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DATA CENTER BANDWIDTH SCENARIOS

Scott Kipp

skipp@brocade.com

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Opinions expressed during this presentation are the views of the presenters, and should not be considered the views or positions of the Ethernet Alliance.

From Applications to Data Centers

- Applications, servers, storage, networks and data centers have varied compute, bandwidth and availability requirements
  - Intel has 150 different processors for server market
  - Servers vary from <1/10U to multiple racks
  - Switch ports range from 100 Mb/s to 100 Gb/s
  - Storage devices vary from 10GB to 100s of Petabytes
  - 100 servers to 100,000 servers in a data center
- Because of the varied requirements and capabilities, it is difficult to talk about anything specific without losing something
- I'll try anyway…

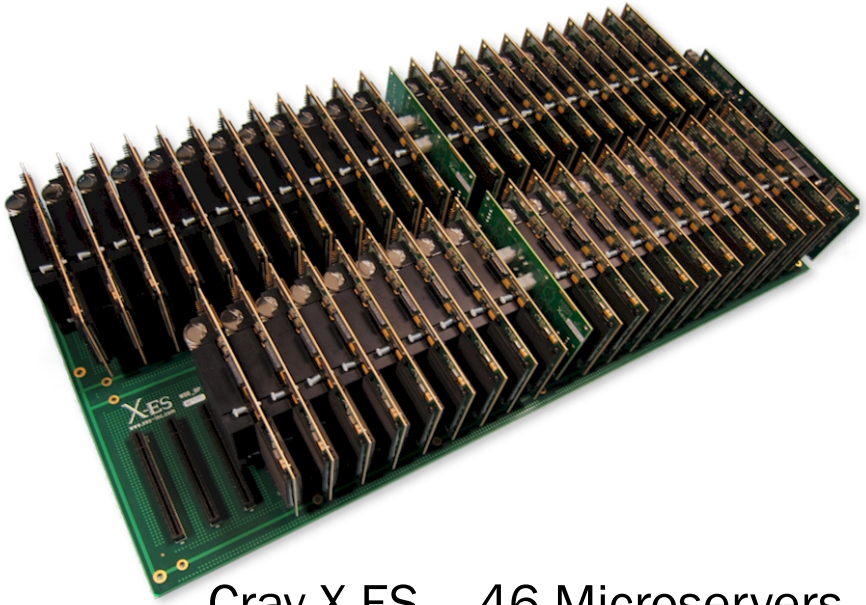
Starting with Servers

Multiple Server Categories

- Microservers
- Blade Servers
- <1U Servers
- 1-2U Servers

95% of Volume,
Not revenue

- 4-12U Servers
- Rack and multi-rack Servers

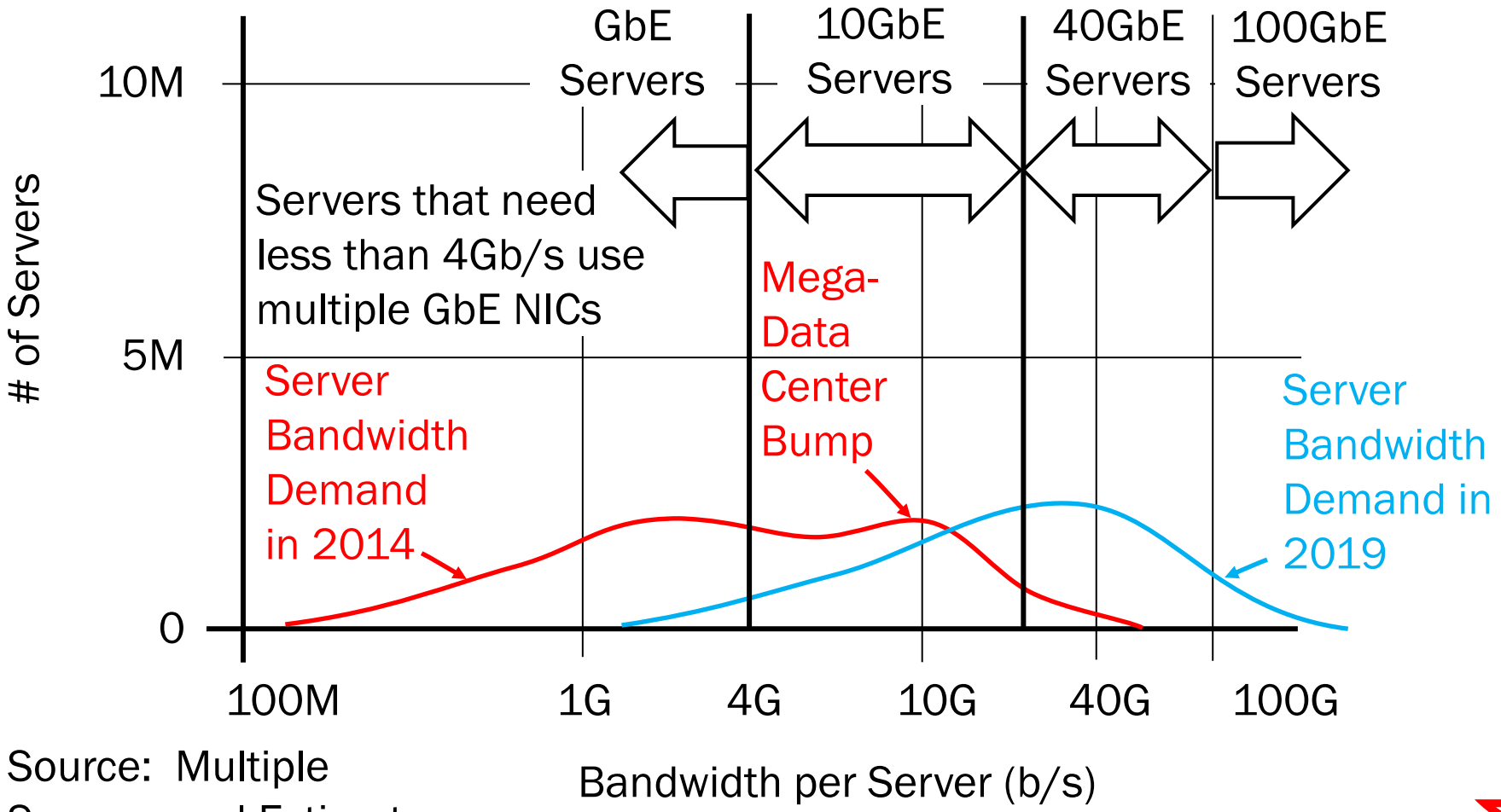


Cray X-ES – 46 Microservers

IBM Mainframe

Bandwidth Requirements of Servers

~10M servers ship every year, >95% are x86



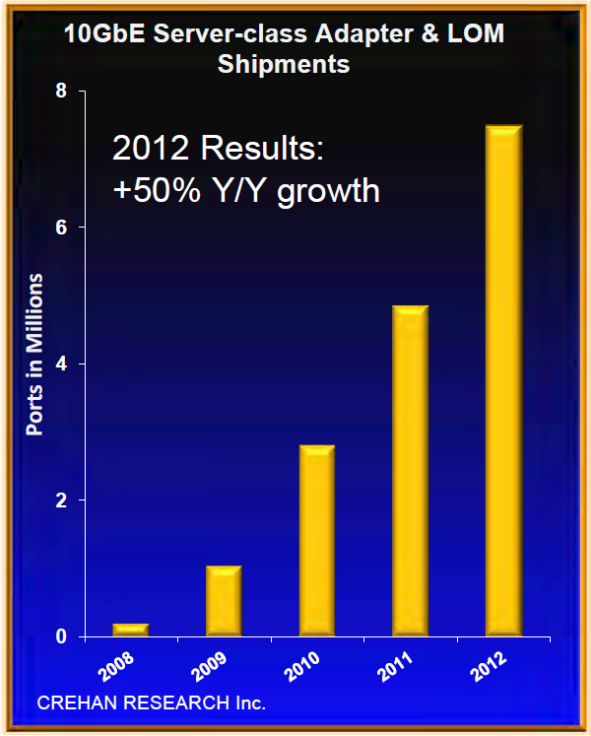
Source: Multiple Sources and Estimates

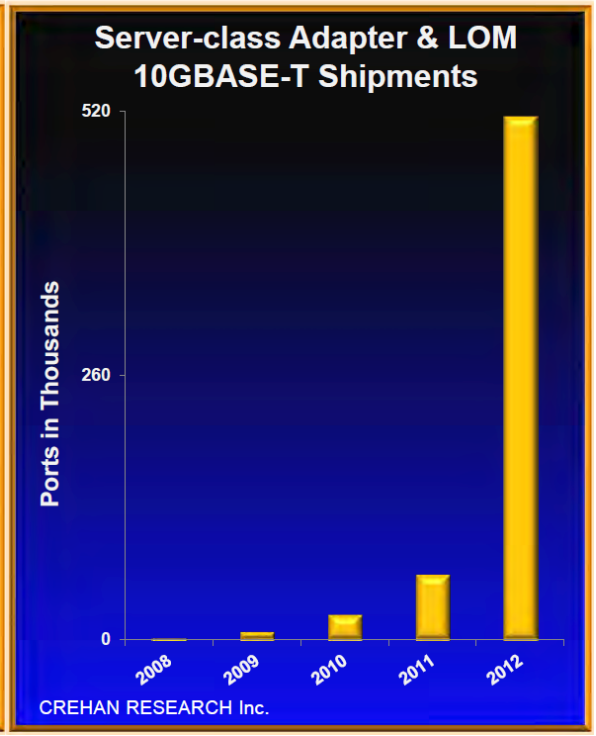
10GbE and 40GbE Server Ports

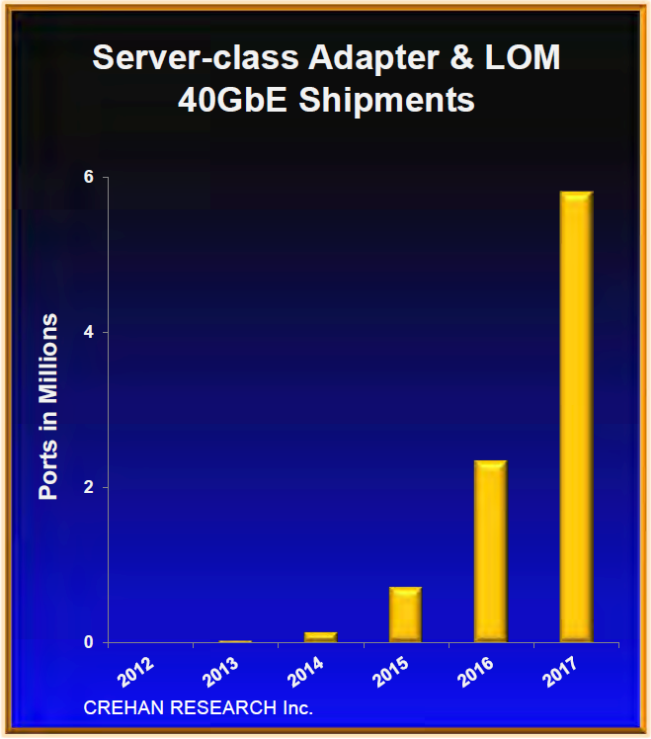
Most 10GbE Servers connect with SFP+ or 10GBASE-KR

