



KEYSIGHT
WORLD 2019

Data Center and Optical Network Innovation: Enabling the 5G Ecosystem

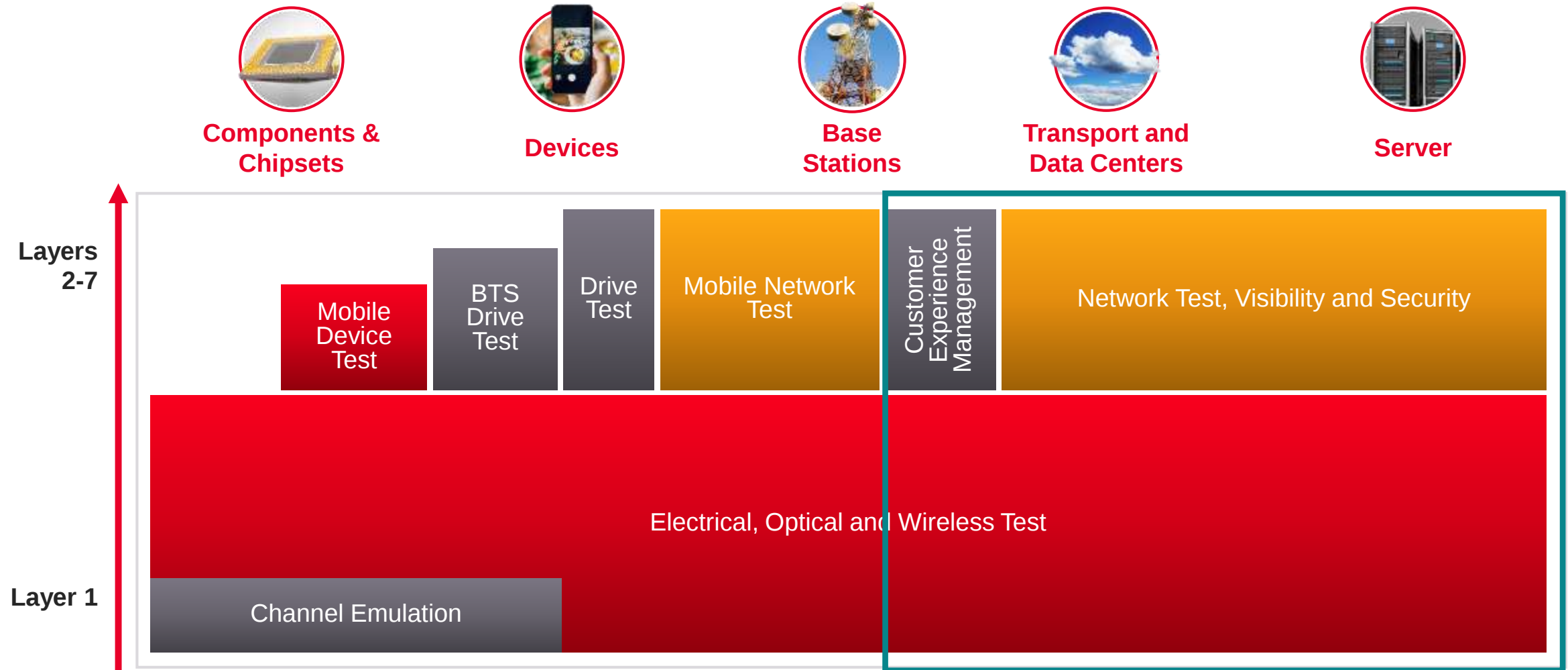
*Internet Infrastructure, Director of Sales & Business Development
Keysight Technologies*

Beate Hoehne

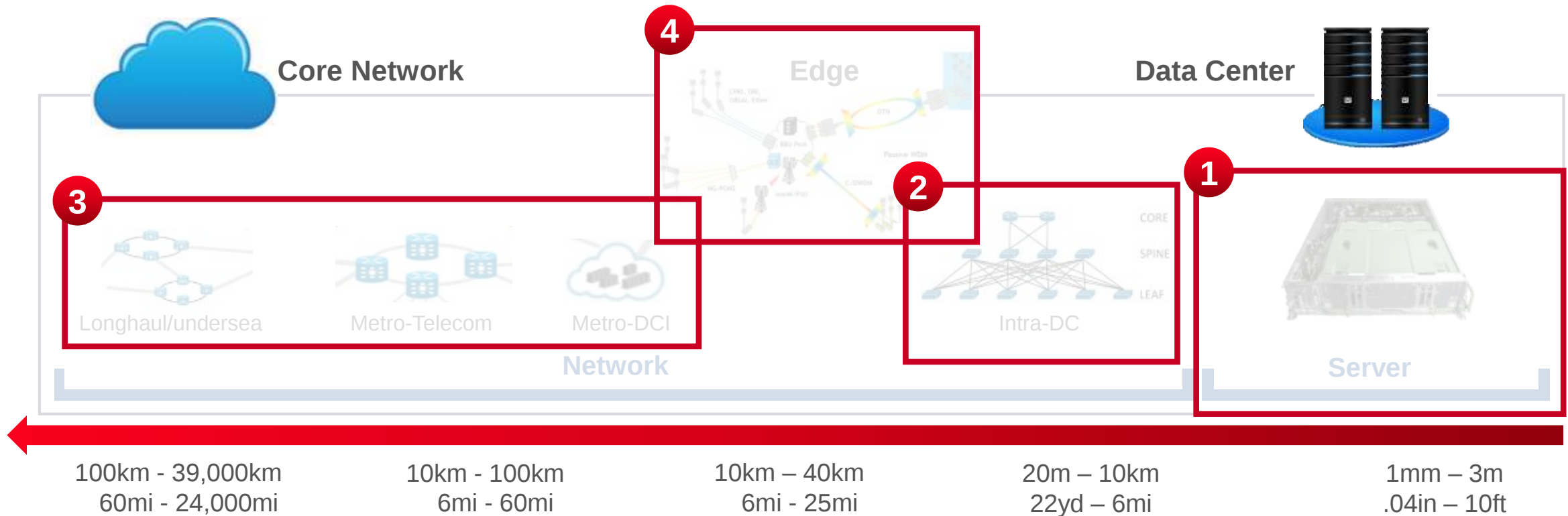




Enabling the 5G Communications Eco-System



Wireline Internet Infrastructure



Trends and Challenges – Bandwidth, Power, Cost, Size

1



Spectral efficiency of copper not exhausted: Move to more complex modulation schemes.
Challenges: Signal integrity and latency.
Leverage from data center networking.

2



Spectral efficiency can be improved.
Challenges: Forward Error Correction. Direct detection limited by signal integrity.
Leverage from telecom long haul transport.

3



Spectral efficiency out-optimized.
Challenges: Further bandwidth increase w/o fiber deployments.

4



Network slicing demands multiple network architectures.
Challenges: High bandwidth at tough environmental conditions. Latency requirements.
Leverage from data center, telecom and wireless.

Conclusions

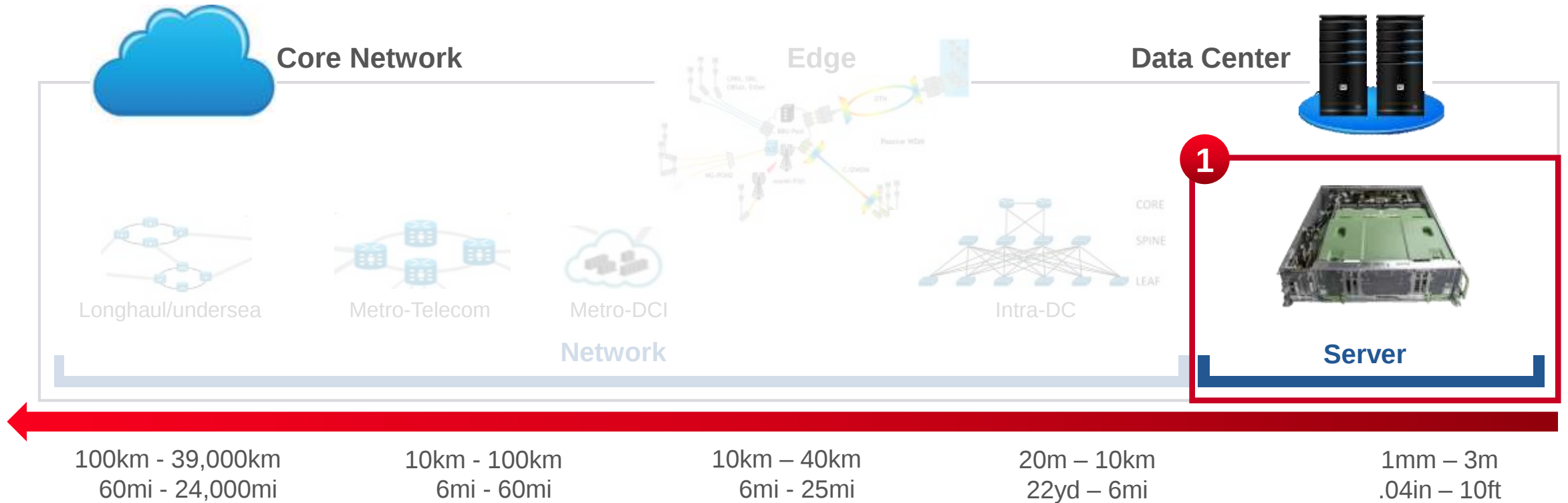
1

A pool of technology building blocks exist that can solve the challenges in all infrastructure segments.
Industry needs to leverage available technology. No fundamental roadblock exists.

2

Today's engineers need to be multi-discipline.
Need to understanding wireline & wireless, electrical & optical, Physical layer & protocol.

