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Data Center Networks Evolution

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Major factors driving DC networks evolution

Advancements in electrical and optical network electronics

Next steps for optical fiber infrastructure

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IT technology drivers in data centers?

Network Architecture

Network Speeds

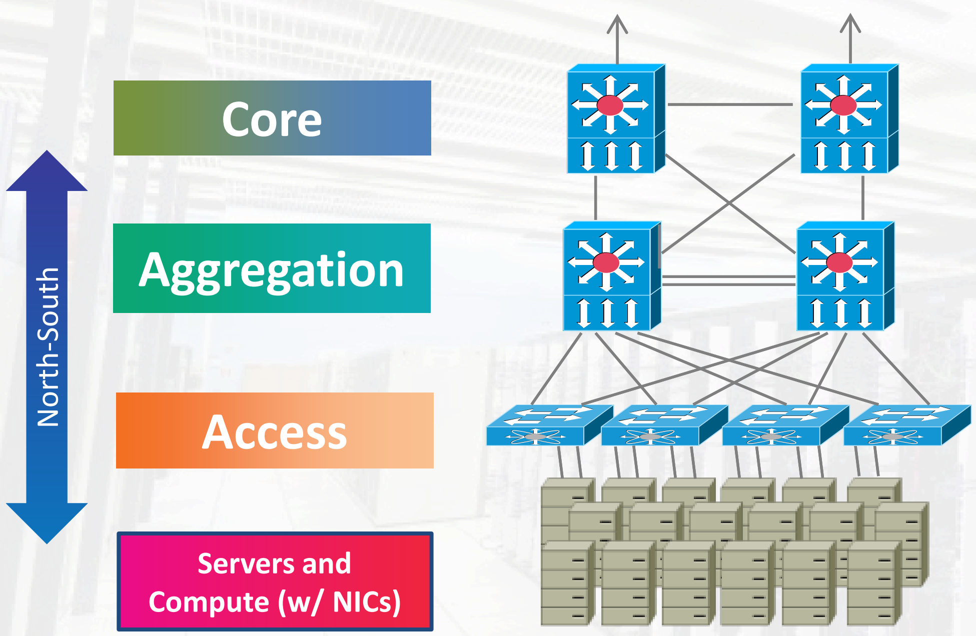
Optical Connectivity

Designed for Availability

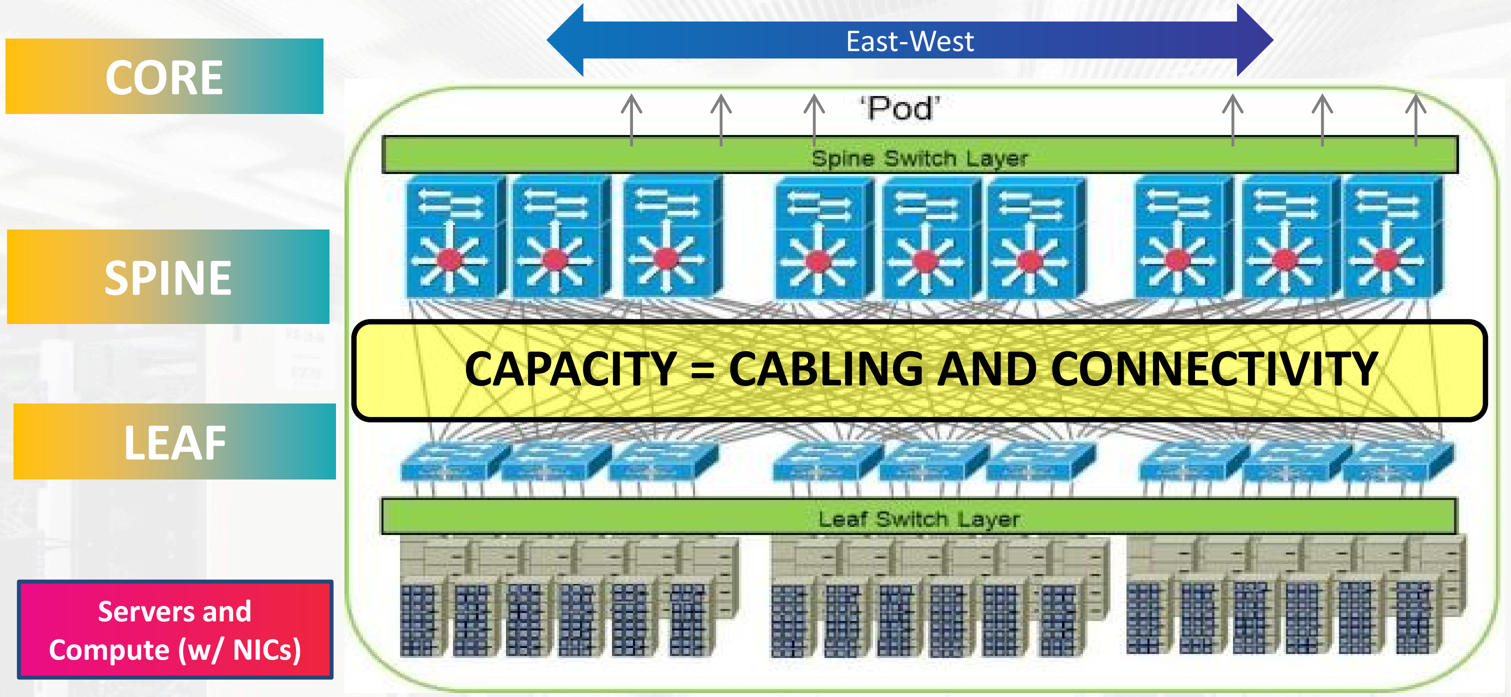
Resilience & Speed

Data Center networks have evolved

Legacy Data Center Network



Leaf-Spine Data Center Network



- **Network Functions defined by switch type**
- **Chassis switches (small, medium, large capacity)**
- **Focus on power/cooling cabinets for switches**

- **Switches can be programmed for network function**
- **Fixed switches (same switch, different capacity)**
- **Focus on cable management**