10GBASE-T will continue to ramp but not used in mega-data centers

40GbE servers will connect with QSFP or 40GBASE-KR



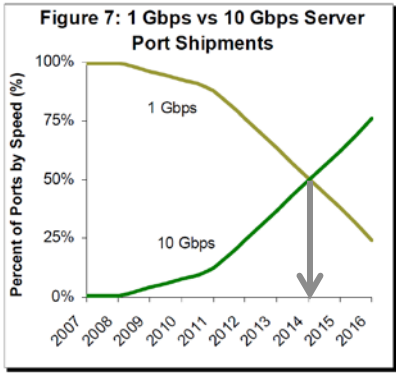




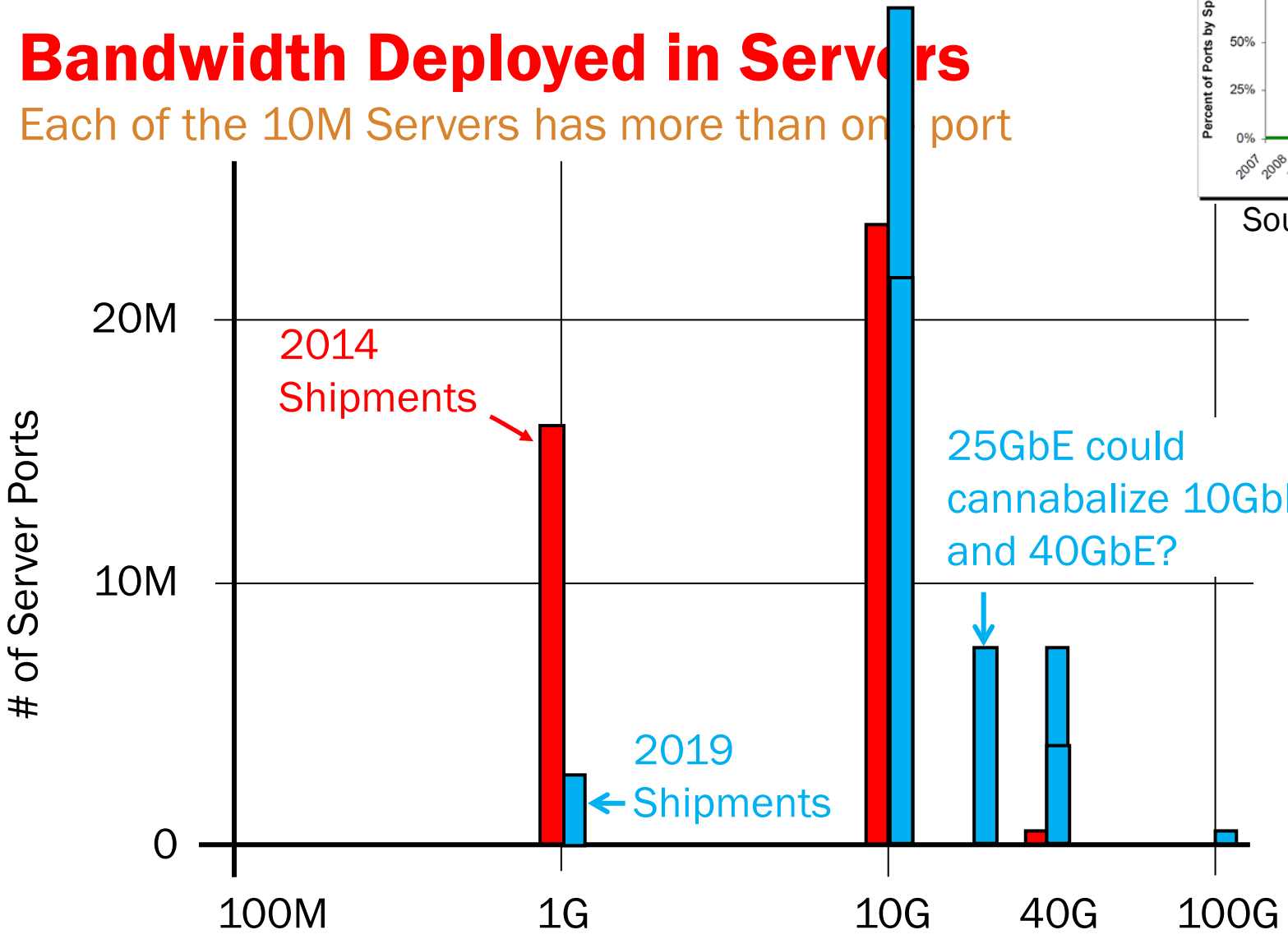
Source: Crehan Research and http://www.ieee802.org/3/400GSG/index.html