Wireline Internet Infrastructure



Requirements on Server Performance



Data Analytics



Artificial Intelligence



Video Transcoding



Cyber Security



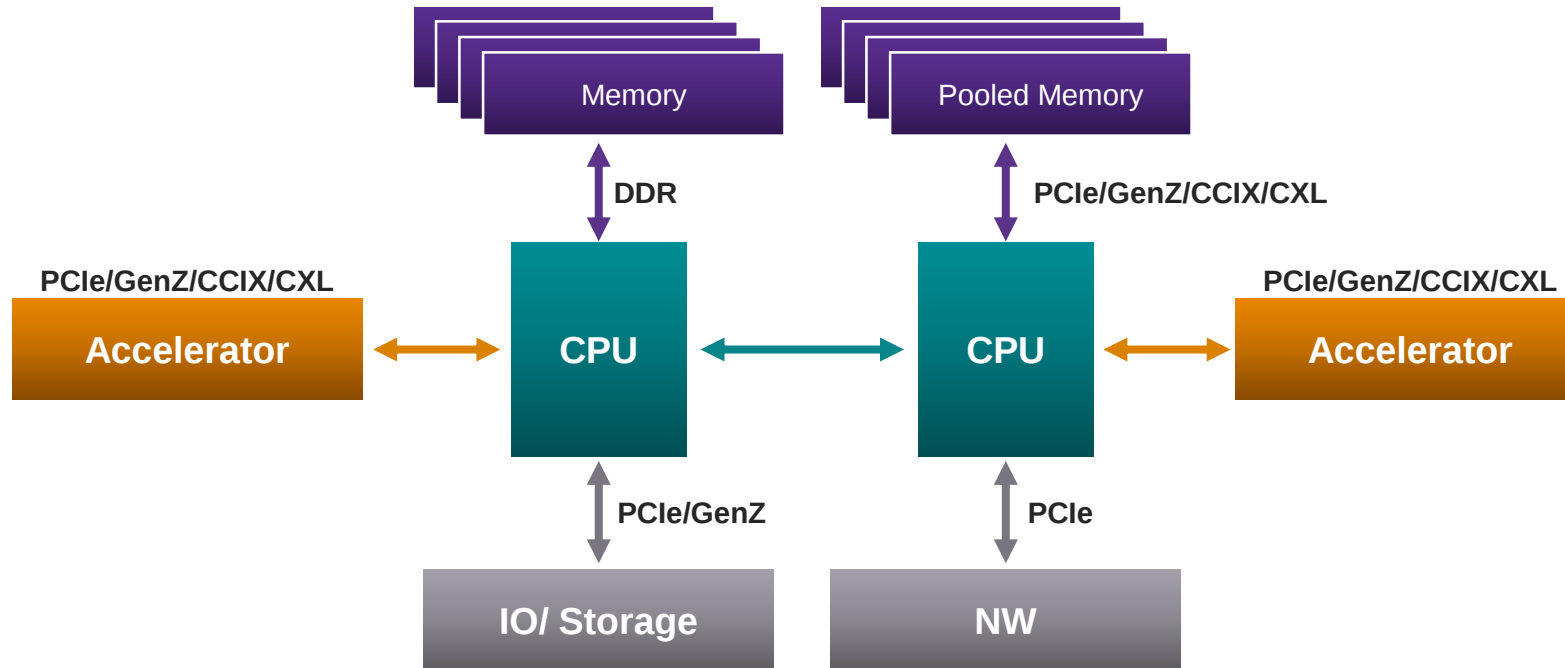
Financial Acceleration



Genomics

Server Architecture Evolution

DISAGGREGATION AND ACCELERATION



90%
of compute happens off CPU

Improve memory utilization by
30%

https://www.microsoft.com/en-us/research/uploads/prod/2018/04/oi2018_final.pdf

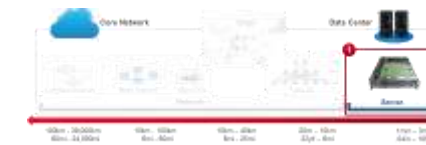
Dis-aggregation Drives BW



		Raw Baud Rate/Lane	Total x16 Bandwidth	Modulation
2003	PCIe 1.x	2.5GT/s	32Gb/s	NRZ
2006	PCIe 2.x	5.0GT/s	64Gb/s	NRZ
2010	PCIe 3.x	8.0GT/s	126Gb/s	NRZ
2017	PCIe 4.x	16.0GT/s	~252Gb/s	NRZ
2019	PCIe 5.x	32.0GT/s	~504Gb/s	NRZ
2022?	PCIe 6.x	64.0GT/s?	~1000Gb/s?	PAM4?



End-to-End Automated Test Solutions for High-Speed I/O



Physical Layer Interconnect Design



ADS Design Software



86100D DCA-X/TDR



N5227B PNA w/ PLTS

Verify PCIe 5.0 Compliant Channels; Verify Return Loss Compliance; Capture break-out channel S-Params

Physical Layer Transmitter Test



UXR-Series Time



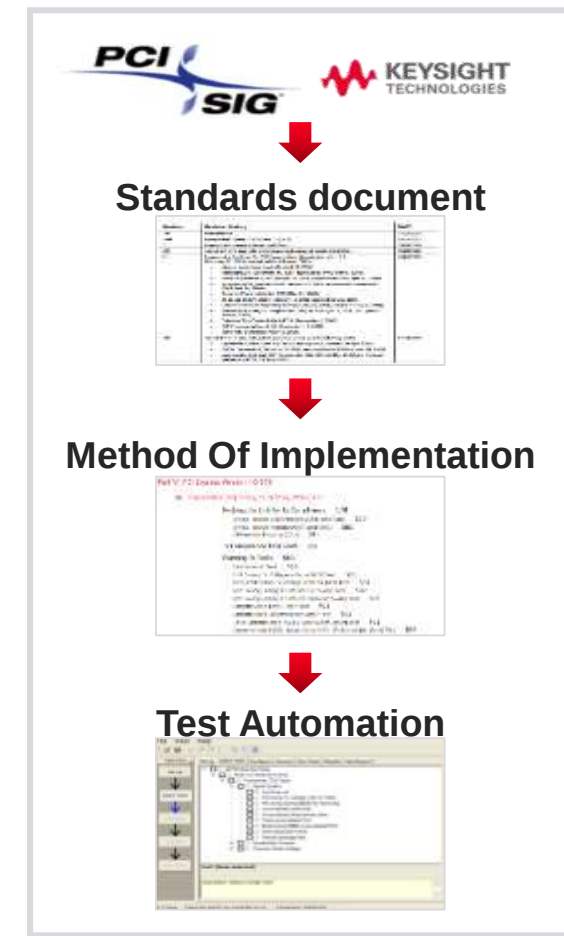
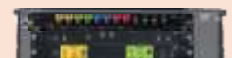
D9050P 5.0 Gbps compliant



86100C Jitter Measurement

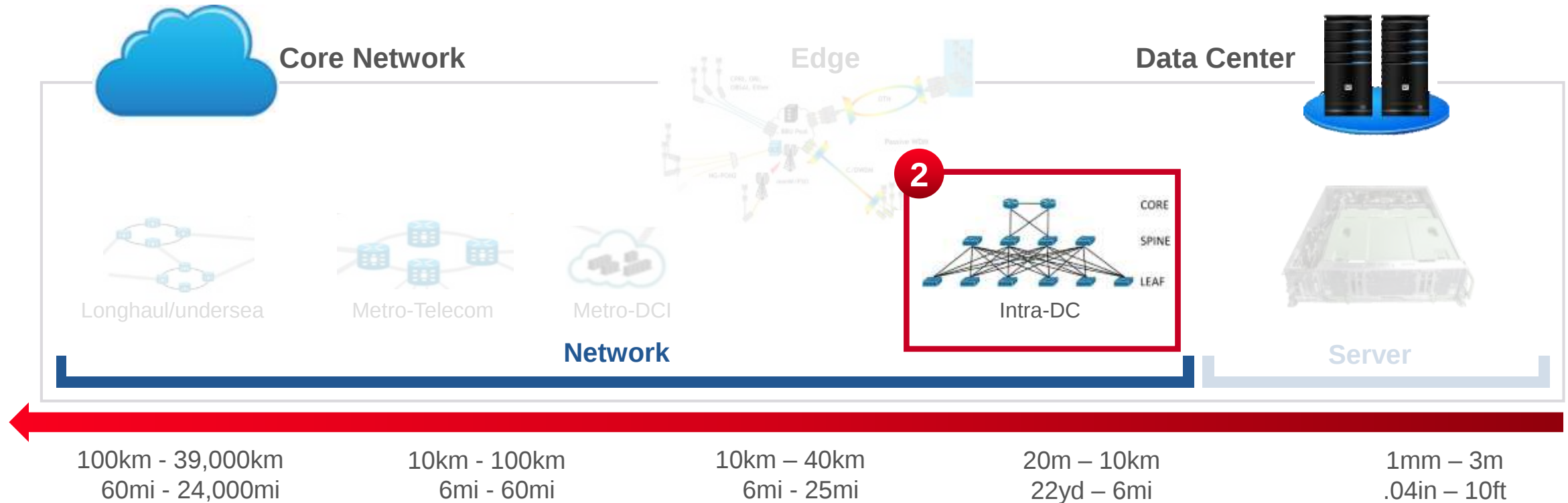
DSA UXR Real-Time

Physical Layer Receiver Test



We enable next generations high-speed I/O by working with market makers, standard bodies, open communities

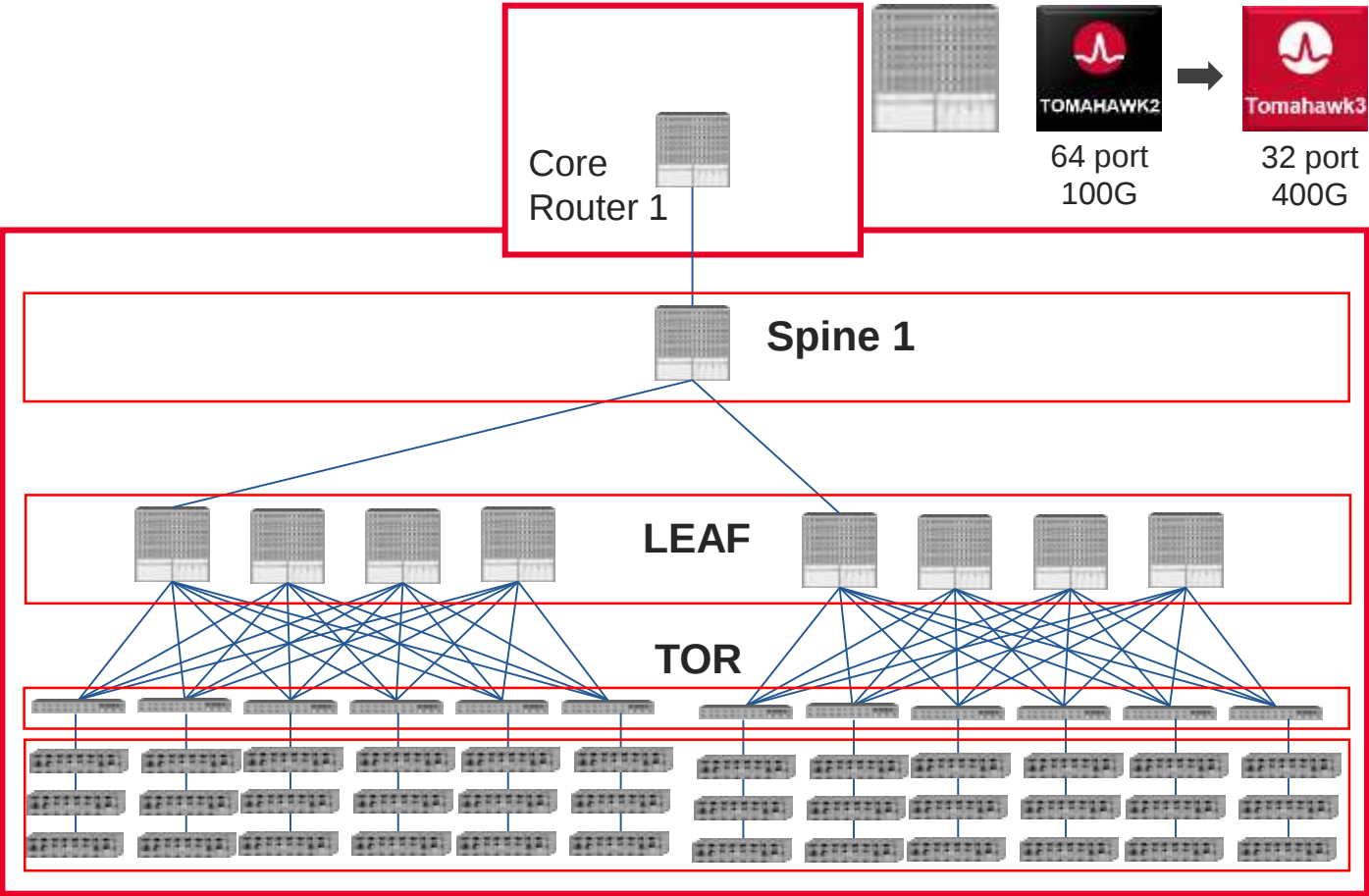
Wireline Internet Infrastructure



100G in the Cloud Network



- < 10-120km
 - 100G-DCO
 - ColorZ
- < 1000m (10km)
 - 100G-LR4
- < 500m (2km)
 - 100G-CWDM4
 - 100G-PSM4
- < 20m
 - 100G-AOC
- < 3m
 - 100G-CR4
 - 25G-CR1



