

400G and 800G Ethernet and Optics

Andreas Bechtolsheim
Arista Networks, Inc
Founder, Chief Development Officer and Chairman

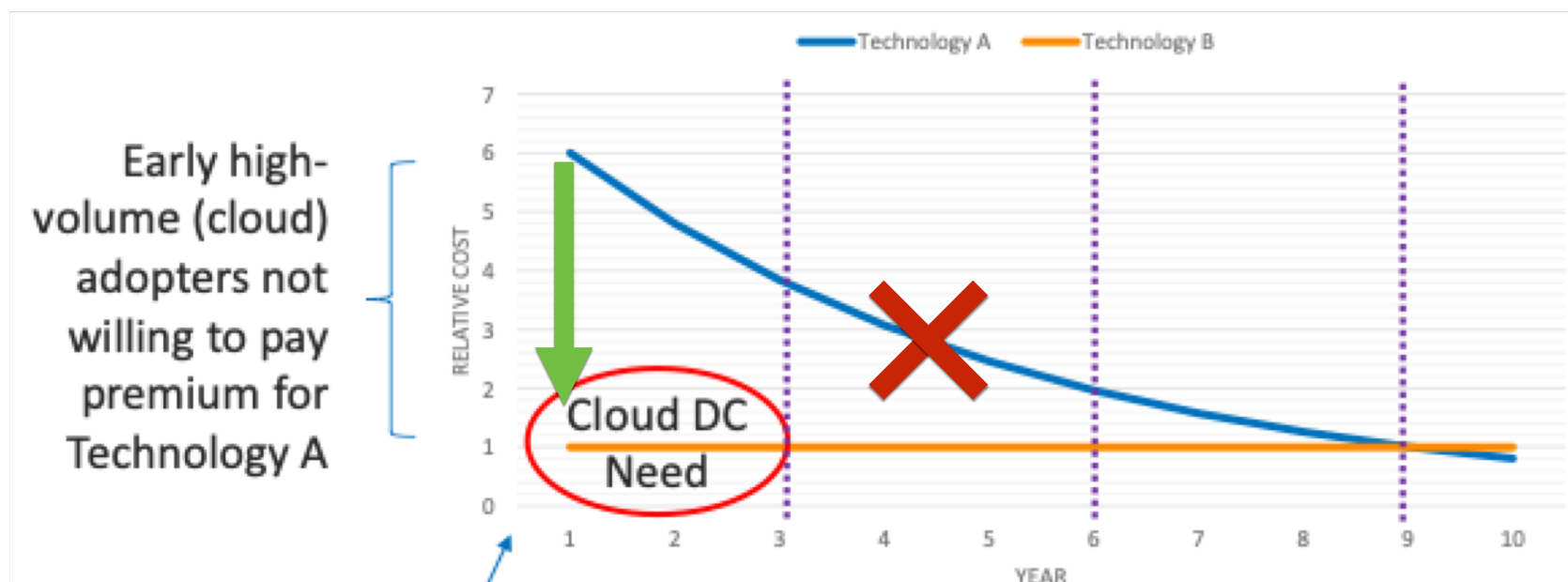
The upcoming 100G-400G Transition



The Easiest Way to go Faster is to go Faster

Ethernet Speed Transitions have been the primary driving force to improve the throughput and the price-performance of data center networks