Industry bandwidth demand

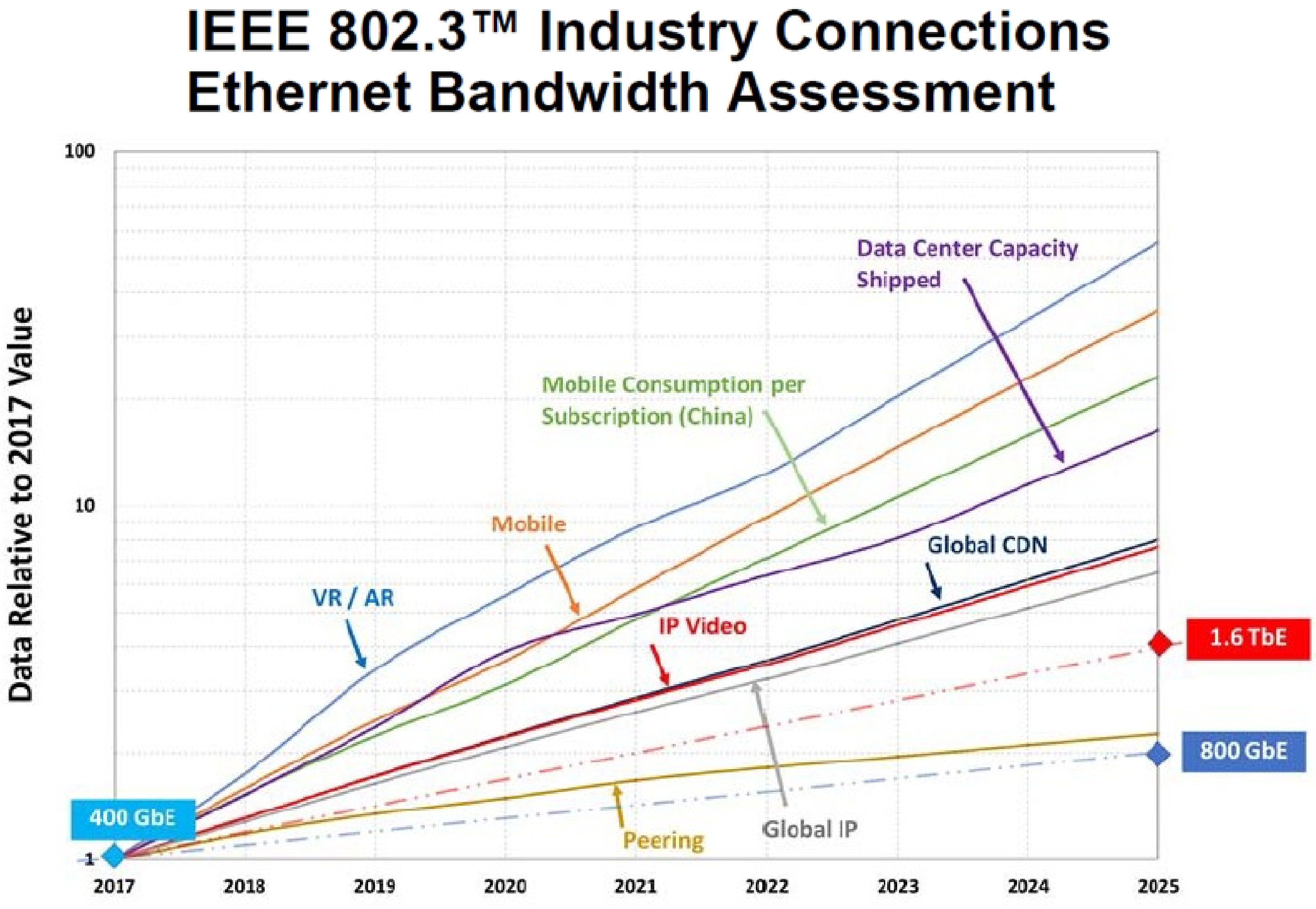