PCIe4/DDR4

400G in the Cloud Network



< 10-120km

400G-DCO

< 1000m (10km)

400G-LR4

< 500m (2km)

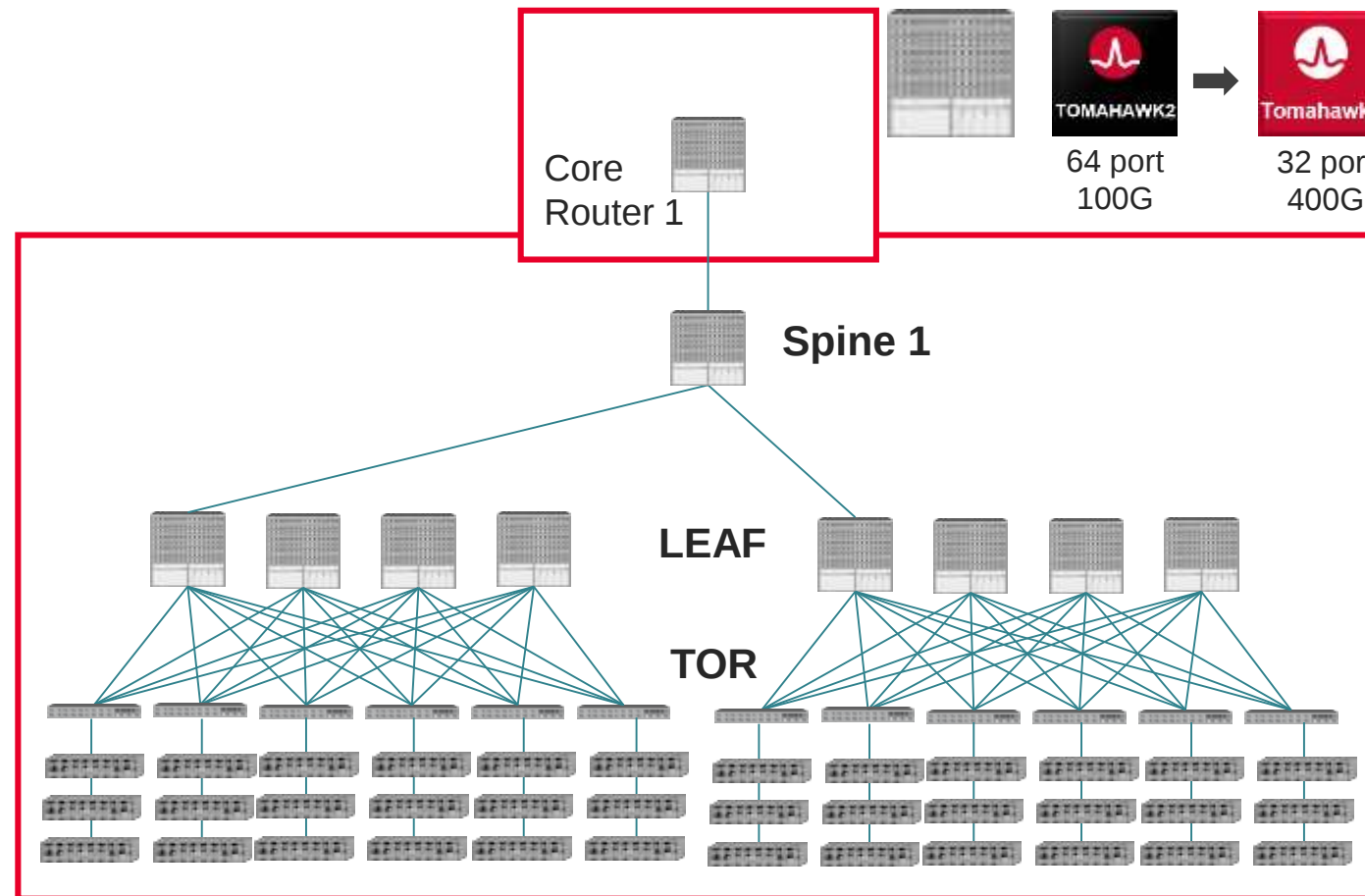
400G-FR4
400G-DR4

< 20m

400G-AOC
400G-SR8

< 3m

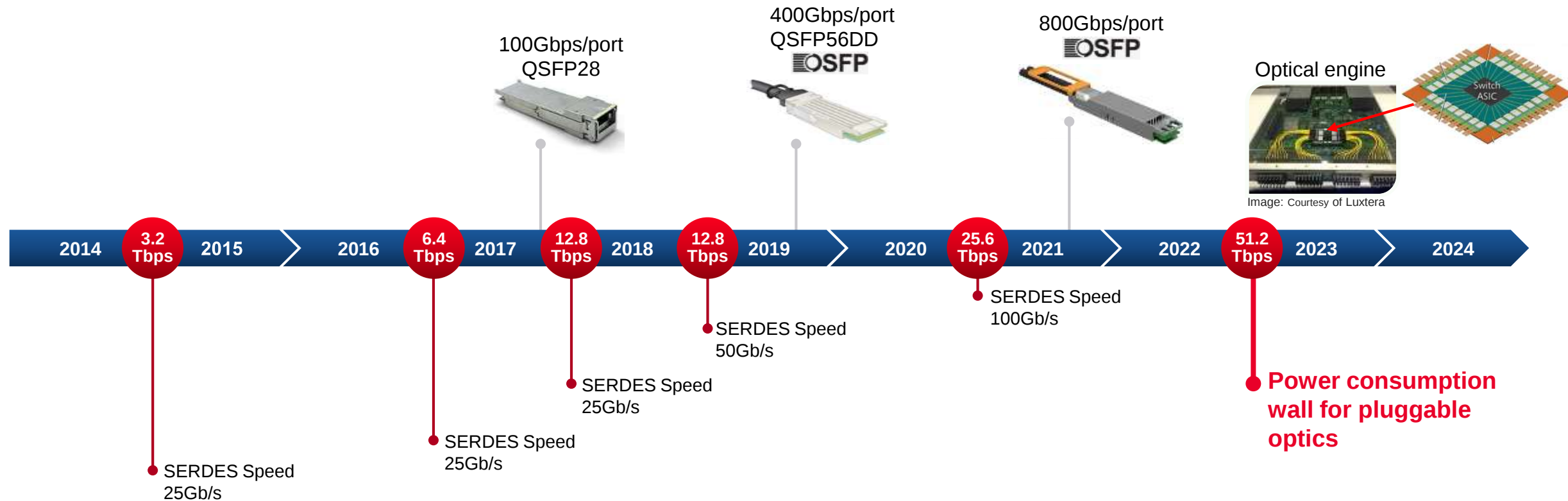
400G-CR8
50G-CR



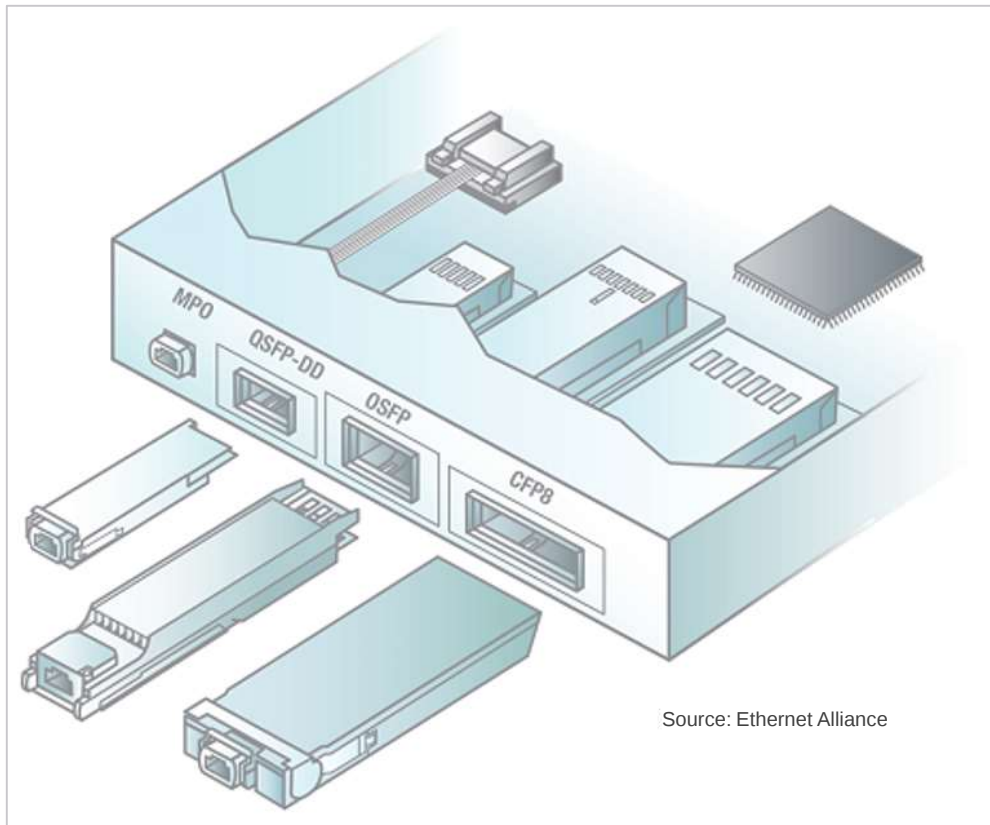
PCIe5/DDR5

Silicon Switch Evolution

THE POWER BRICK-WALL FOR PLUGGABLES

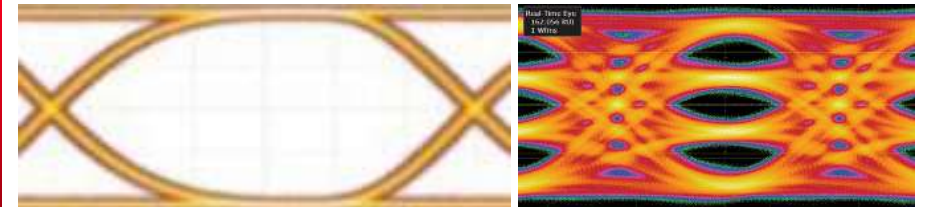


Data Center Networking Choices

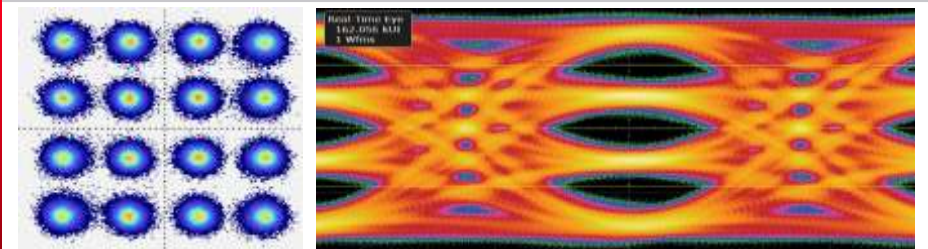


Source: Ethernet Alliance

100G or 400G



Coherent or
Direct Detection



Pluggable or
Co-package



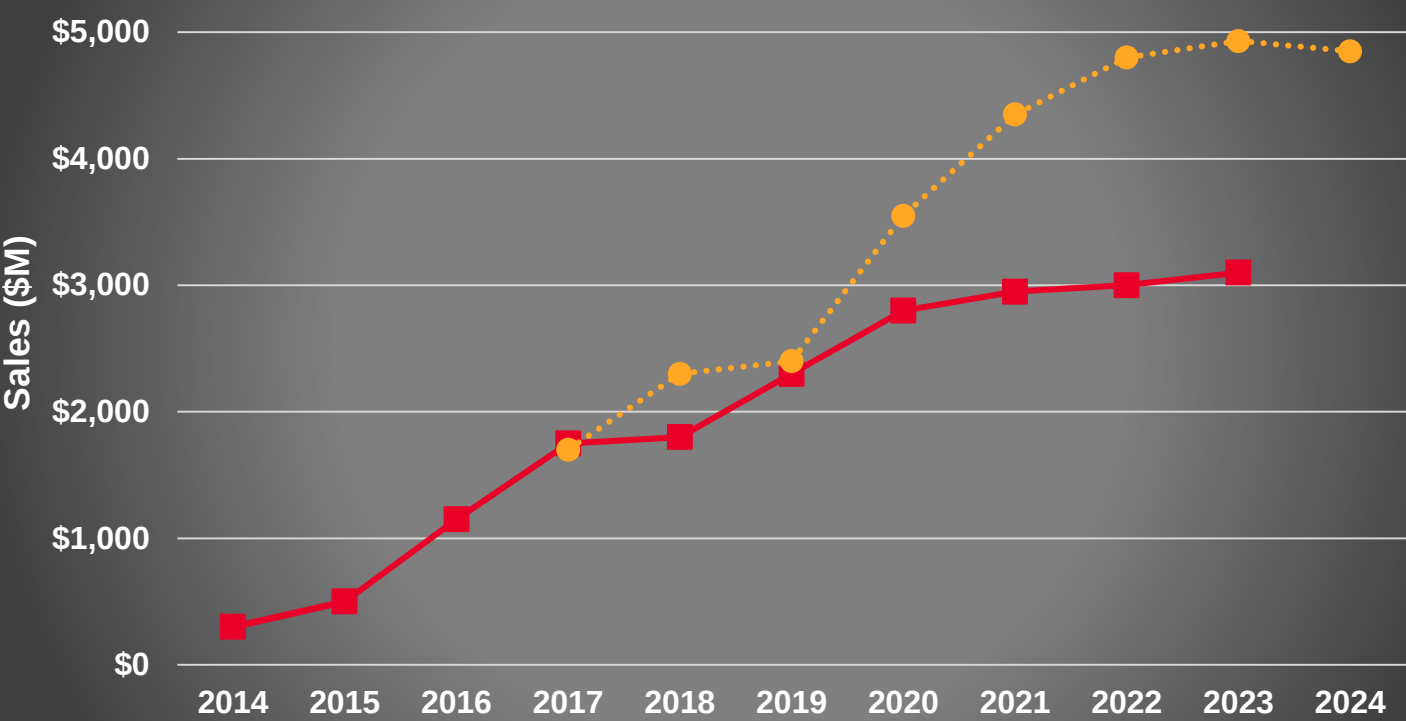
<https://www.laserfocusworld.com/articles/print/volume-54/issue-10/features/photronics-for-datacenters-integrated-optics-permeate-datacenter-networks.html>