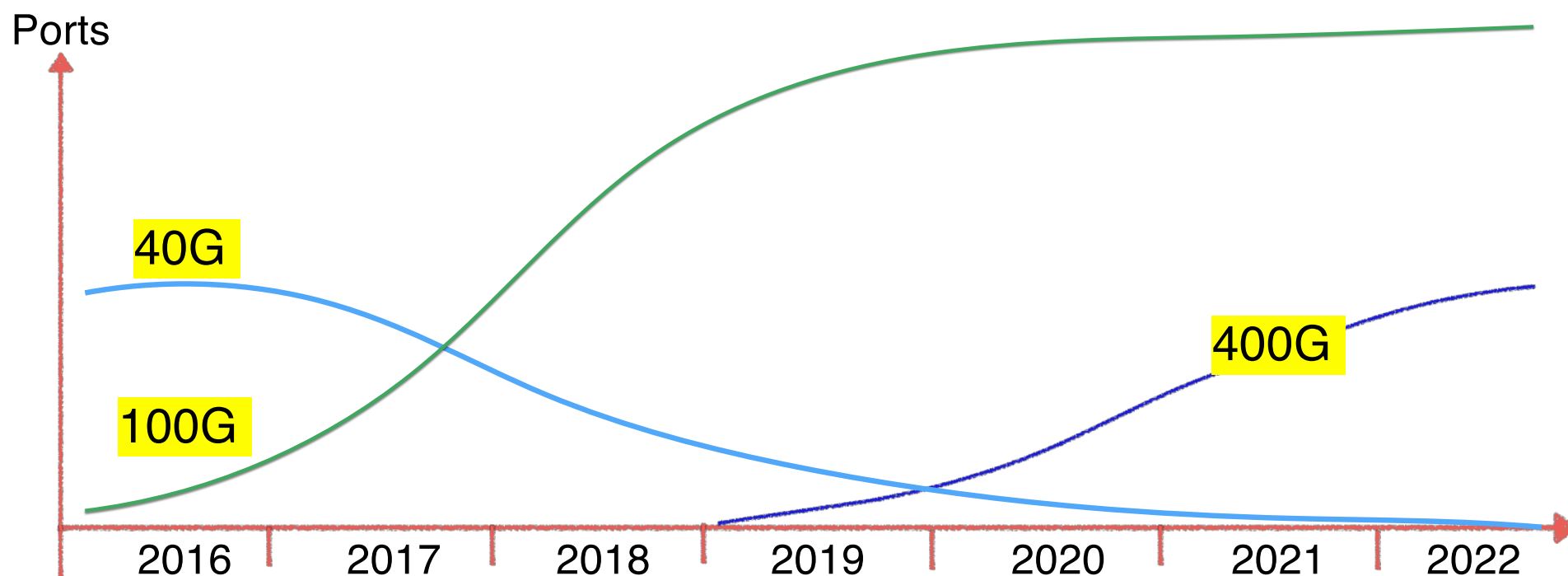
The NEW Technology Learning Curve



Source: Brad Booth and Tom Issenhuth Microsoft, IEEE 802.3 400G

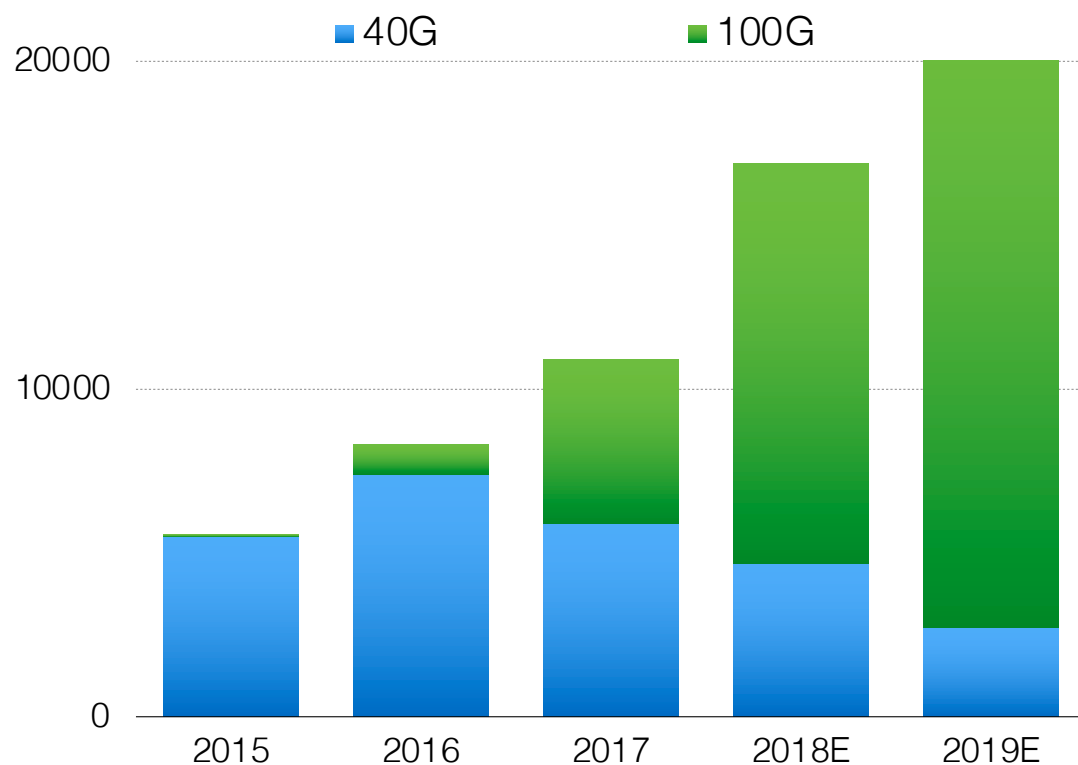
For a new technology to ramp quickly, it must be more cost-effective than the previous technology it displaces

40G - 100G - 400G Switch Port Transition



Source: Dell'Oro Group July 2018 Ethernet Switching Forecast

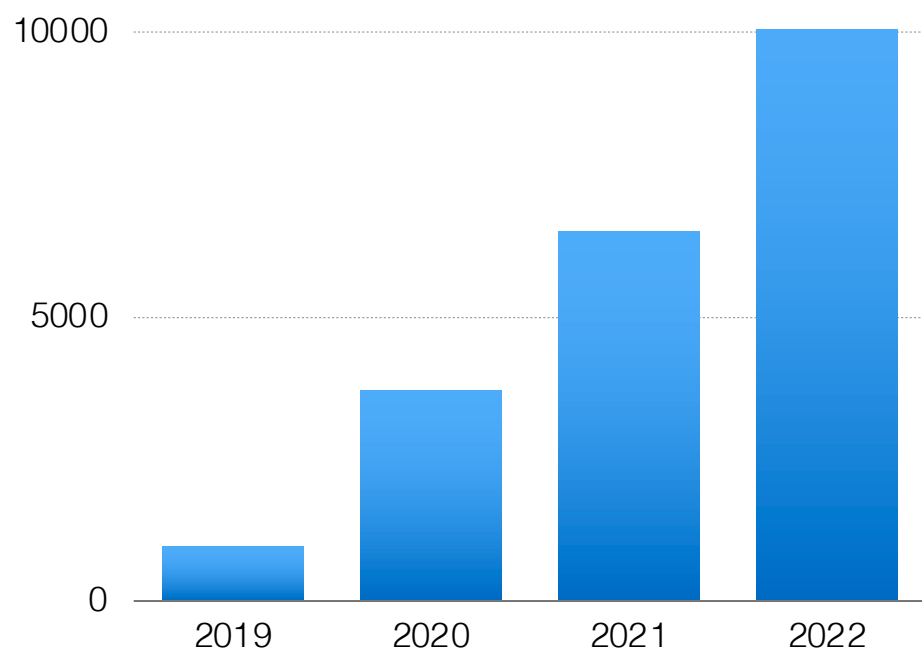
40G to 100G Ethernet Transition [Ports]



100G went from < 10%
to > 50% in one year

Source: Dell'Oro Market Research, Ethernet Switch Update, July 2018

Expected 400G Ethernet Ramp [Ports]

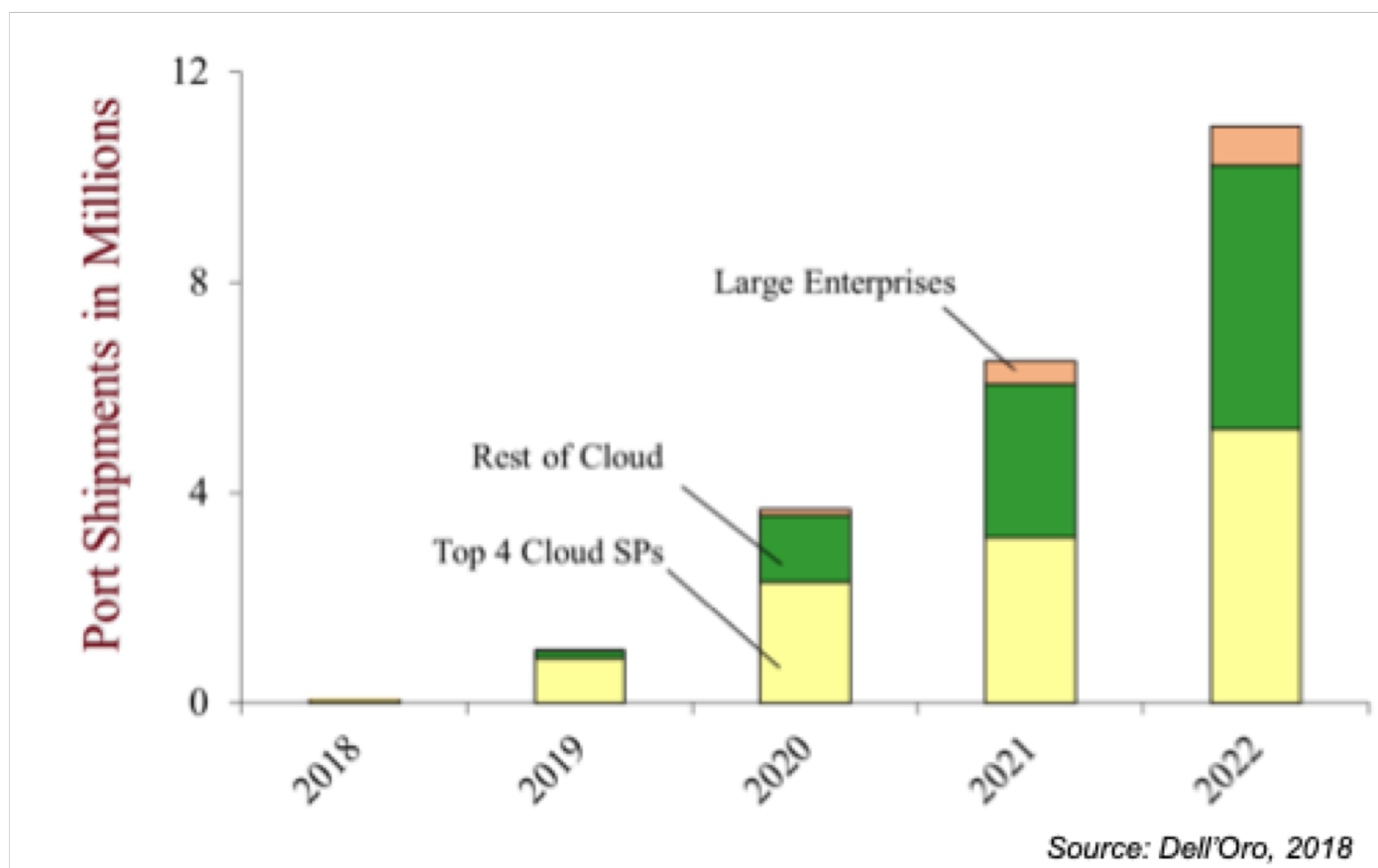


400G ramp is slower than 100G for at least three key reasons:

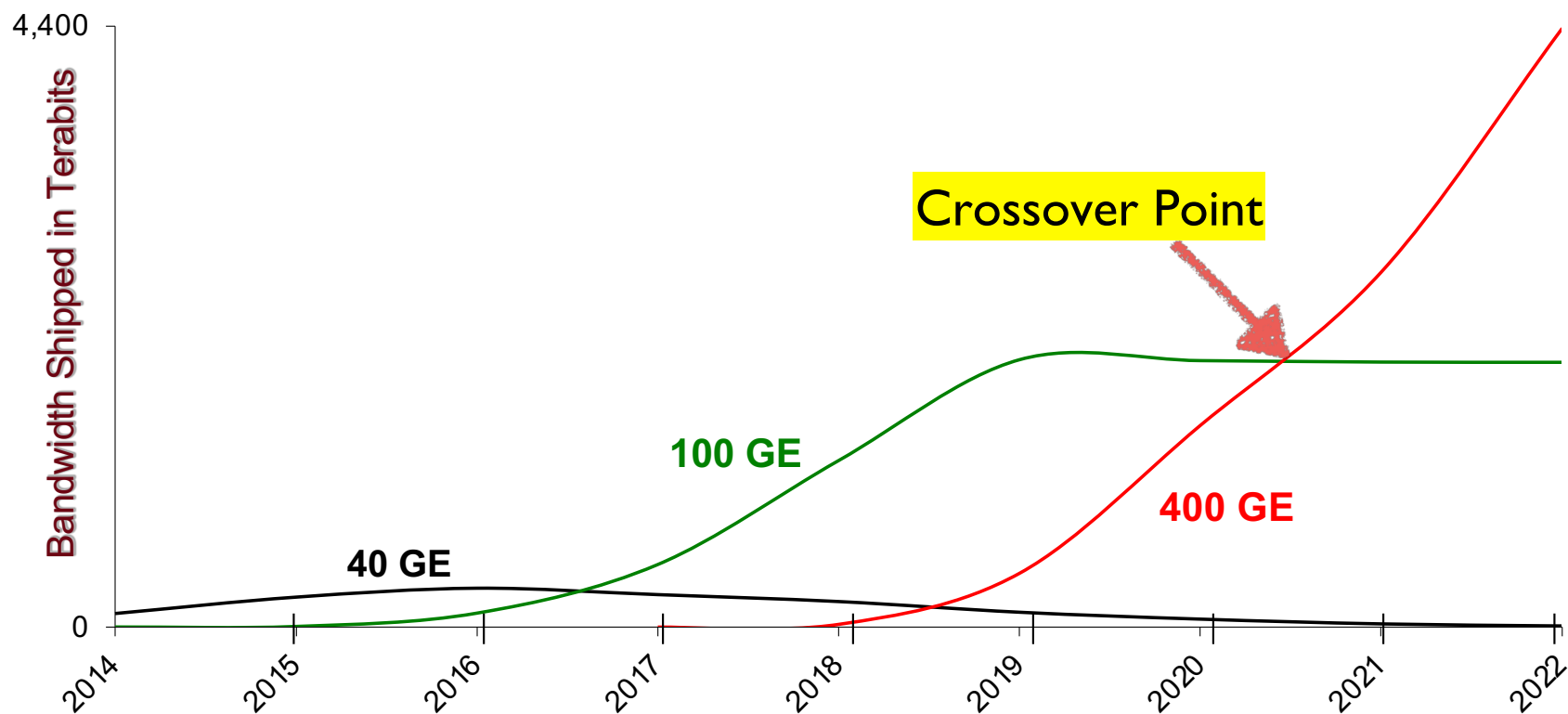
1. Availability of new 400G optics
2. Availability of new 400G switches
3. Qualification of new systems

