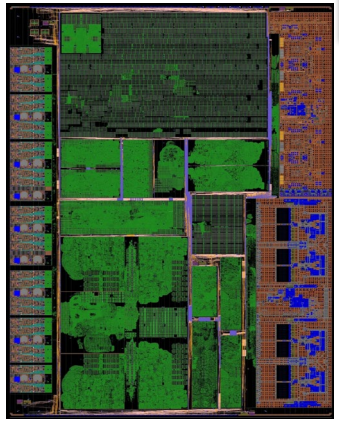
- Link engineering
- Network design tools
- Multi-layer, multi-domain controller
- SDN applications for increased automation / network optimization
- Emulation cloud

Unique in the market with the significant, requisite technology investments to address wide range of network provider requirements for leading edge and deployable coherent optical solutions

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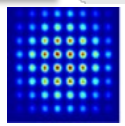
Ciena Foundational Technologies

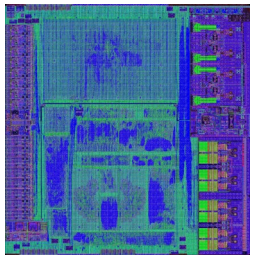
High-Performance, Low Power Optical DSP



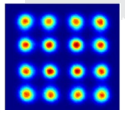
800G, LH/Trans-Oceanic







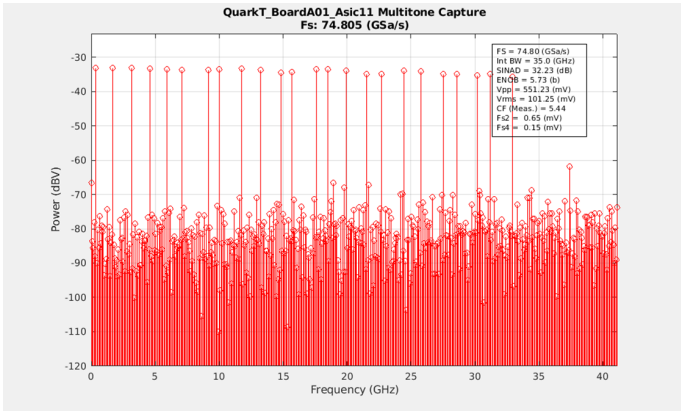


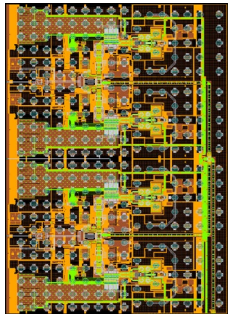


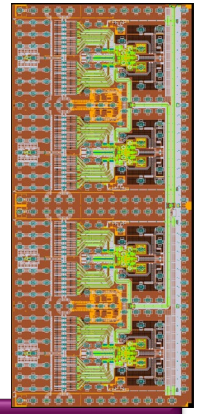
400G, 7 Watts

7nm Mixed-Signal CMOS

High-Speed Converters

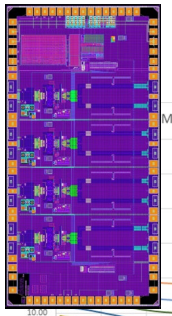


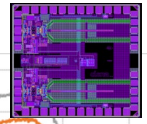




Quad DAC/ADC
75 GS/s & 115 GS/s
Low Power, High SNDR

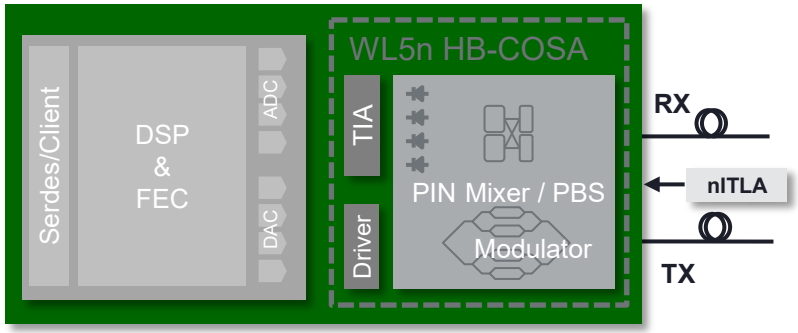
High-Speed Analog VGA

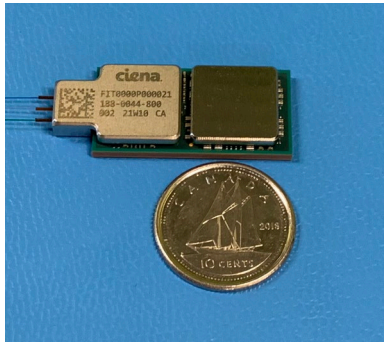




SiGe Drivers & TIAs
BWs ~50GHz
Low Power, High SNDR

High-Perf Packaging & Optics Integration



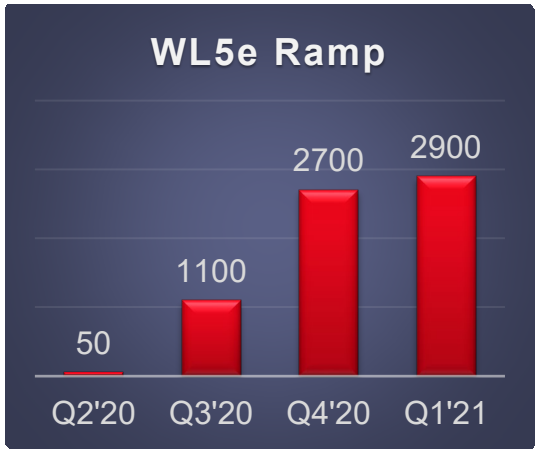