100G vs. 200G/400G



VOLUME AND TIMING

100GbE Forecast



Source: LightCounting

facebook

100G CWDM-4 demand increase in H2 2019

Google

2x200GbE deployments have started demand will peak in 2022 transition to 2x400GbE in 2022

amazon

4x100GbE DR4 (400G-DR4)

阿里巴巴 Alibaba.com

Deployment 100G in 2017; 400G planned for 2019

Tencent 腾讯

Deployment 100G started (2017-2021) 400G planned for end 2019

Baidu 百度

Deployment 100G in 2017 400G planned for 2021

> 13 companies showed 400G readiness at OFC 2019

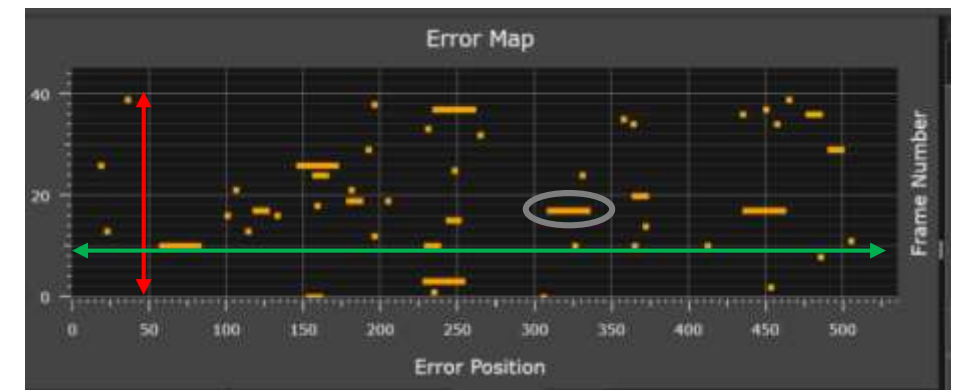
Characterizing Error Mechanisms



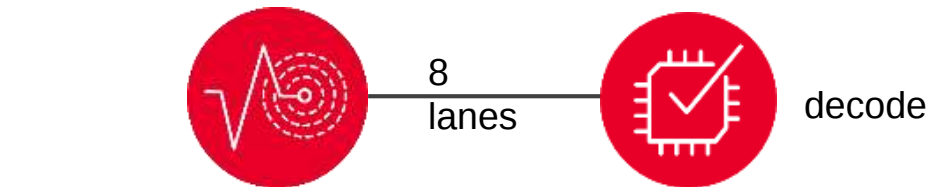
Layer 2, 64B – 14,000B frames

(FEC) Interoperability

FEC symbol errors

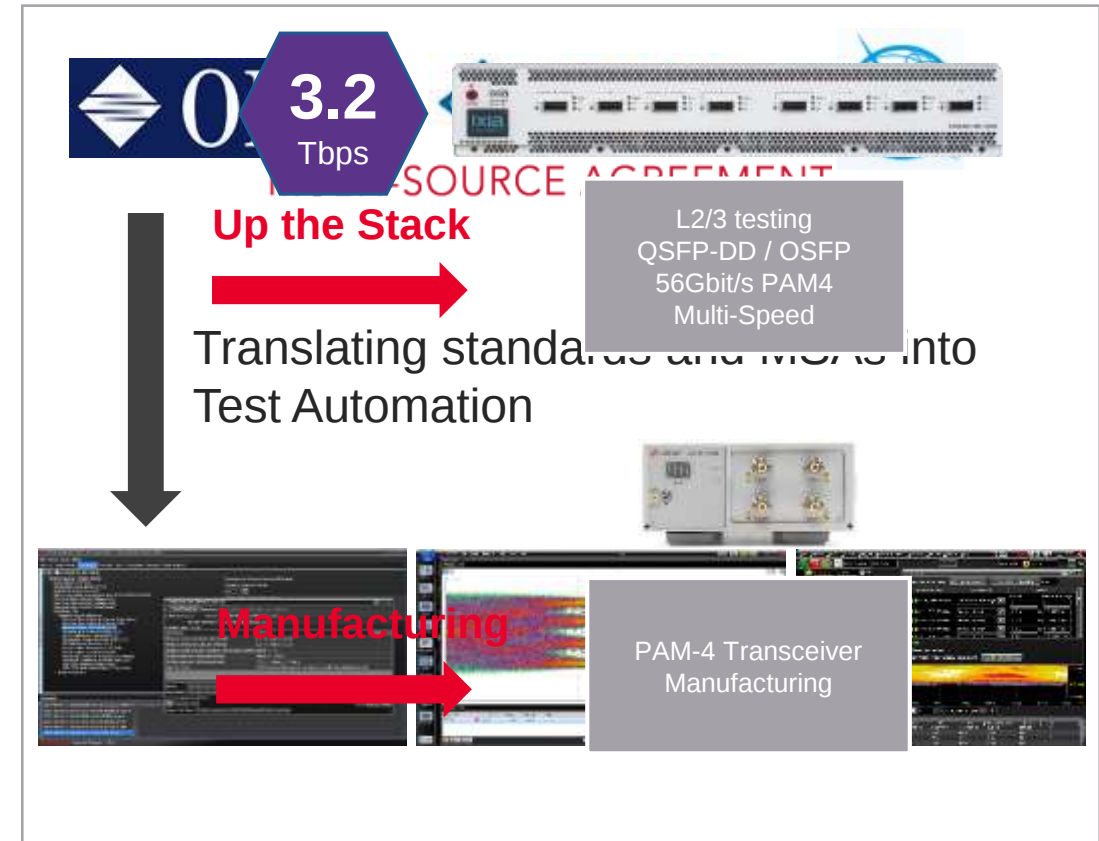
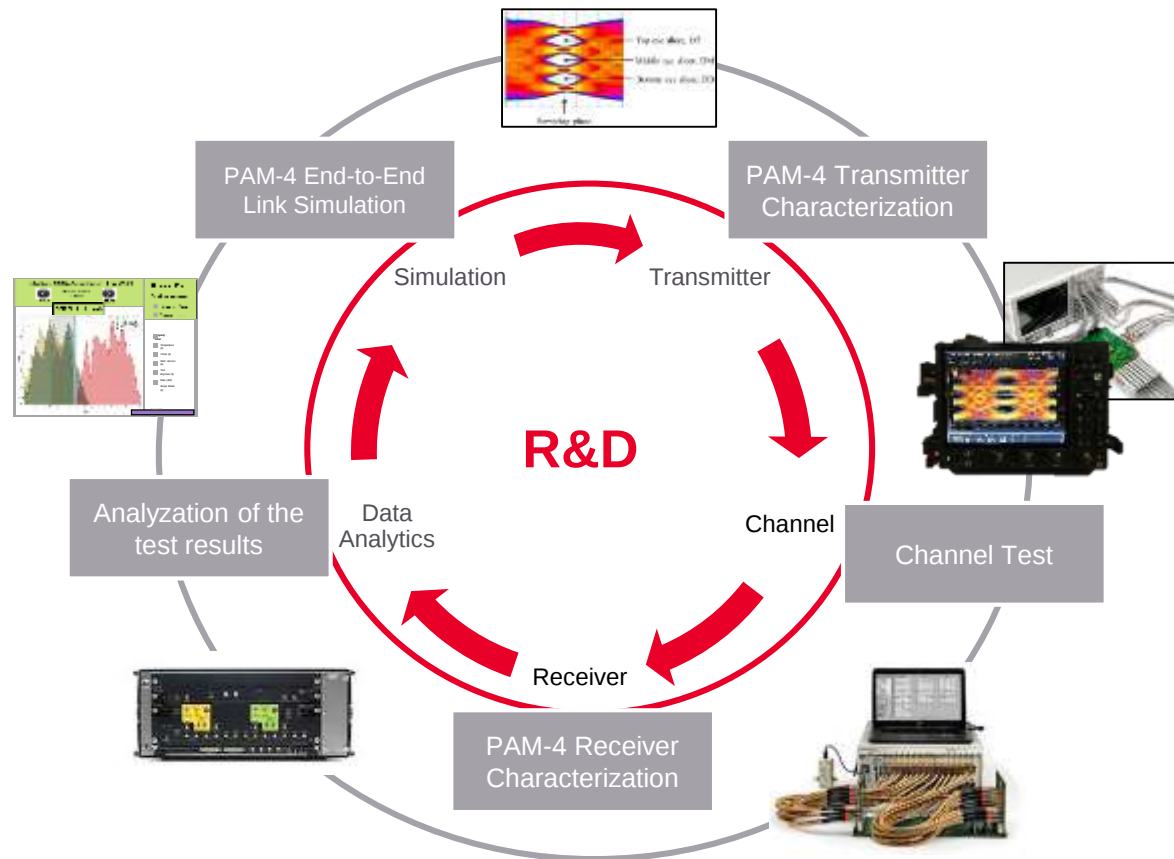