Source: Dell'Oro Market Research, Ethernet Switch Update, July 2018

Vast Majority of 400G Will be Deployed in Cloud

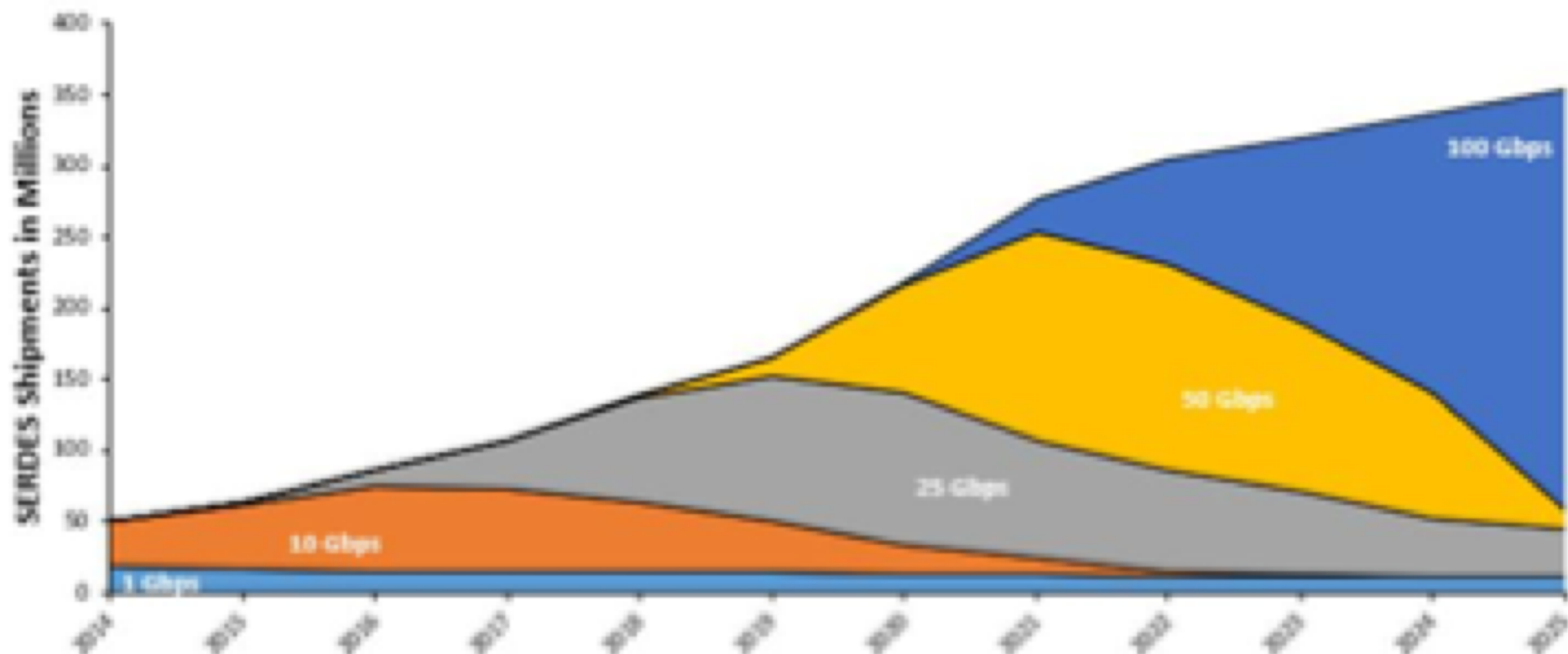


Expected 100G to 400G Bandwidth Cross-Over



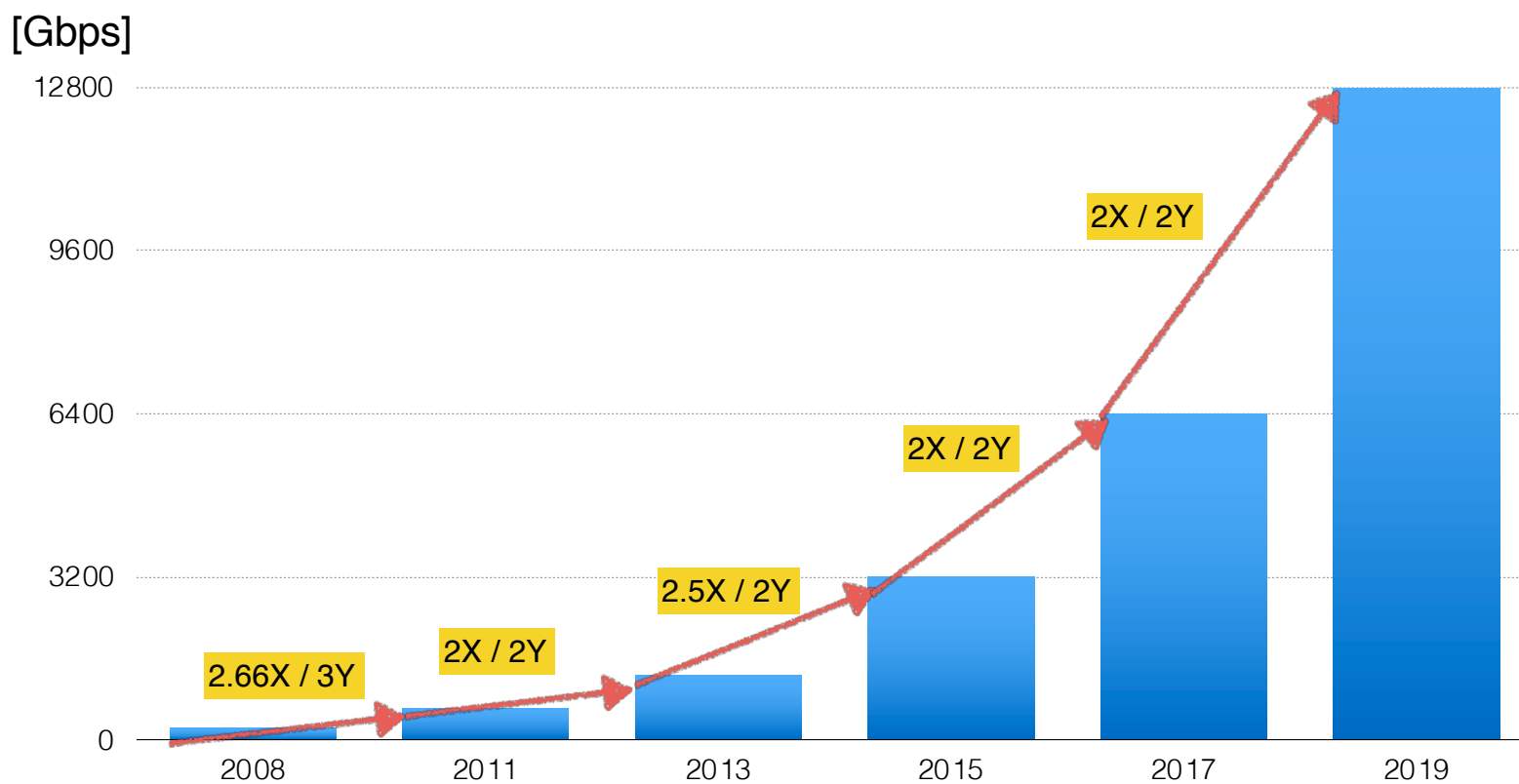
Source: Dell'Oro Group July 2018 Ethernet Switching Forecast