Bandwidth Deployed in Servers

Each of the 10M Servers has more than one port



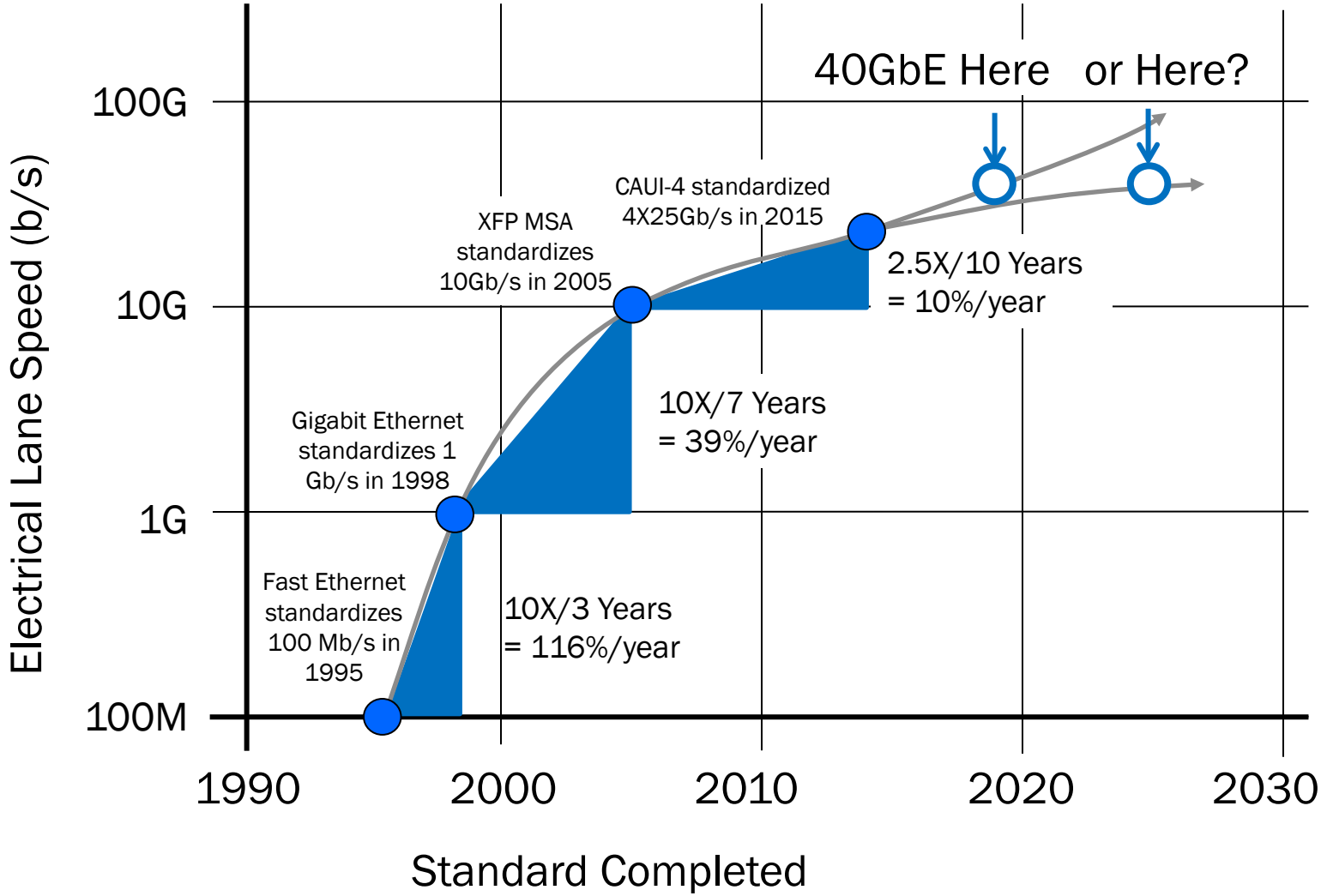
Source: Dell'Oro



Source: Scott Kipp

Electrical Signaling Rates

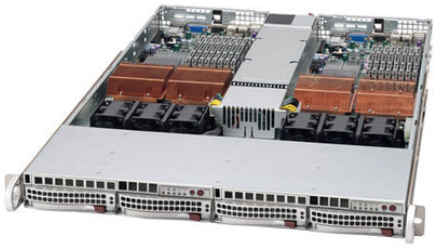
10 Years to go from 10G to 25G, will it take another 10 to go to 40G?



25GbE SFP+ or 40GbE QSFP+

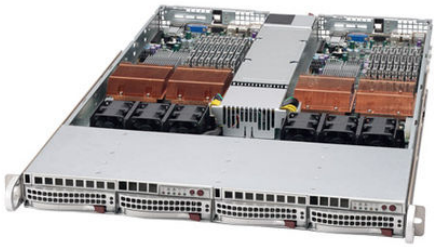
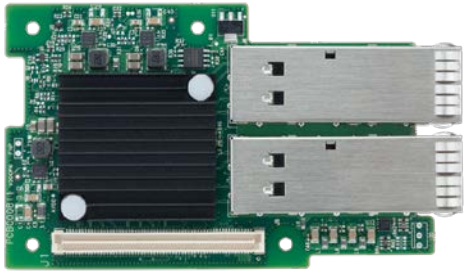
- Typical Server - 10GbE now, 25GbE next year and 40GbE in ?

1U Server | 2X nGbE SFP+ | SFP+ | Duplex LC




- High Performance Server - 40GbE now and 100GbE in 2016?