Protocol



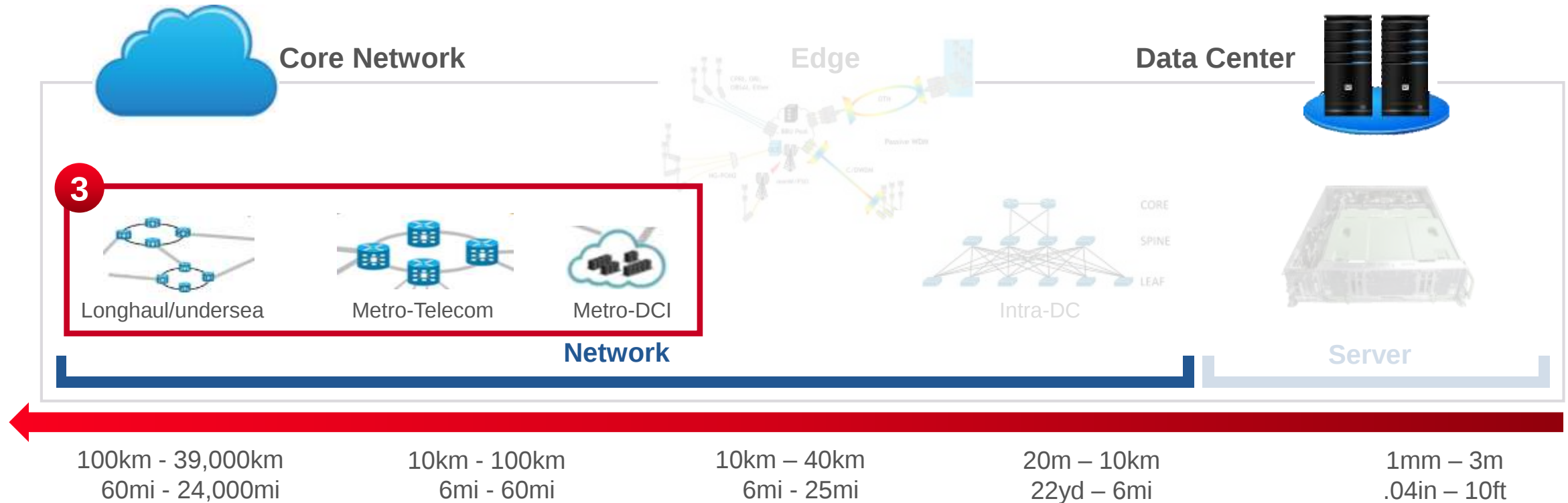
Physical stress

End-to-End Automated Test Solutions for Direct Detection



Keysight partners with key players in the optical component and transceiver industry and OIF, IEEE, OCP, ODCC

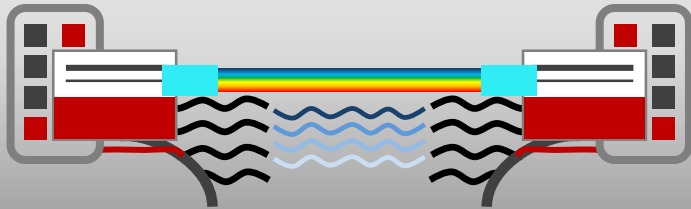
Wireline Internet Infrastructure



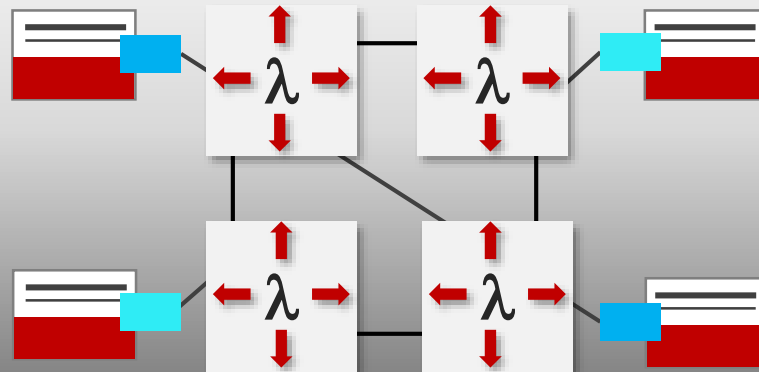
Different Challenges for Long-Haul and Metro/DCI



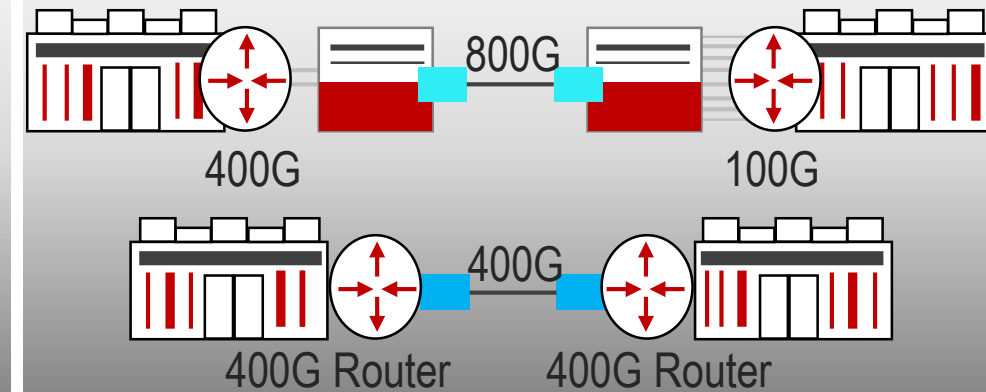
Sub-Sea



Terrestrial Long Distance



DCI



Coherent DSP Silicon for 400G, 600G and 800G



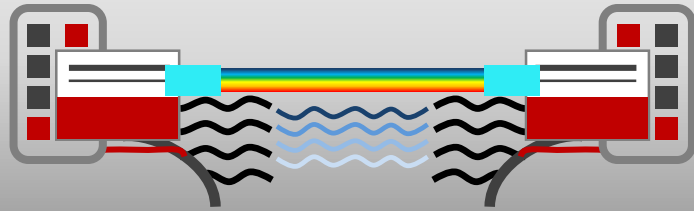
2018/2019 DSP INTRODUCTIONS

	Acacia Pico	NEL	Nokia PSE-3	Infinera ICE5 Stopped Coriant 600G offering	Infinera ICE6	Ciena Wavelogic Ai	Ciena Wavelogic 5	Inphi M200 LightSpeed-III
Speed-classes	100G-600G	100G-600G	100G-600G	100G-600G	800G	100G-400G	800G	100/200G
Availability	Second half 2018, commercial	Second half 2018, commercial	Second half 2018, internal	Second half 2018, internal	OFC announcement	2017, licensed to Lumentum, Oclaro, NeoPhotonics	OFC announcement	2018, commercial

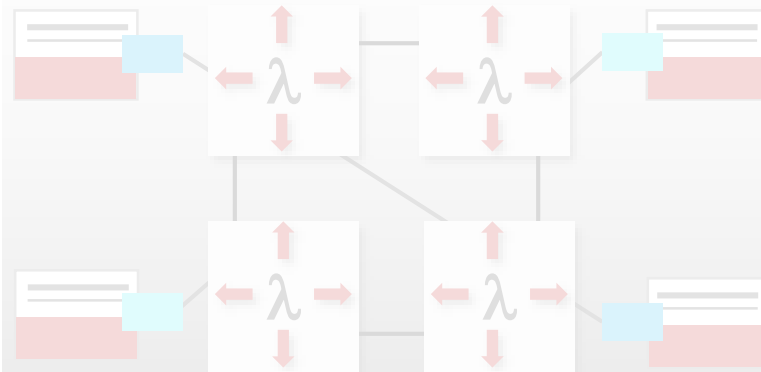
Different Challenges for Long-Haul and Metro/DCI