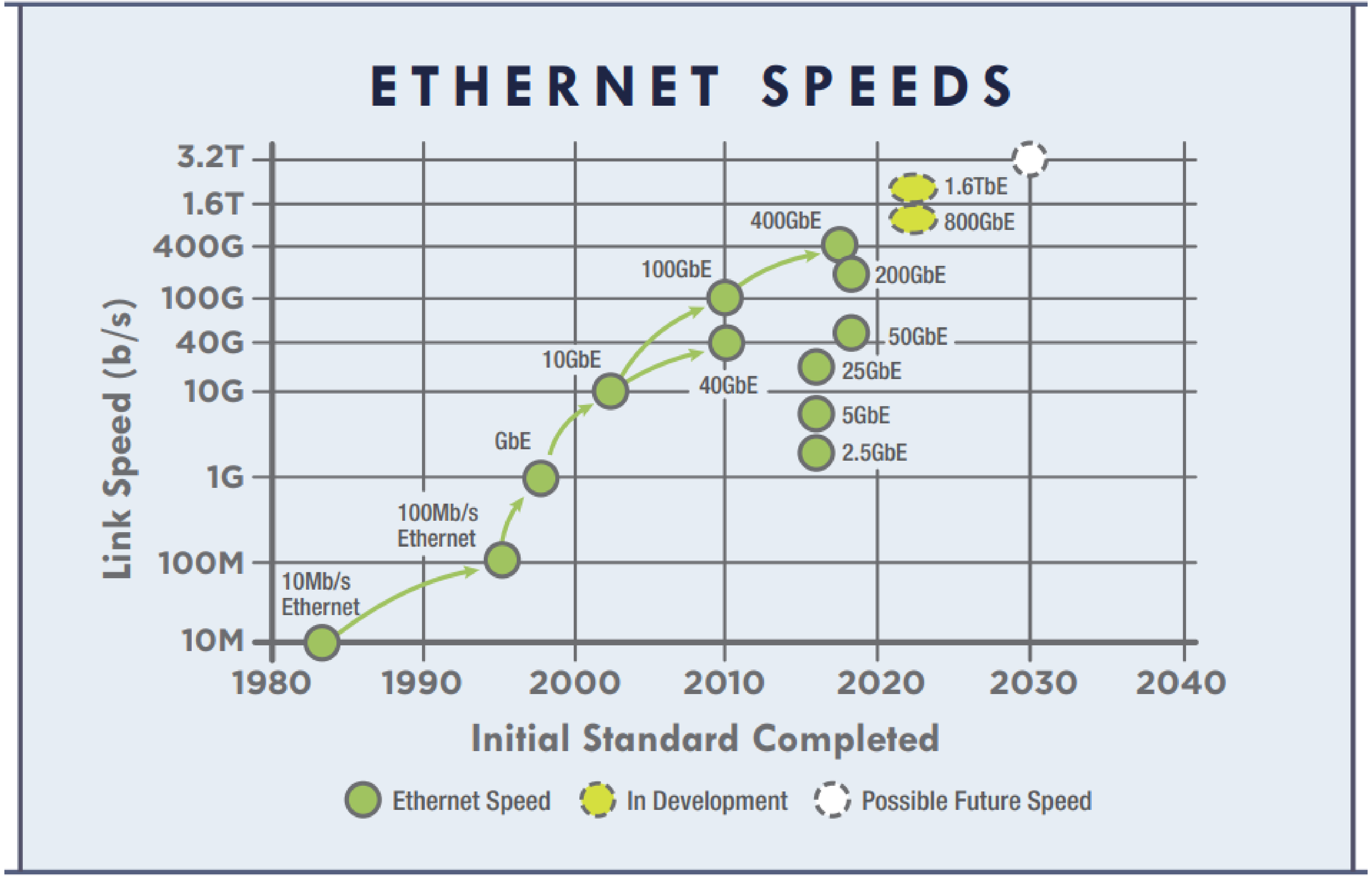