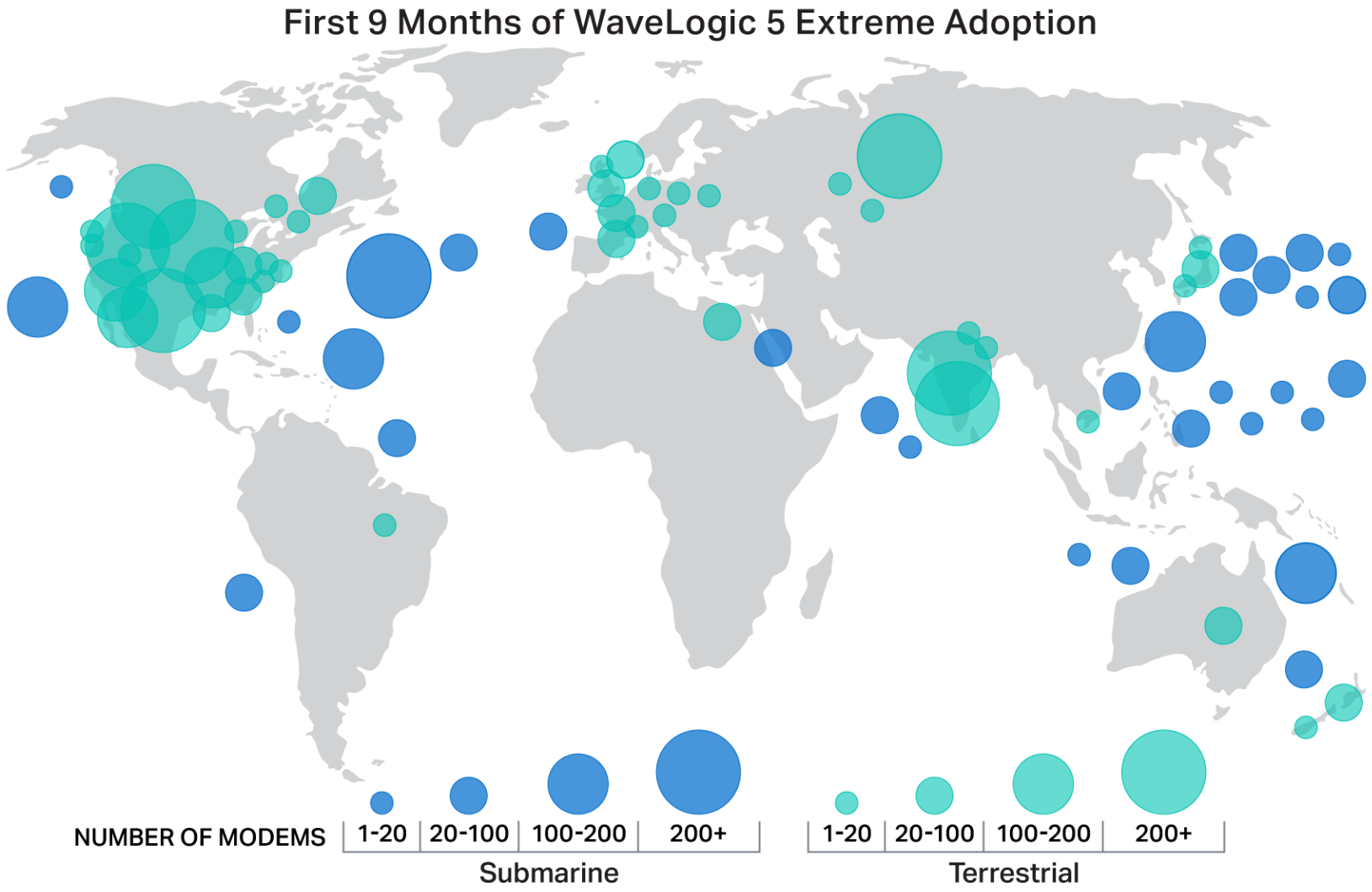
Silicon ICs & Silicon Photonics PICs

information.

Ciena 800G Leadership: Understanding of networking requirements + right solution + strong supply chain

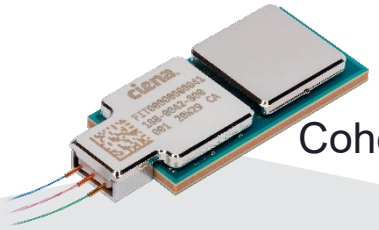






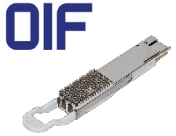
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Ciena WaveLogic 5 Nano design enables multiple, application-specific products

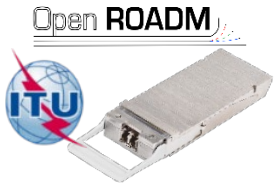


7nm DSP and
Silicon Photonics-based
Coherent Optical Sub-Assembly

Different Transmission Mode Profiles
DSP and E/O optimized for application and client traffic