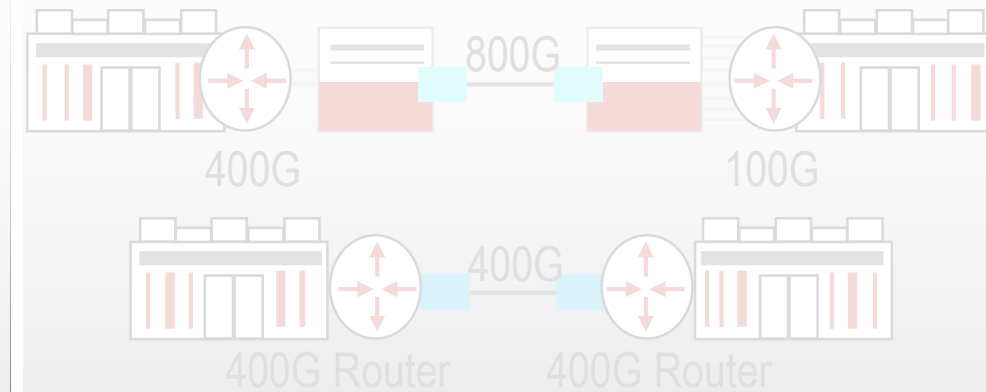
Sub-Sea



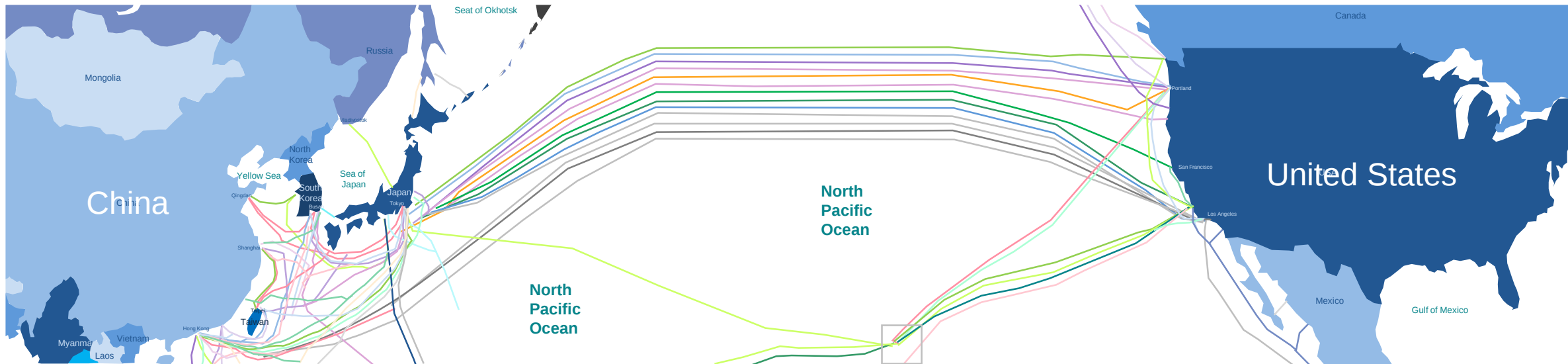
Terrestrial Long Distance



DCI



Subsea Cable Deployment



100

new cables

between 2016

and 2020

Content providers

used

54%

of subsea

bandwidth in

2018

Content providers

will used

80%

of subsea

bandwidth by

2027

Content Provider Investments

Consortium Member

Major Capacity Customer

Sole Owner

Unity Google	SJC Google	GTT Express Microsoft	FASTER Google	Monet Google	Tannat Google	PLCN Facebook Google	SJC2 Facebook
RFS 2010	2013	2015	2016	2017	2018	2019	2020

Curle
Google

Havfrue
Facebook
Google

Junior
Google

Hawaiki
Amazon

AEC-1
Facebook
Microsoft

APG
Facebook

INDIGO-Central
Google

INDIGO-West
Google

JGA-S
Google

Dunant
Google

HKA
Facebook

JUPITER
Amazon
Facebook

Malbec
Facebook

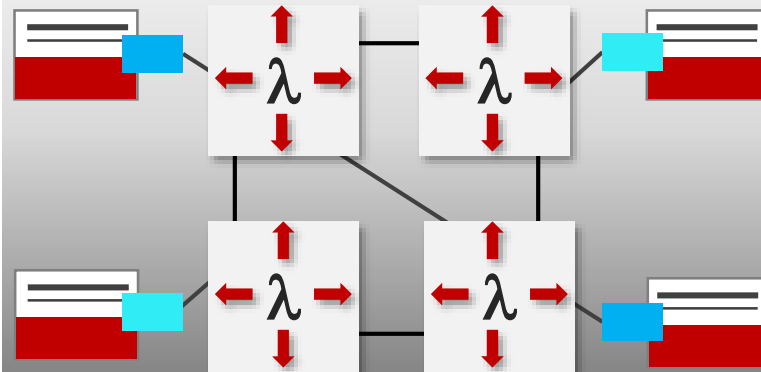
Different Challenges for Long-Haul and Metro/DCI



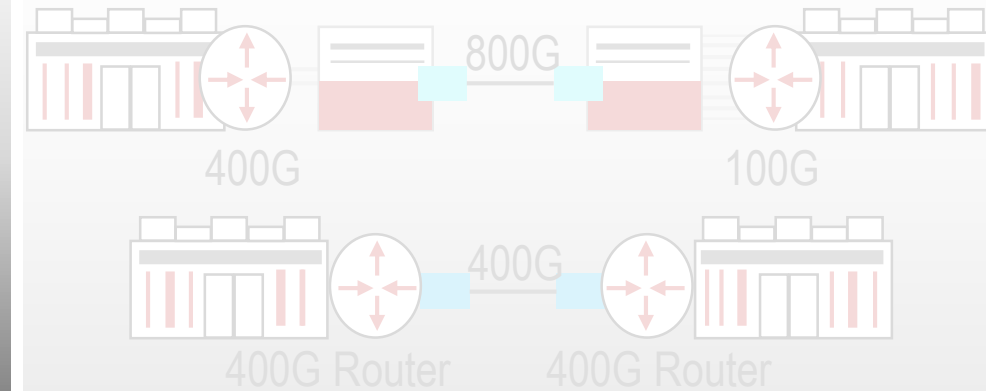
Sub-Sea



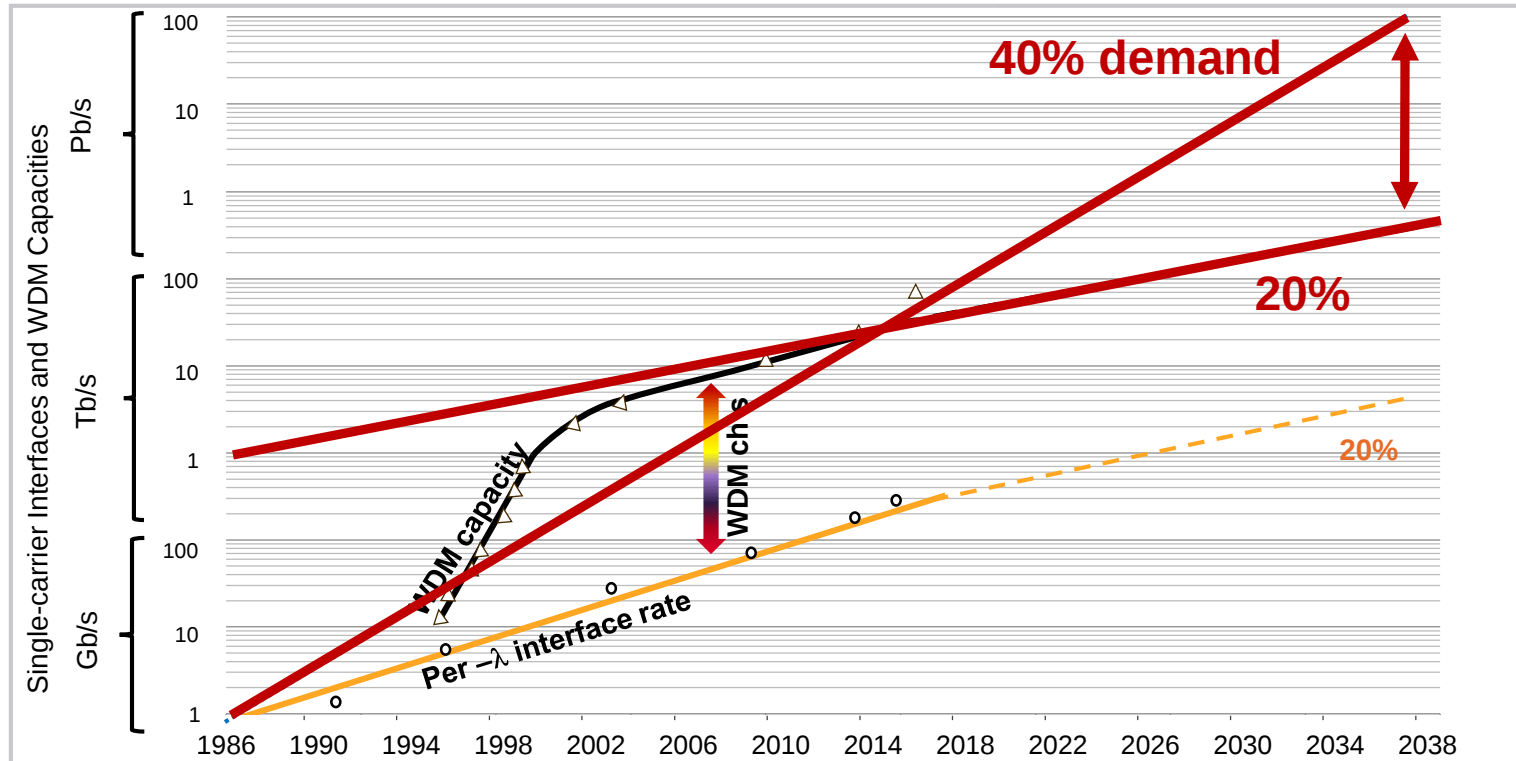
Terrestrial Long Distance



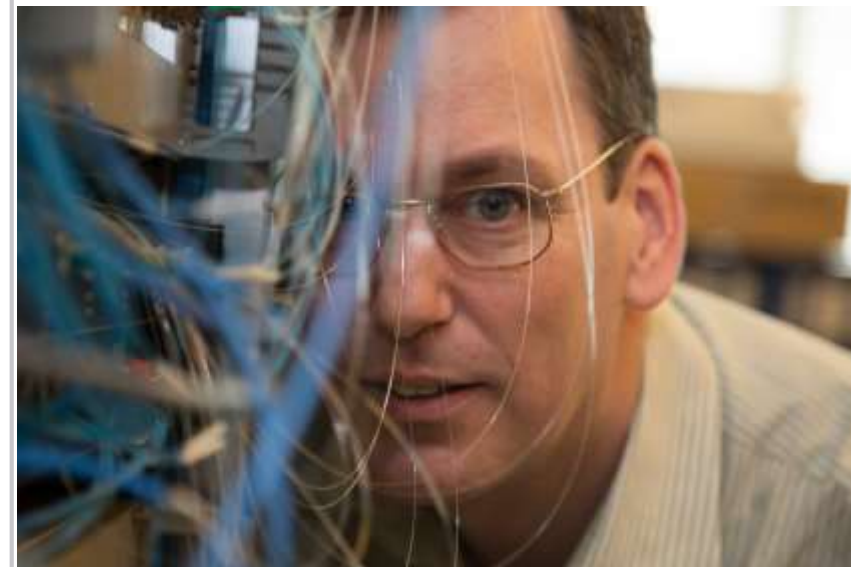
DCI



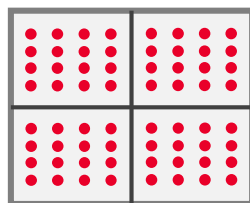
Capacity Crunch in Long-Distance/Metro



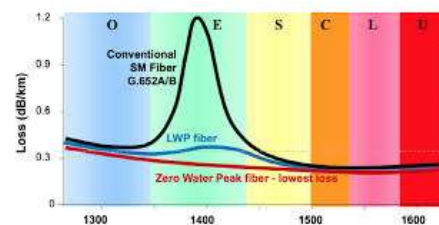
Source: Nokia



Improvement potential



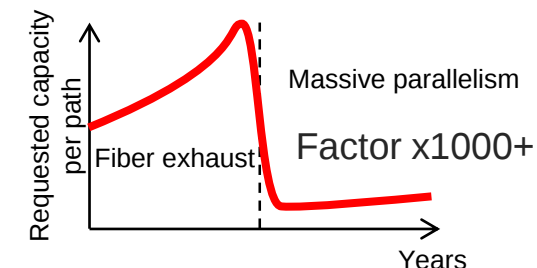
Factor x2



Factor x2 –x5



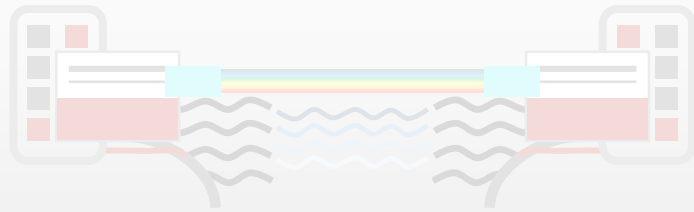
Factor x2



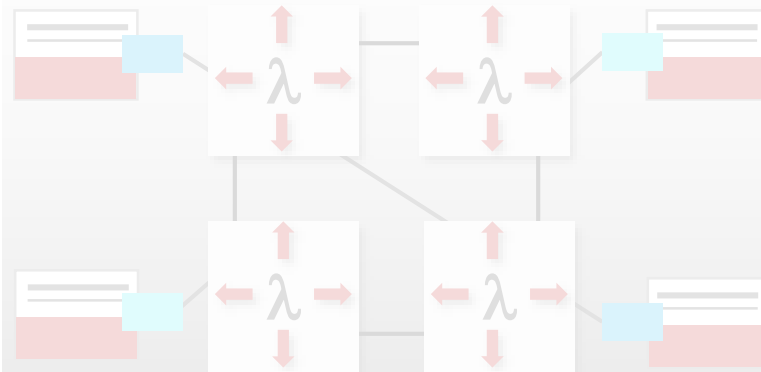
Different Challenges for Long-Haul and Metro/DCI