1U Server | 2X n0GbE QSFP+ | QSFP+ | Parallel MPO

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WHICH PROTOCOL HAS SOLD MORE OPTICAL BANDWIDTH BETWEEN 2007-2013?

OPTICAL BANDWIDTH = NUMBER OF MODULES X SPEED OF MODULE

a) Ethernet

b) Infiniband

c) Fibre Channel

d) FTTx

e) DWDM

Source: Lightcounting

Fibre Channel wins with 462 Petabits/second of Bandwidth!

Optical Bandwidth Sold 2007-2013

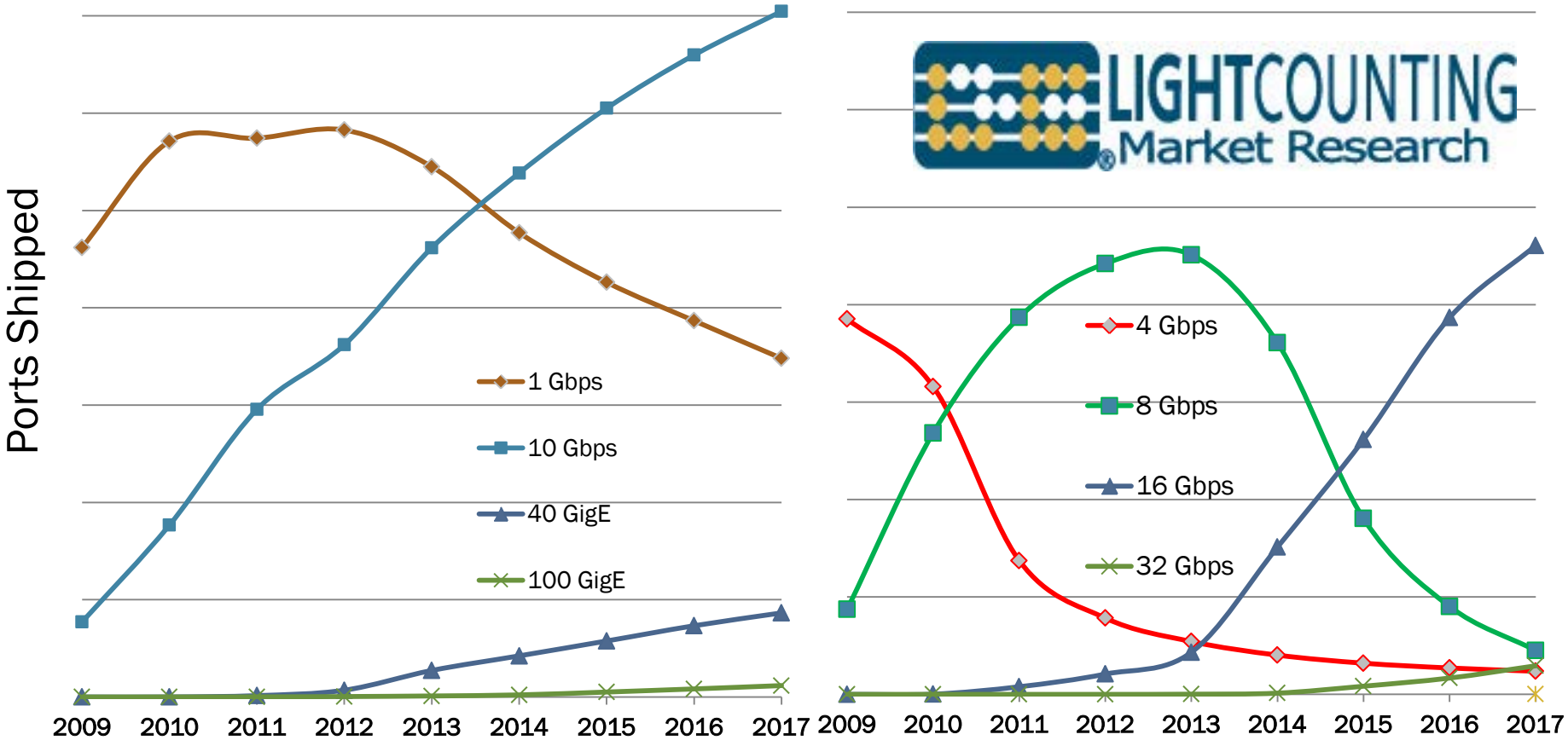
FC is >95% low cost VCSEL-based Solutions

Ethernet	Modules Sold	Data Rate (Gb/s)	Bandwidth (Petabits/s)
GbE	74,027,190	1.25	92
10GbE	29,141,697	10.3125	300
40GbE	712,604	41.25	29
100GbE	32,652	103.125	3
Total	**103M**		**425**
Fibre Channel	**Modules Sold**	**Data Rate (Gb/s)**	**Bandwidth (Petabits/s)**
4GFC	37,492,028	4.25	159
8GFC	33,285,112	8.5	282
16GFC	1,441,255	14.025	20
Total	**72M**		**462**