400ZR



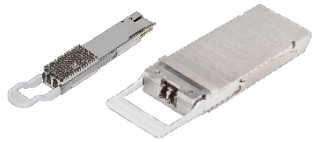
100G-400G
Interoperable
Metro



100G-200G
50GHz
compliant



200G
Extended
Temp



High
Performance



100G
Access

Interoperable

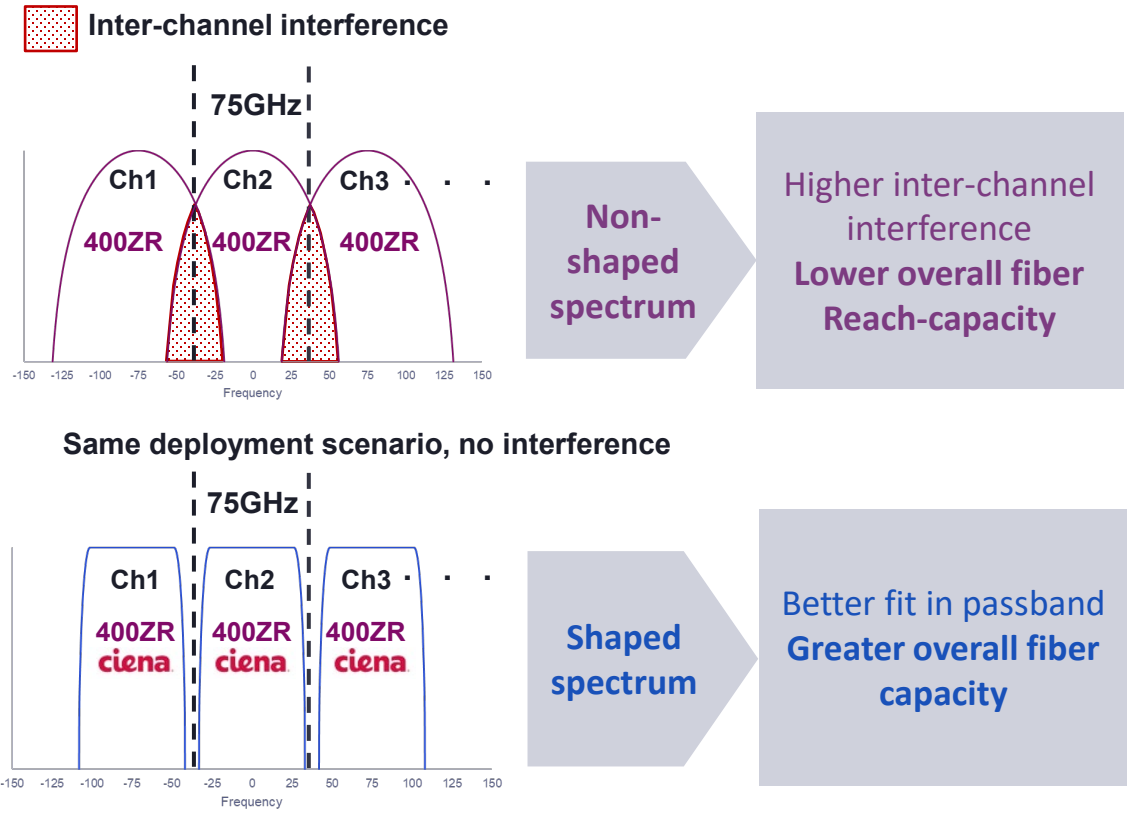
Proprietary / Bookended

“Right product” dependent on application and operational requirements

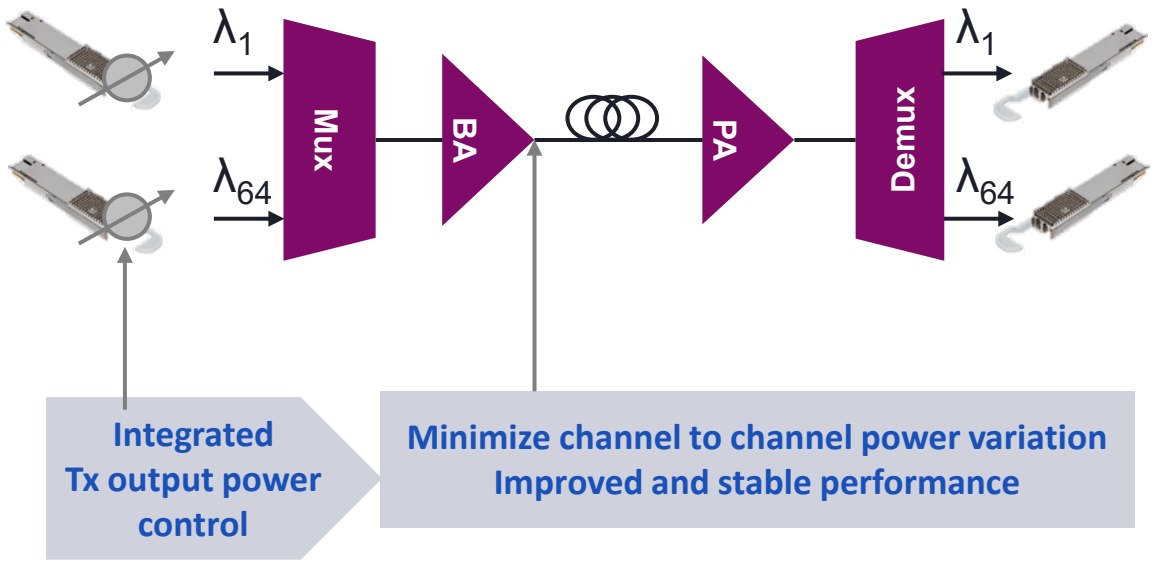
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WaveLogic 5 Nano 400ZR: interoperable AND differentiating performance