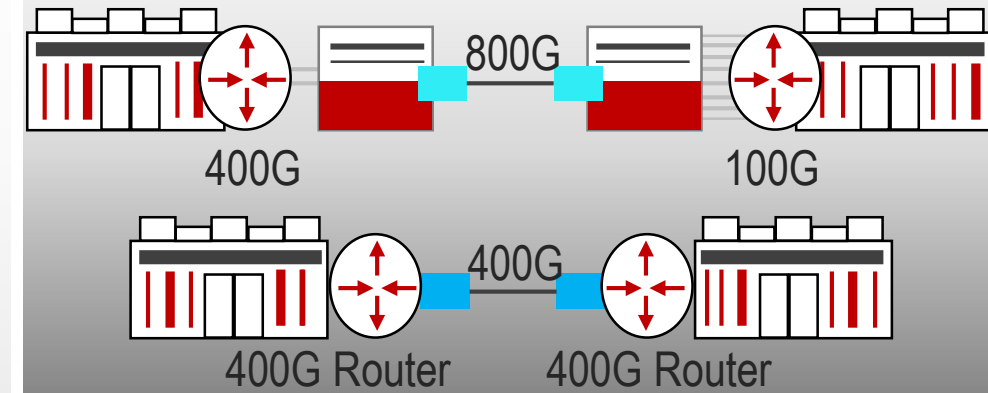
Sub-Sea



Terrestrial Long Distance



DCI



Coherent Optical Standards Activities

ITU

- 100G OTN over up to 450 km using DP-DQPSK

OIF

- Project **400ZR**
- 400G Ethernet over up to 80 km using DP-16QAM

IEEE

- Project 802.3ct
- 100G & 400G Ethernet over up to 80 km

CableLabs

- 100G full duplex coherent for cable access networks

OpenROADM

- 100G, 200G, 300G, 400G for metro applications

Speed-class

Coherent

Direct-detection

400G (2019+)

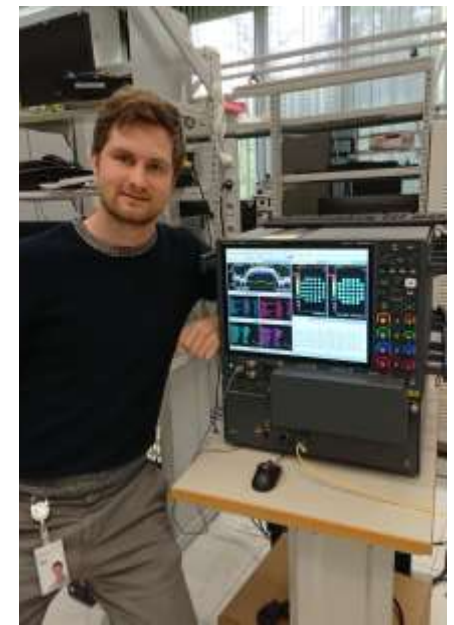
> 10 km

< 10 km

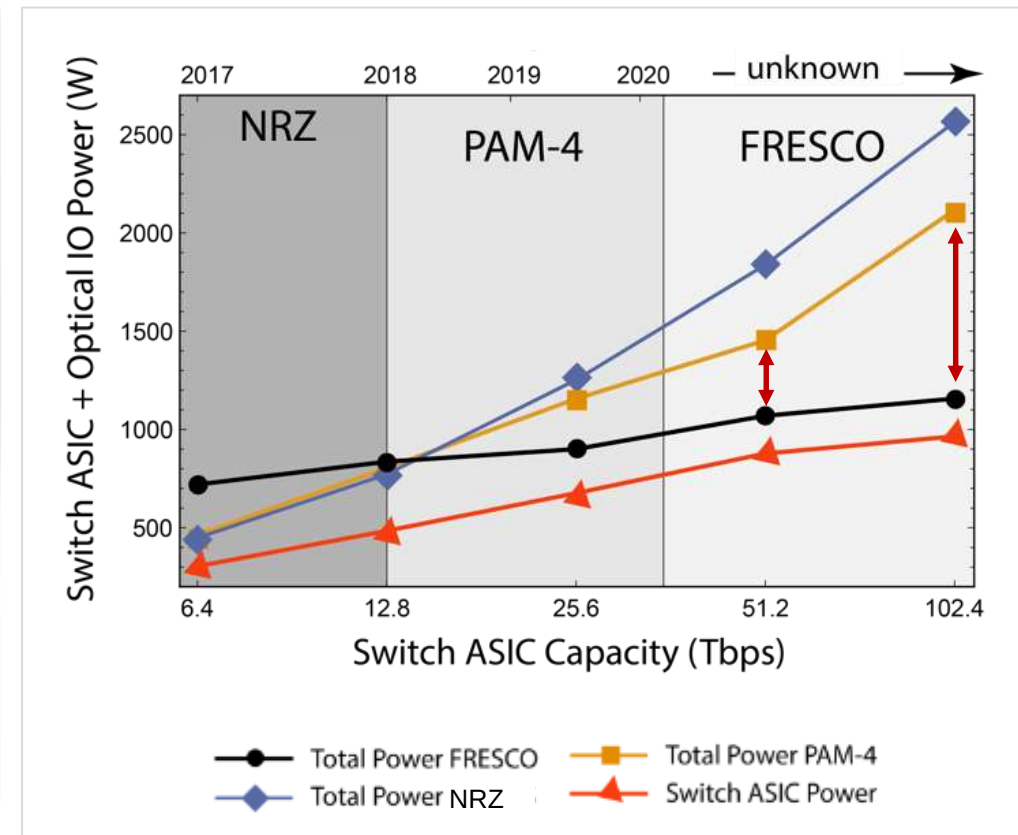
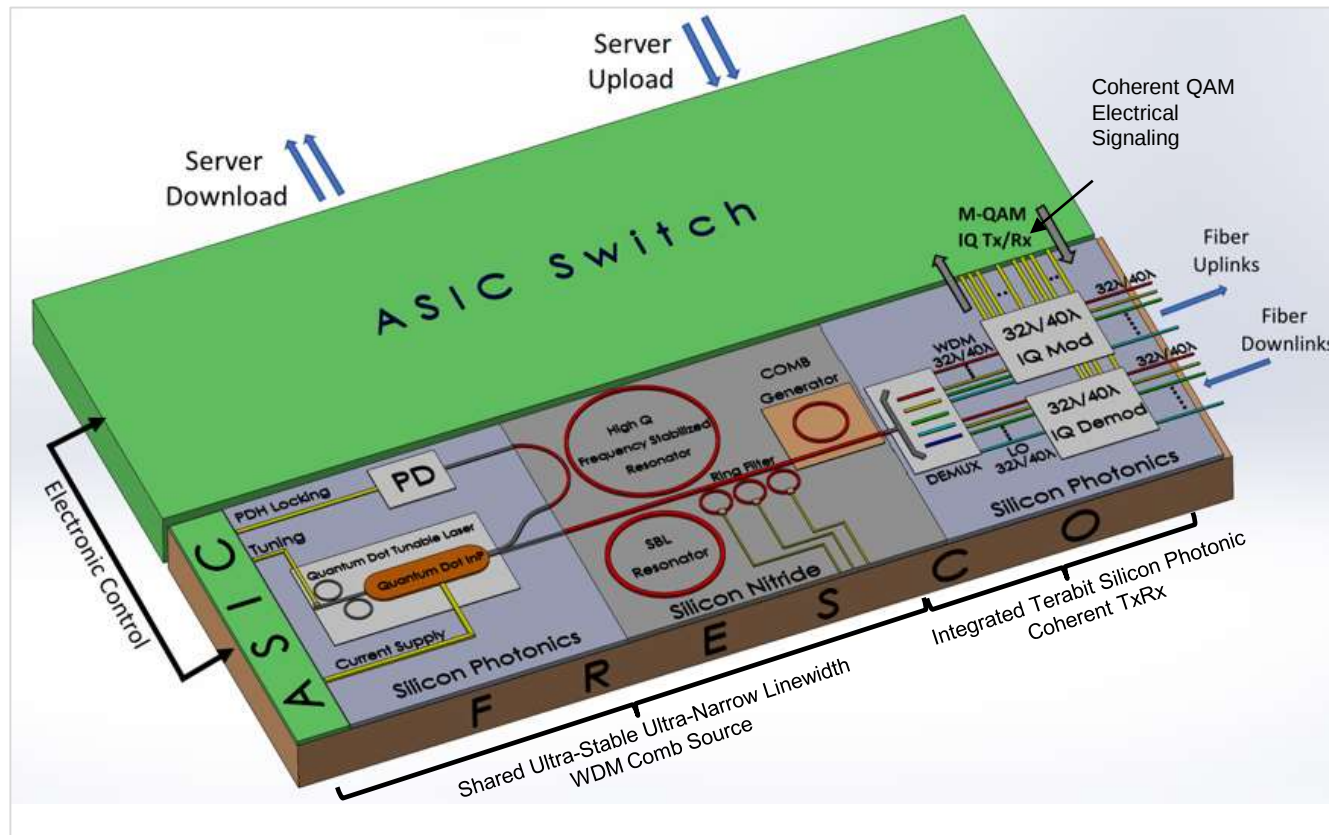
600G/800G (2023+)