Source: Multiple Lightcounting Forecasts

Data Center Optical Port Shipments

Ethernet on much longer cycles than Fibre Channel



Source: Lightcounting July 2013 Forecast Database

32GFC Standard Completed Last Month

6 Generations of Fibre Channel

Doubling the Speed as Low Cost Technology Matures

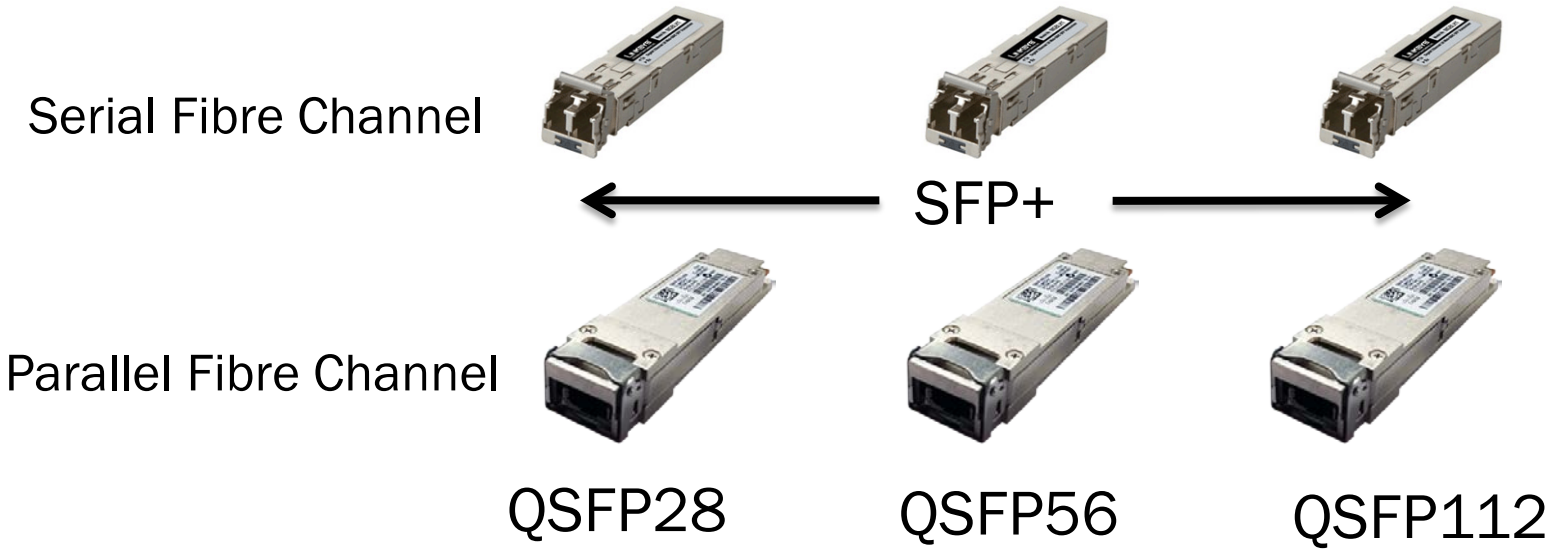
Generation	1st Gen	2nd Gen	3rd Gen	4th Gen	5th Gen	6th Gen
Electrical / Optical Module	1GFC / GBIC/ SFP	2GFC / SFP	4GFC / SFP	8GFC / SFP+	16GFC / SFP+	32GFC / SFP+
Electrical Speeds(Gbps)	1 lane at 1.0625	1 lane at 2.125	1 lane at 4.25	1 lane at 8.5	1 lane at 14.025	1 lane at 28.05
Encoding	8b/10b	8b/10b	8b/10b	8b/10b	64b/66b	64b/66b
Availability	1997	2001	2006	2008	2011	2016

GBIC ← SFP / SFP+ →

Future Generations of Fibre Channel

Serial and Parallel

Generation	6th Gen	7th Gen	8th Gen
Electrical / Optical Module	32GFC and 128GFC /SFP+ and QSFP28	64GFC and 256GFC /SFP+ and QSFP56	128GFC and 512GFC /SFP+ and QSFP112
Electrical Speeds (Gbps)	1 lane of 28.05 4 lanes at 28.05	1 lanes of 56.1 4 lanes at 56.1	1 lane of 112.2 4 lanes at 112.2



Ethernet Speeds

10X Increase Moving to 4X or 2.5X Increase

Name	Speed	Date Standard Ratified
10Mb/s Ethernet	10 Mb/s	1983
100Mb/s Ethernet	100Mb/s	1995
Gigabit Ethernet	1 Gb/s	1998
10 Gigabit Ethernet	10 Gb/s	2002
40 Gigabit Ethernet	40 Gb/s	2010
100 Gigabit Ethernet	100 Gb/s	2010
400 Gigabit Ethernet	400 Gb/s	2017 (est.)*

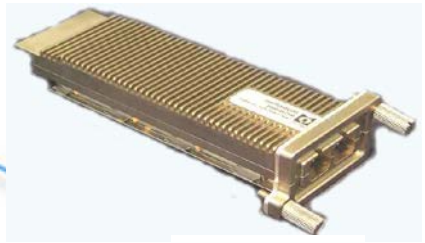
*Estimated on a 4-year standardization process that started with the CFI in March 2013

Generations of 10GbE

Fractured Market Until SFP+ Took Over

Generation	1st Gen	2nd Gen			3rd Gen	4th Gen
Optical Module	300 Pin MSA	XENPAK	XPAK	X2	XFP (Retimed)	SFP+ (Unretimed)
Electrical Speeds (Gbps)	16 lanes at 0.644	4 lane at 3.125	4 lane at 3.125	4 lane at 3.125	1 lane at 10.3125	1 lane at 10.3125
Encoding	8b/10b	8b/10b	8b/10b	8b/10b	64b/66b	64b/66b
Availability	2001	2002	2002	2003	2005	2009