Expected Transition from 50G to 100G SERDES

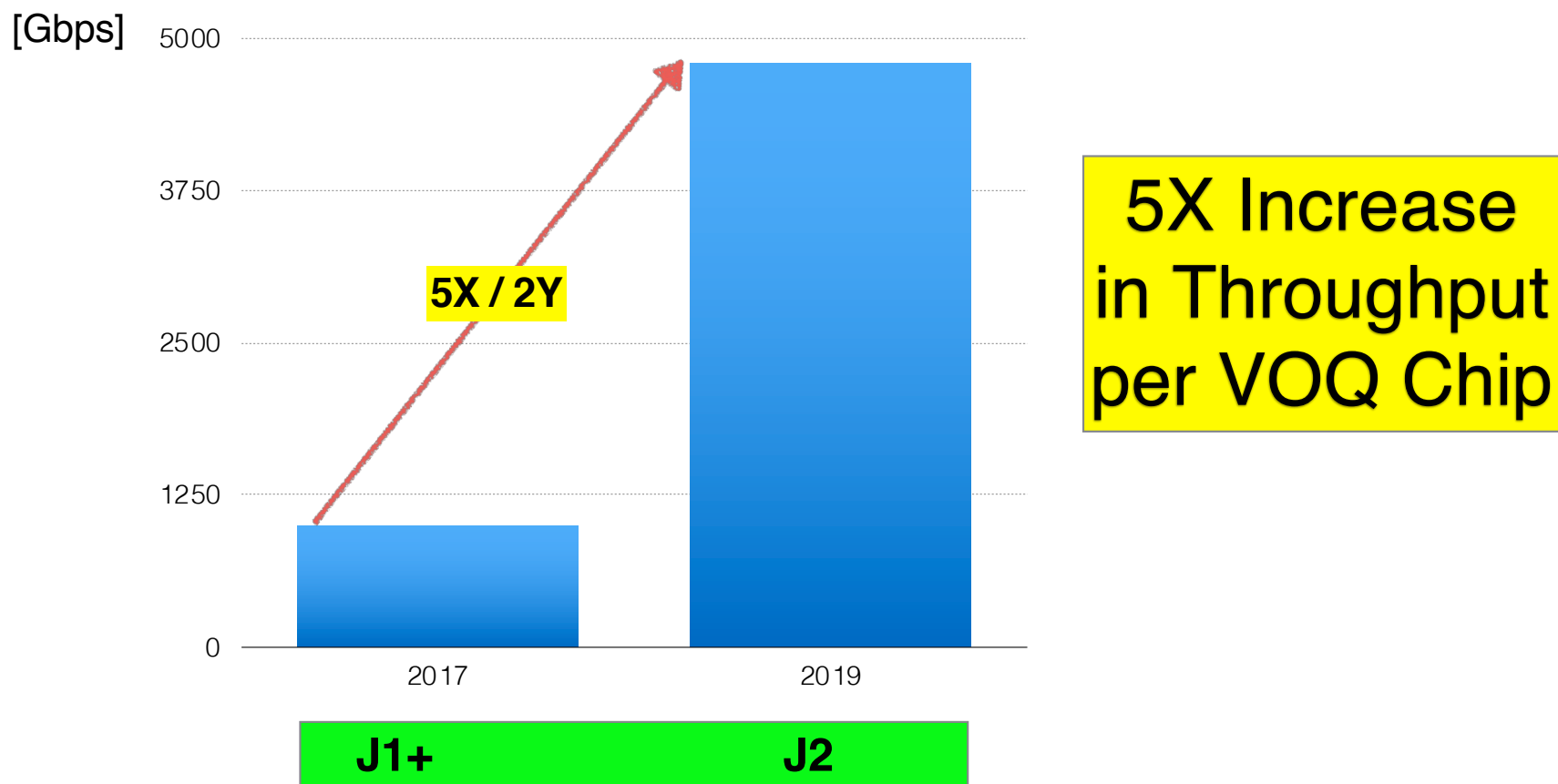


Source: 650 Group LLC, December 2018

Merchant Switch Silicon Bandwidth Growth



Jericho VOQ Big Buffer Bandwidth Per Chip



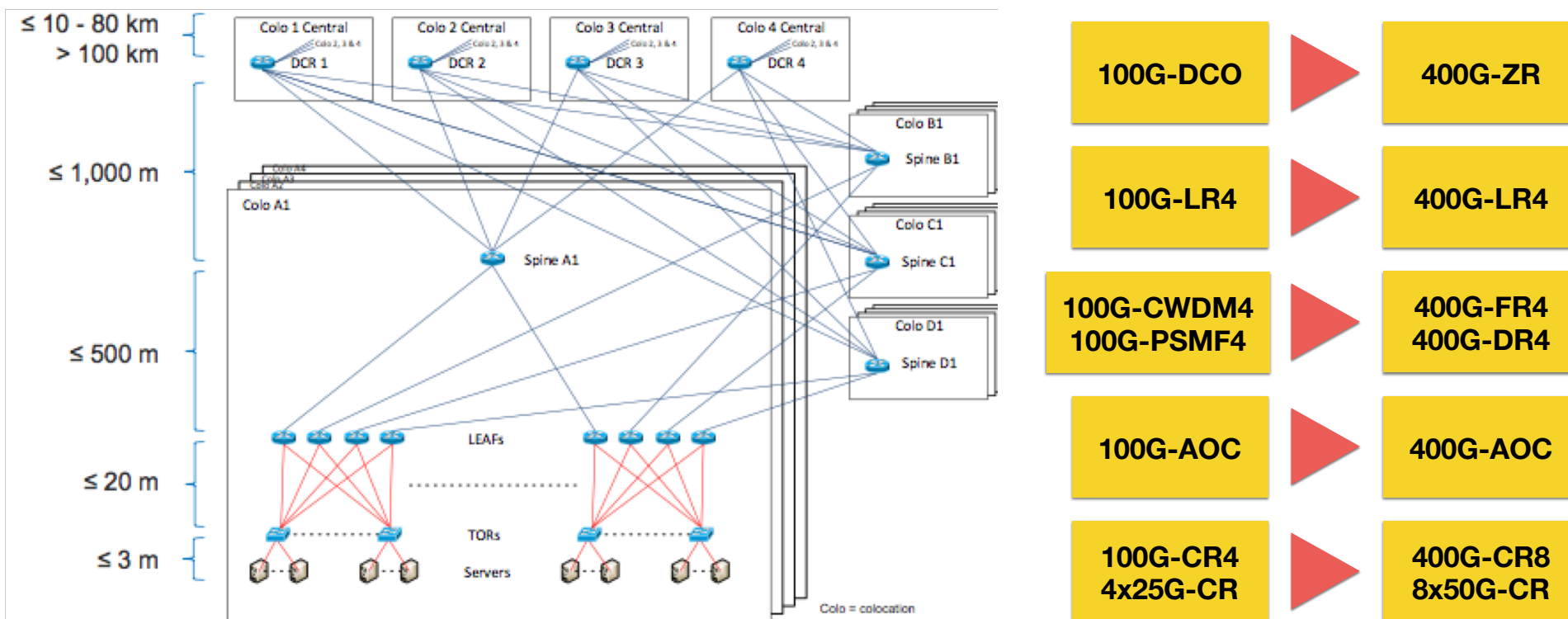
400G Datacenter Optics

400G Datacenter Optics Standards

Name	Fiber	Reach	Modulation
400G-ZR/ZR+	Duplex SMF	10km-1000km	16-QAM
400G-FR4/LR4	Duplex SMF	2km/10km	100G-PAM4
400G-DR4	8xSMF	500m/2km	100G-PAM4
400G-SR8	16xMMF	50m	50G-PAM4
400G-CR8	copper	3m	50G-PAM4

Arista will support all 400G Optics that are relevant in market

Transition of Cloud Networks from 100G to 400G



4X the Network Capacity with same network topology

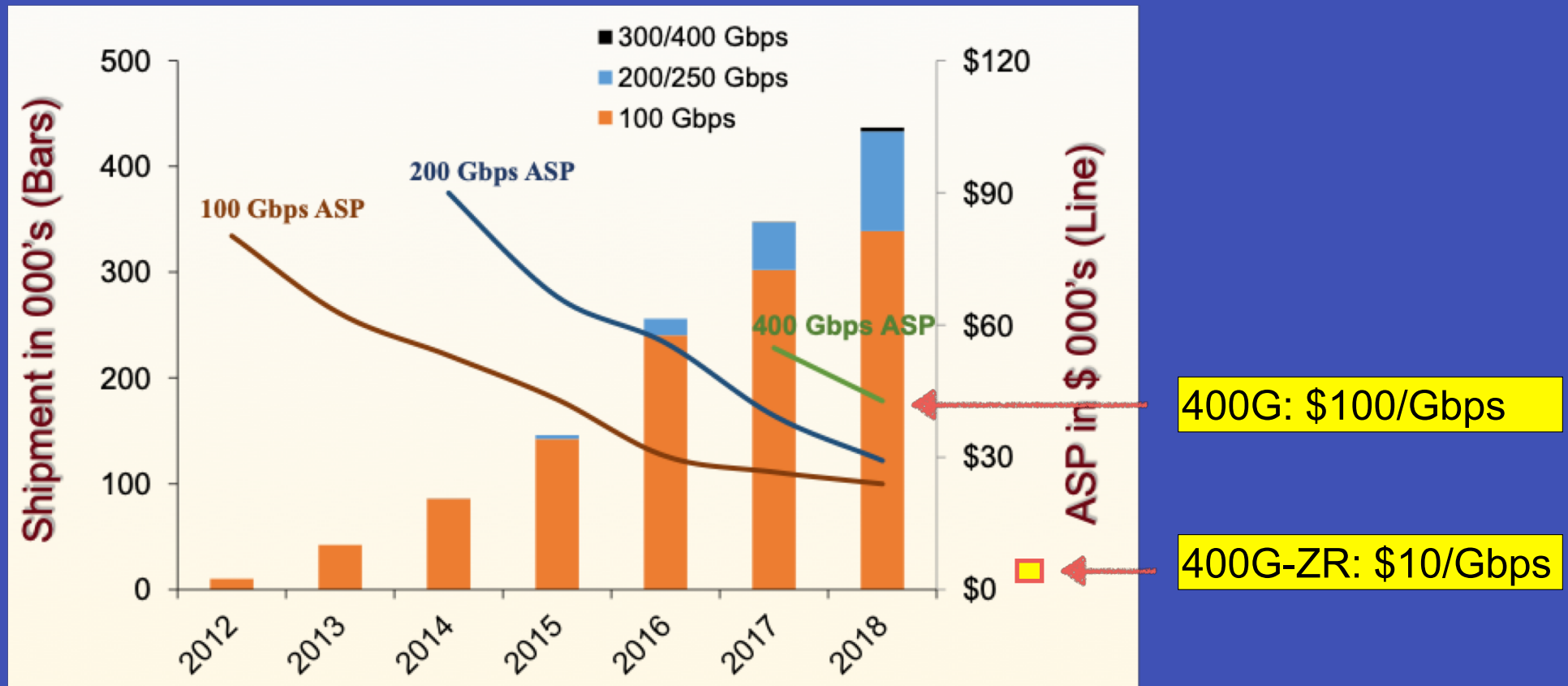
The most interesting new optics:
400G-ZR and 400G-ZR+

What is 400G-ZR/ZR+?