Spectral shaping



TX power control



Interoperable 400ZR optimized for full-fill on 75GHz fixed-grid networks

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Ciena WaveLogic 5 Nano: Unmatched combination of networking experience and vertical integration to deliver the right design for the right application, for any consumption model

Unmatched networking expertise

+

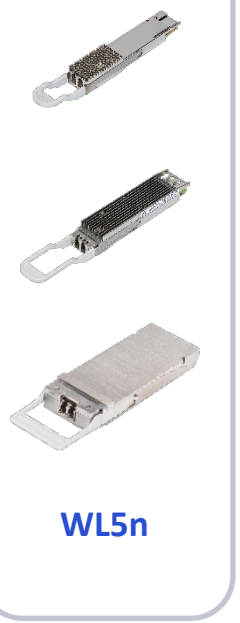
Unmatched expertise in reliable coherent solutions

+

Ownership of foundational technologies for cost/design efficiencies



Transceiver-on-Chip



WL5n

ciena Systems



Waveserver 5



6500-S 6500-T



5166



5171



8180

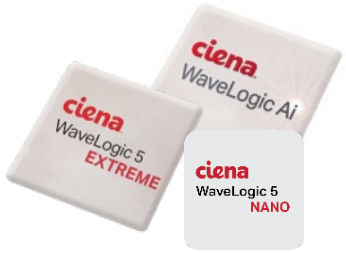
ciena | Optical Microsystems

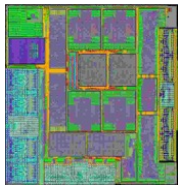
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Uniquely positioned to deliver the aggressive pace of innovation needed to address network provider challenges

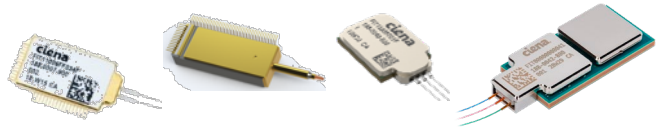
Proven, Industry Leading Network Economics

DSP, FEC, high Speed RF, DAC/ADC





High B/W E/O: SiPhot & InP



Ownership of key foundational technologies for faster innovation and time to market

Programmability & Automation



MCP **Liquid Spectrum™**

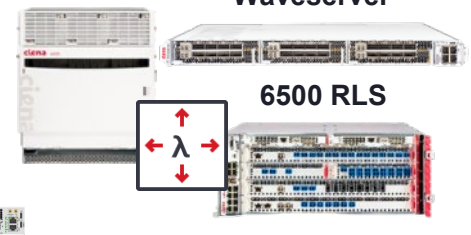




51xx/81xx switch/ routers



6500 **Waveserver**



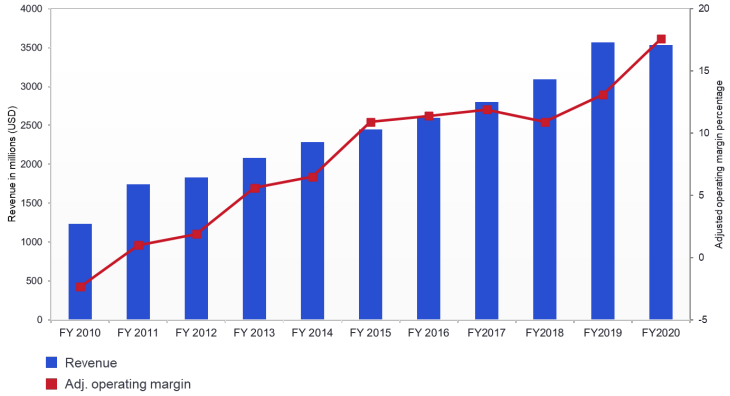
6500 RLS

Coherent pluggables



Embedded instrumentation, intelligence and programmability across full range of systems enabling more adaptive networks

Sustained Innovation Leadership



Financial strength, expertise and global scale to continue to drive and deliver leading innovation

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Thank You

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