300 Pin MSA



XENPAK

XPAK/X2

XFP

SFP+

Current Generations of 10GbE

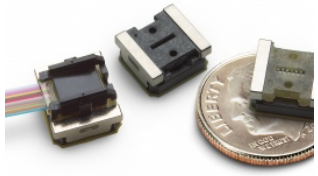
SFP+ and now QSFP+ and Embedded Optics

Generation	4th Gen	5th Gen	6th Gen
Optical Module	SFP+ (Unretimed)	QSFP+	Embedded Optical Modules
Electrical Speeds (Gbps)	1 lane at 10.3125	4 lanes at 10.3125	12+ lanes at 10.3125
Availability	2007	2011	2013

VCSEL /MMF Dominate –Not Silicon Photonics/SMF through 2020

SFP+

QSFP+ 40GbE too



EOMs (Embedded Optical Modules)

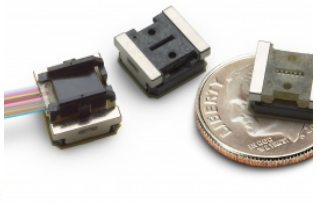
Generations of 100GbE

Early Stages of 100GbE Still

The Holy Grail of Ethernet – 100G Serial

Generation	1st Gen	1.5G	2nd Gen		3rd Gen
Optical Module	CFP, CXP, EOM	CFP2/CPAK	QSFP28	CFP4	XFP/SFP+
Electrical Interface (Gb/s)	CAUI–10 10 lanes of retimed 10.3G	CAUI-10 and CAUI-4 4 lane at 25.8G	CAUI-4 4 lane at 25.8	CAUI-4 4 lane at 25.8	CAUI-1 1 lane at 100
Standard Availability	2010	2013	2013	2014	2024?