- Industry's First Multi-vendor DWDM Standard
- Coherent, Tunable, Pluggable DCO Module
- 400G, 300G, 200G and 100G speeds
- Dense Client Optics Formfactor
- Supports 14.4 Tbps per 1U
- Max 20W power for 400G-ZR+



Order of Magnitude Cost Reduction



Source of Chart:: Dell'Oro DWDM Update July 2018

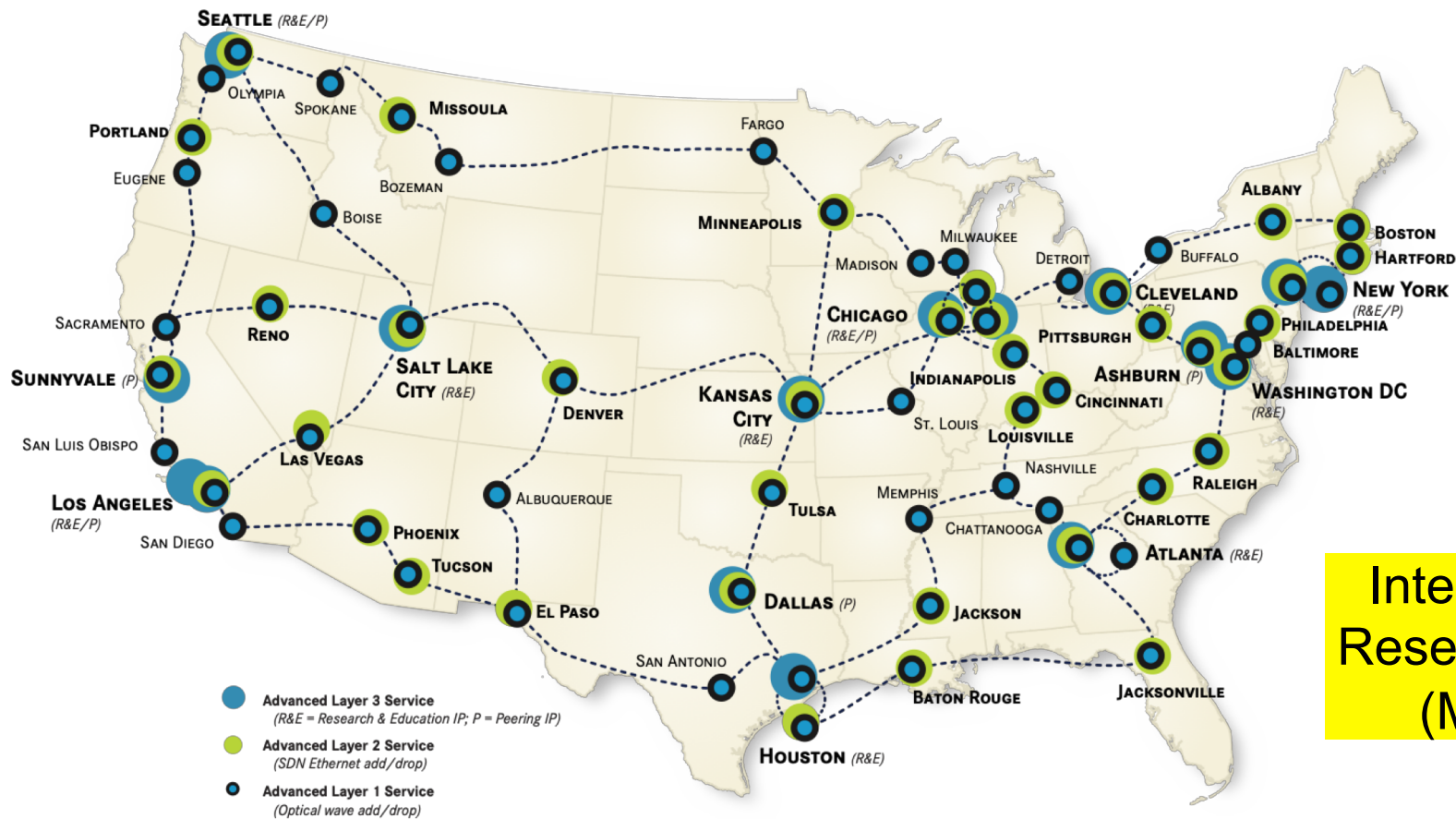
400G-ZR Standards and Reach

Client Interface	Framing/FEC	Modulation	Reach
400GE	OIF 400ZR	400G-16QAM	Up to 1000km
2x200GE	OpenROADM 2.1	300G-8QAM	Up to 2000km
4x100GE	OpenROADM 3.1	200G-QPSK	Up to 4000km
OTU4	ITU G709.2	100G-QPSK	Up to 8000km
	ITU G709.3		
	IEEE 802.3ck		

Use Cases for 400G-ZR/ZR+

- DCI (Datacenter Interconnect)
- Metro-Reach DWDM Networks
- Long-Reach DWDM Networks
- 5G Aggregation
- Cable R-PHY Aggregation

400G-ZR+ Covers Most of USA with 400G DWDM



Internet-2 100G
Research Network
(May 2017)