> 2 km

< 2 km



Advance in Integrated Photonics - FRESCO



Integrated Photonics Requires On-Wafer Test



Electrical and Optical
RF Measurement



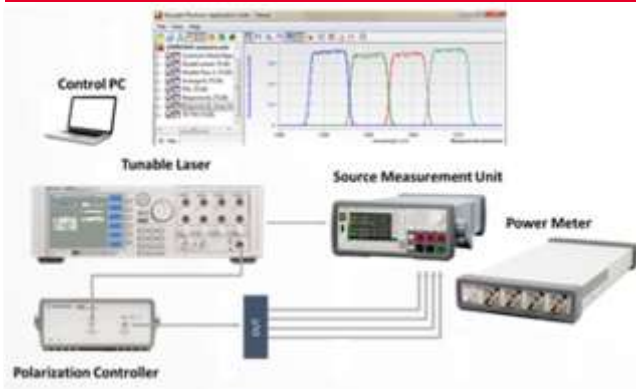
Time-Domain
Measurement



Wafer Probing and Alignment



Optical and DC Electro-Optical
Measurement

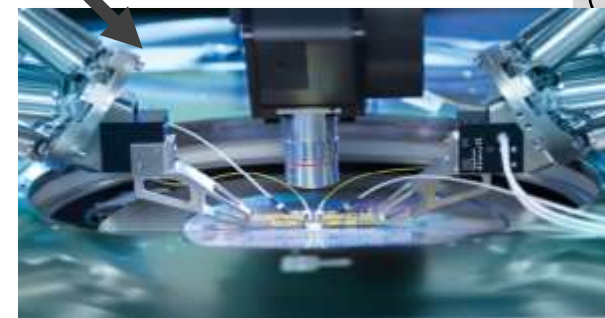


Keysight partnering
with FormFactor /
Cascade Micro

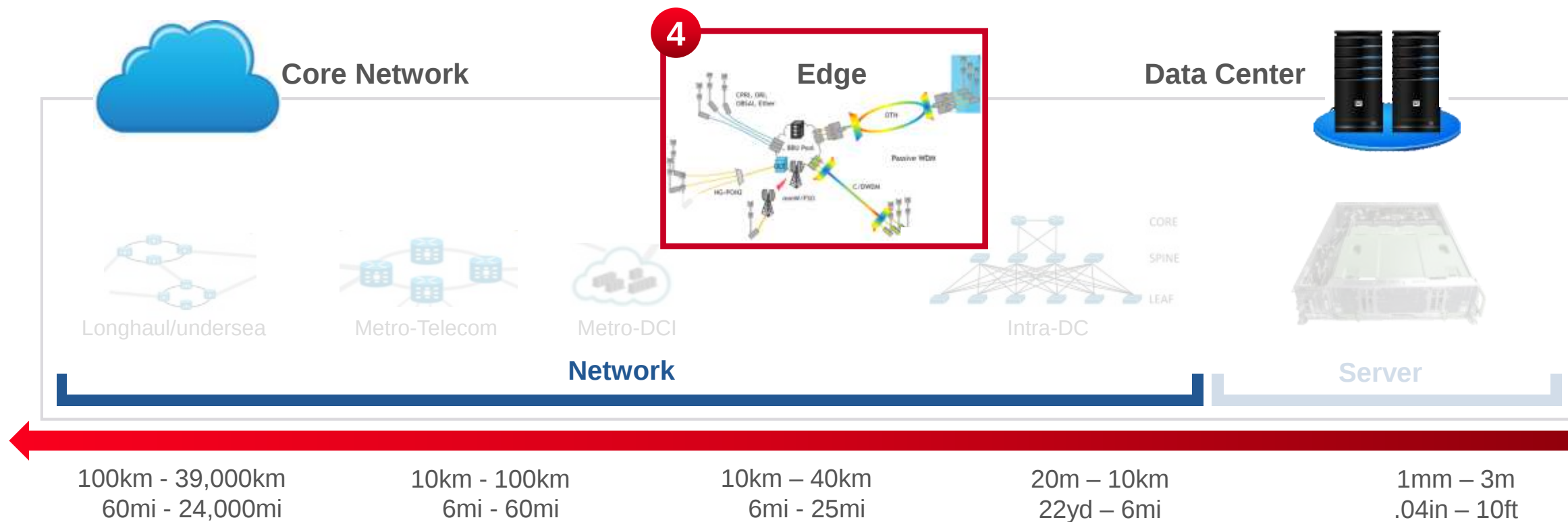
Fiber Probing



Optical
RF
DC Probing



Wireline Internet Infrastructure



Fiberization of Planet Earth



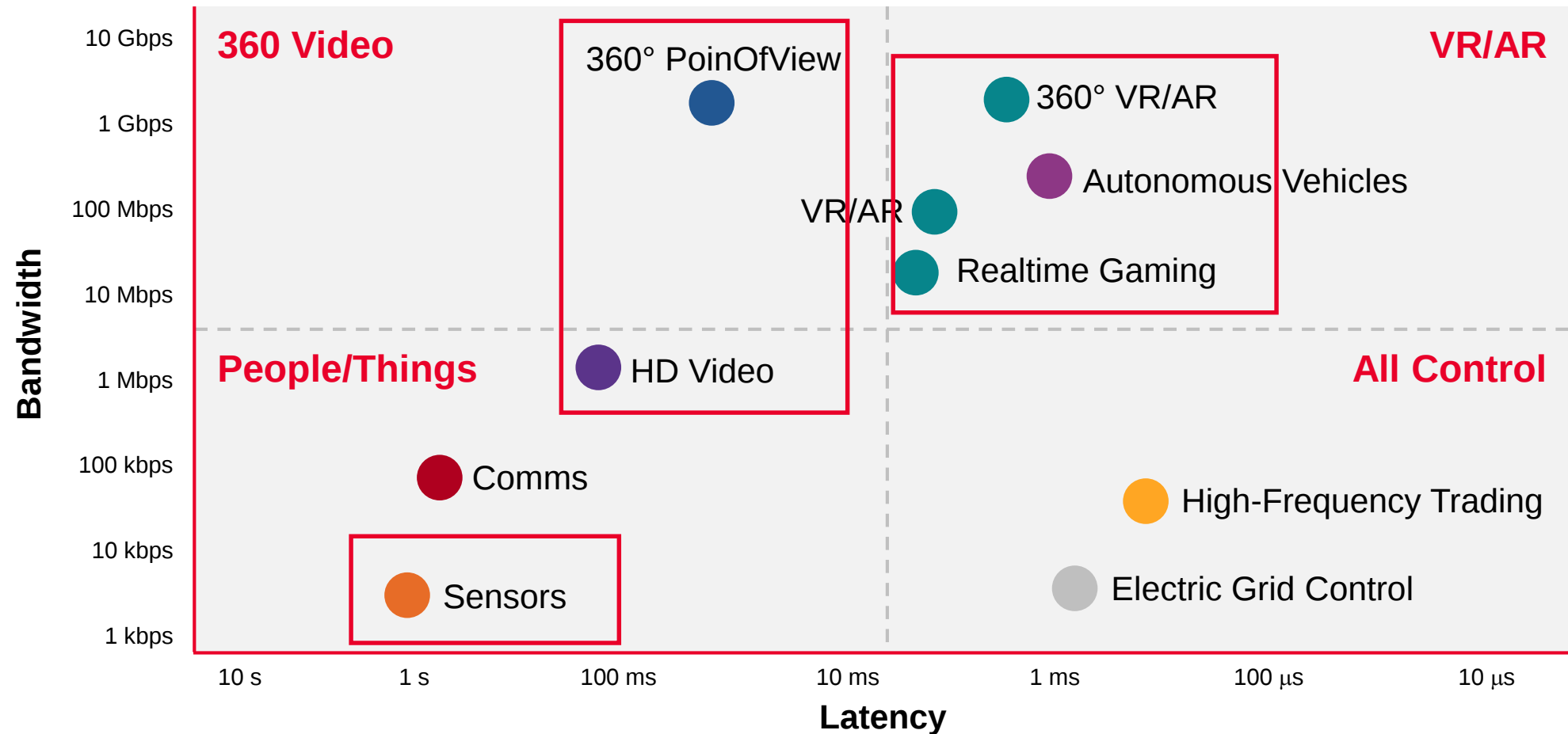
564 million Fiber-km in 2018

760 round trips

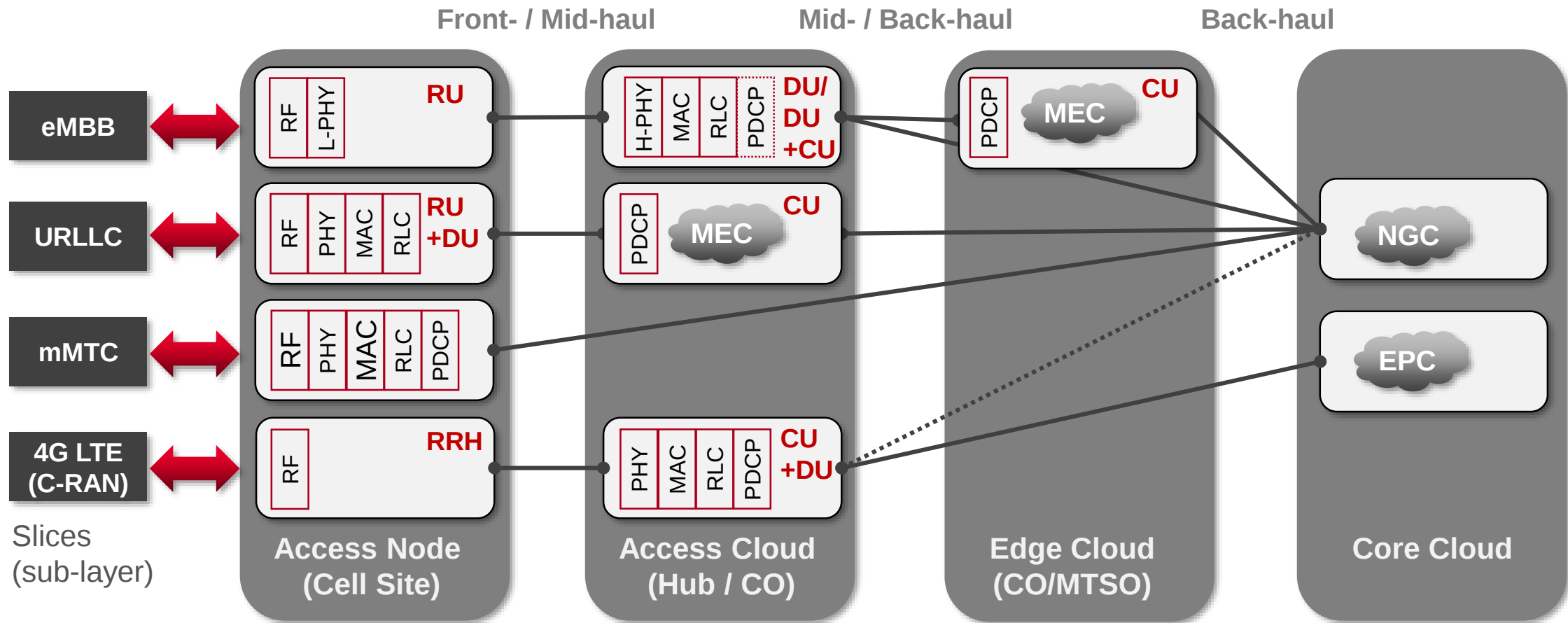
Applications and Latency Requirements



HIGH-BANDWIDTH AND LOW LATENCY



NW Slicing, RAN Functional Split and Interfaces



Data Center and Optical Network Innovation

ENABLING THE 5G ECOSYSTEM

1

Test can be seen as a cost.

2

Test can be seen as competitive advantage.

3

Keysight can accelerate your innovation throughout the whole communication infrastructure.

Test enables and accelerates innovation. Keysight is here to make test your competitive advantage.





KEYSIGHT
WORLD 2019