CFP



EOMs

CFP2

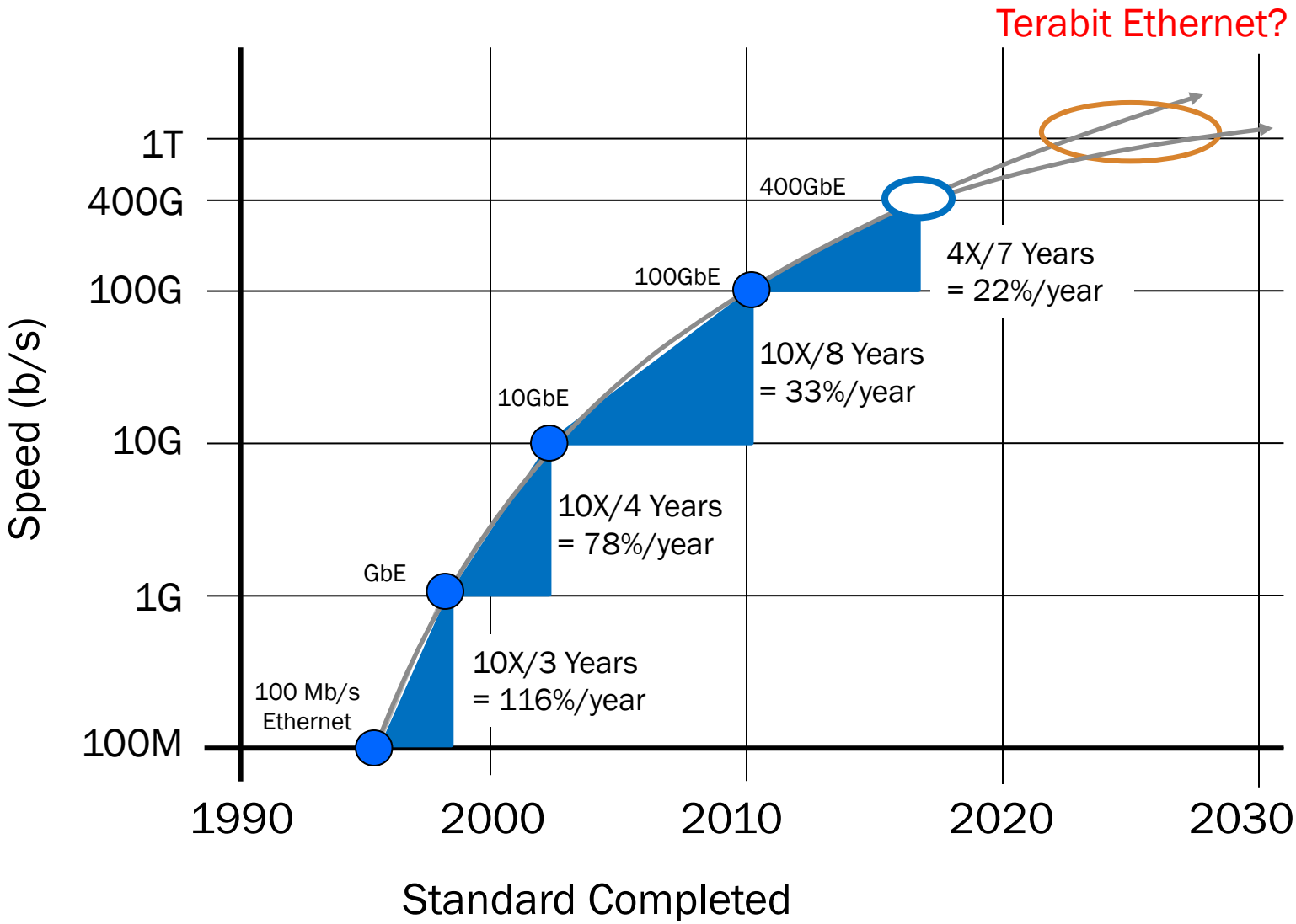
QSFP28

CFP4

XFP

SFP+

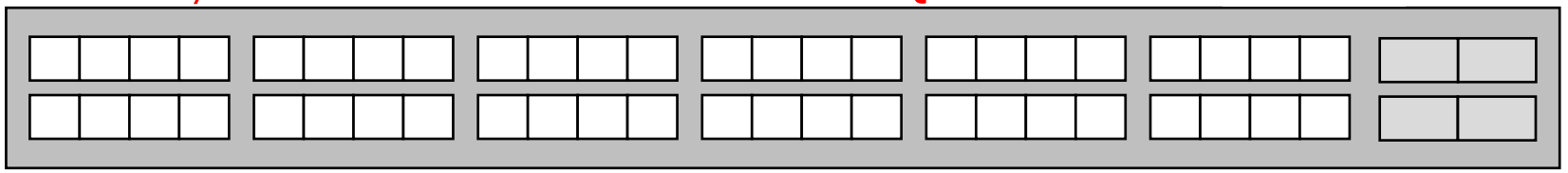
When do we get Terabit Ethernet?



Ethernet Switch Bandwidth

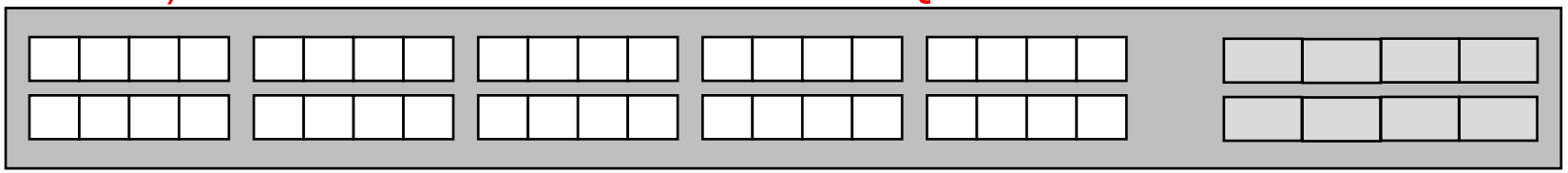
Exceeding 10 Tbps in 2020?

640 Gb/s = 48 10GbE SFP+ + 4 40GbE QSFP+



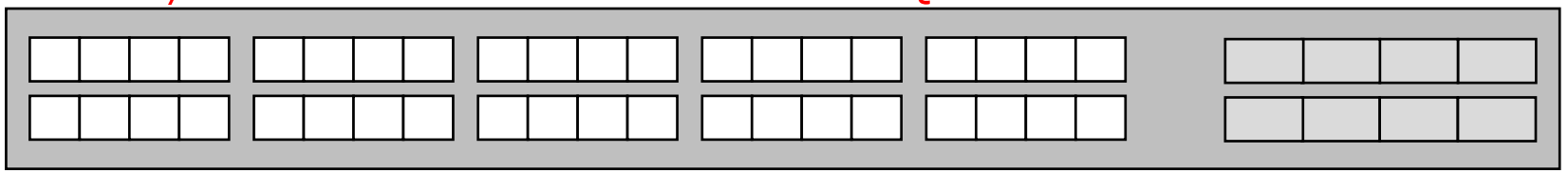
2010

1.8 Tb/s = 40 25GbE SFP+ + 8 100GbE QSFP+



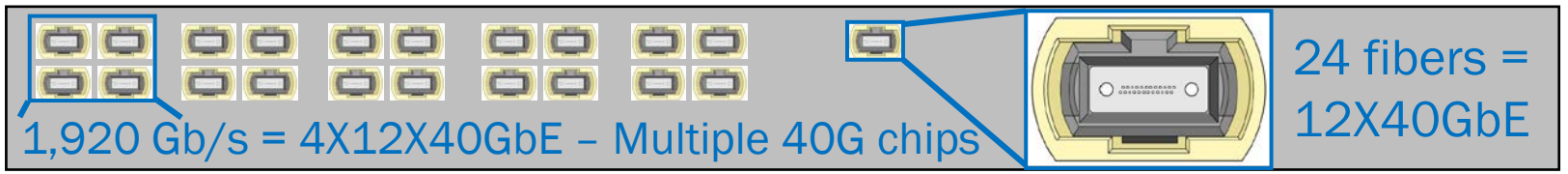
2016

2.4 Tb/s = 40 40GbE SFP+ + 8 100GbE QSFP+



2020?

10.08 Tb/s = 252 Embedded 40GbE ports, 126W at 6W/12 SW Ports



2020?

To 10 Tb/s 1U Switches

This analysis is for Switches, Routers are a Different Beast

- The best switch bandwidth increases are within an ASIC and combine increasing:
  - Switch ASIC Port count – 64 =>128 => 256?
  - Port Speed - 10G => 25/28G => 40G => 50/56G →100G?
  - >10Tb/s 1U switches possible this decade
- Embedded optics enable significant bandwidth port density increases to overcome faceplate density challenges
- Pluggable optics enable significant flexibility in deployments, but are facing limitations
- Combinations of pluggable and embedded optics can be effective in meeting all data center needs

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THANK YOU