400G-ZR+ Covers all of Europe with 400G-DWDM

PAN EUROPEAN FIBEROPTIC NETWORK ROUTES PLANNED OR IN PLACE

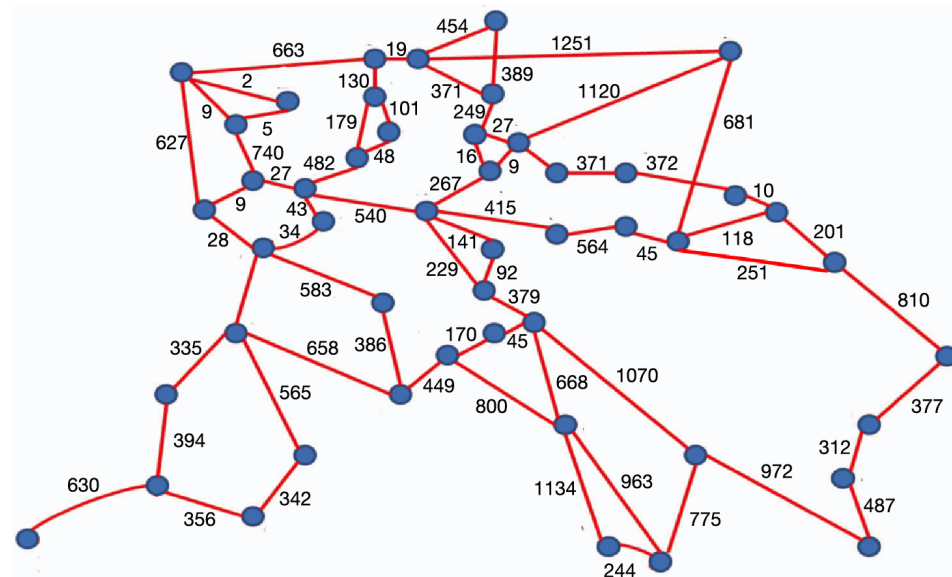
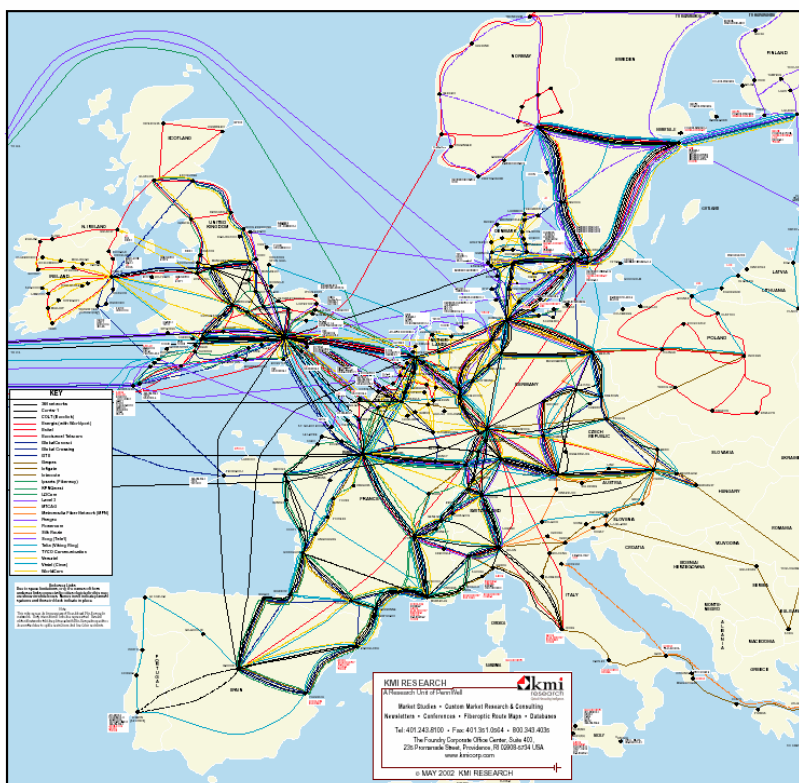


Image Credit: Mattia Cantono, Roberto Gaudino, Vittorio Curri, Stephan Pachnicke, "Potentialities and Criticalities of Flexible-Rate Transponders in DWDM Networks: A Statistical Approach," J. Opt. Commun. Netw. **8**, A76-A85 (2016);

400G-ZR+ Covers Most of Asia



Japan's fiber optic cable backbone





Why Pluggable Form Factor?

Customers Can Source 400G-ZR Modules Directly

-> Avoids Margin Stacking

System Vendor Can Build One System Design

-> No extra Investment Required to Deliver DCO

Customers Can Mix and Match DCO and Client Optics

-> Easy configurability and easy field replacement

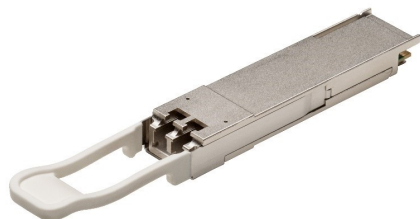
Multiple SKUs Expected

-> 10km-100km-300km-1000km, high-output-power, etc

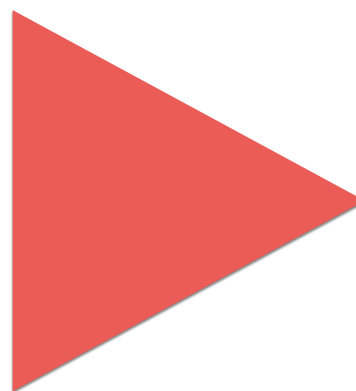
Pluggable DCO Form Factor Transition to OSFP



200G-16QAM 1000km
16 per 1U (3.2T)



100G-2PAM56 100km
36 per 1U (3.6T)



OSFP



400G-16QAM 1000km
36 per 1U (14.4T)

Roadmap to 800G-ZR

- 800G-16QAM Feasible with 120 Gbaud
- Same Pluggable Formfactor (800G-OSFP)
- Targeting Same Power Envelope ~ 20W
- Double the Power Efficiency per bandwidth
- Significantly improved price-performance
- Backward compatible with 400G-ZR/ZR+

400G-ZR/ZR+ Summary

- First True Multi-vendor Interoperable DCO Standard
- Revolutionary Price-Performance
- Very High Density: 14.4T per 1U
- Very Low Power: 20W for 400G 1000km Reach
- High-density Pluggable Formfactor
- Eliminates Separate Transport Shelf
- Eliminates Special DCO System Designs
- Roadmap to 800G-ZR/ZR+ in 2022/2023

400G and 800G Optics Module Form Factors

The OSFP (Octal Small Form Factor Pluggable)

High Port Density: Up to 36 per 1U

28.8T with 8x100G SerDes

High Thermal Capability

Up to 20W Power Capability

Backward Compatible with QSFP

With Simple OSFP-QSFP Adaptor



The logo for OSFP (Octal Small Form Factor Pluggable) consists of a stylized 'O' made of horizontal lines, followed by the letters 'SFP' in a bold, sans-serif font.

The QSFP-DD (QSFP Double Density)

Eight Lanes at 56G-PAM4

Supports 400G with 8x50G lanes

Port Density: 36 per 1U

14.4 Tbps per 1U

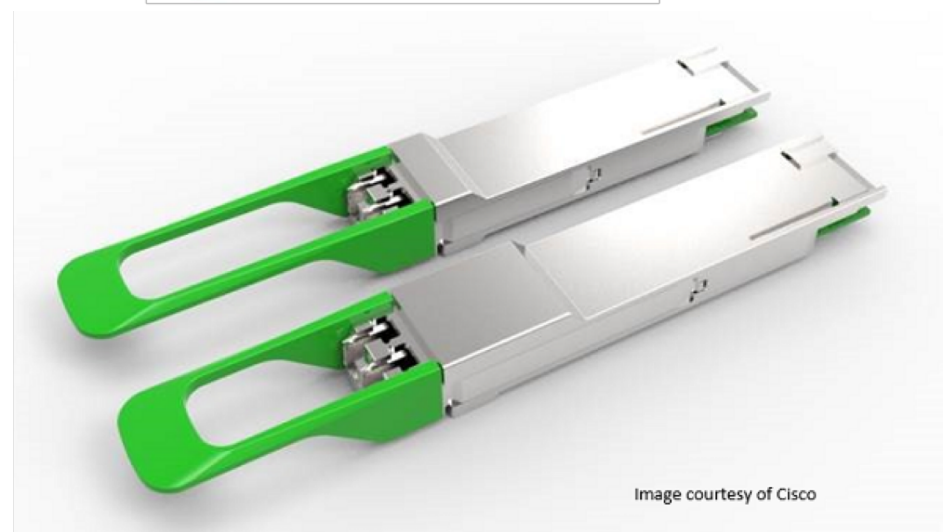
Dual Row Connector Design

Challenging to support 112G

Thermal Limitations

Difficult to support > 15W

QSFP-DD 



QSFP-DD Type 1 and Type 2 form factors.

Pluggable Form Factors Comparison

The logo for OSFP (Octal Small Form-factor Pluggable) consists of a stylized icon of horizontal lines on the left and the text "OSFP" in a bold, sans-serif font.The logo for QSFP-DD (Quad Small Form-factor Pluggable - Double Density) features the text "QSFP-DD" in a bold, sans-serif font, followed by a stylized icon of a square with four smaller squares inside.

36 Port Density per 1U



20W Thermal Capacity
for 400G-ZR+ and 800G



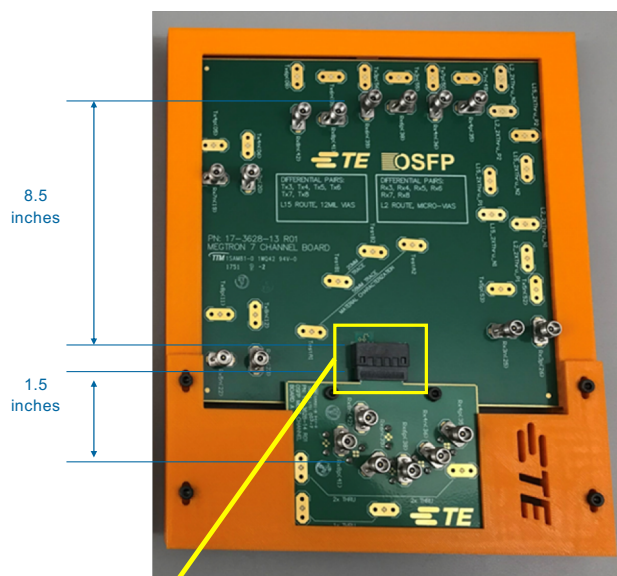
High Signal Integrity for
112G-PAM4 SerDes



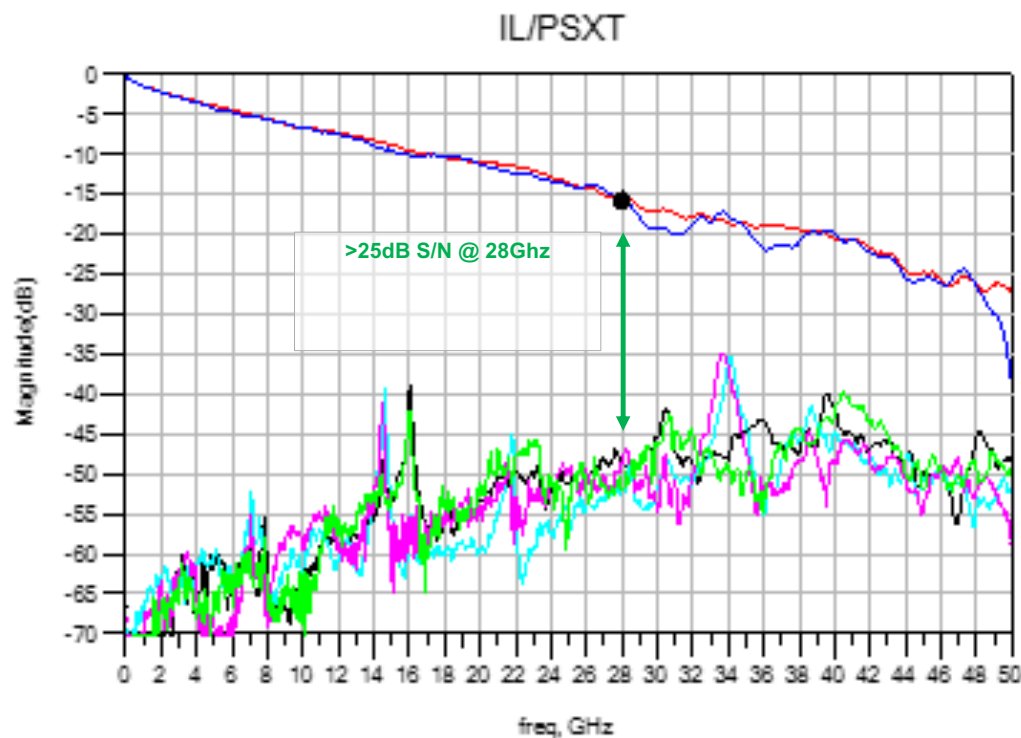
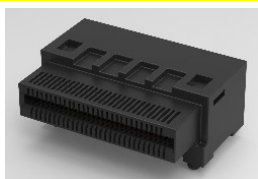
OSFP is the right good choice for ZR+ and 800G (Dual 400G)

112G-PAM4 SerDes Demonstration (OFC 2018)

10 inch overall channel



OSFP
Connector



10" Trace Channel plus OSFP Connector
 24db Insertion Loss Die to Die, 16db Ball-to-Ball
 Measured BER= approx. 6×10^{-7}



Thermal Requirement for 400G-ZR+: 20W

400G-ZR
100km Reach
15W Power

400G-ZR+
up to 1000km Reach
20W Power

400G-ZR+ Optics Approaching the Performance
of Traditional High-end DWDM Optics



Thermal Requirement 800G Optics: 20W

400G-FR4/LR4 Optics
10-12W Thermal
Envelope

Dual 400G/800G Optics
Need 20W Thermal
Envelope

No Significant Power Reduction going from 400G to 800G

The Biggest Challenge for Operators

How to Increase Bandwidth for next-gen Applications
while simultaneously lowering CAPEX and OPEX

400G Router Price per Port



Legacy Router



Merchant Silicon

10X Improvement in Price-Per Port with
with Merchant Silicon Routers compared
to legacy Router Price Points

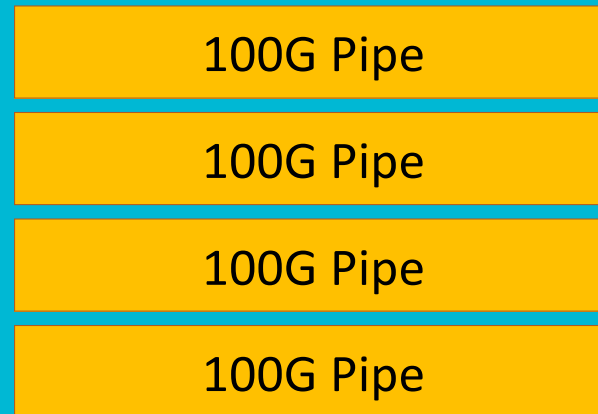
400G DWDM Price Per Bandwidth



Order of Magnitude Cost-Reduction
with 400G-ZR/ZR+ compared to
legacy Optical Transport Price Points

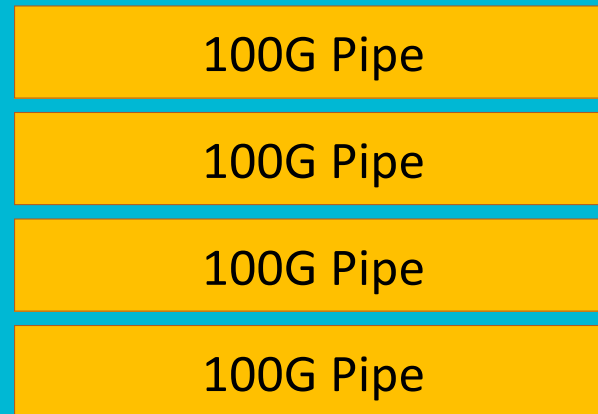
Fatter Pipes are Easier to Manage

Fatter Pipes are more efficient and easier to manage than equivalent bandwidth with smaller pipes



Fatter Pipes are Lower Cost per Bandwidth

400G is fundamentally lower cost than 4x100G



400G Summary

Large Improvement in Bandwidth Price-Performance

Enables Fundamentally more cost-effective Networks that are also more efficient and easier to manage

Timeline: Field Trials in 2019, Production in 2020