Figure 52—Bandwidth Curves (2017-2025)

Ethernet speeds evolution



Ethernetalliance.com

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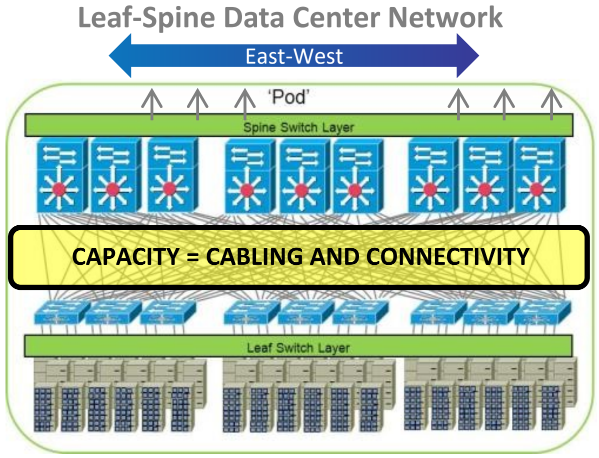
Overview of next generation transceivers

Mode	Data Rate	Lane Speed	Standard or MSA	PMD	Fiber Count	Connectors	Reach OM4/5 - SM
Multimode	100G	100G	802.3db	100G-VR1	2	LC	30/50m
	100G	100G	802.3db	100G-SR1	2	LC	70/100m
	400G	100G	802.3db	400G-VR4	8	MPO8, MPO8 APC	30/50m
	400G	100G	802.3db	400G-SR4	8	MPO8, MPO8 APC	70/100m
	800G	100G	Terabit BiDi MSA	800G-VR4.2	8	MPO8, MPO8 APC	30/50m
	800G	100G	Terabit BiDi MSA	800G-SR4.2	8	MPO8, MPO8 APC	70/100m
	800G	100G	802.3df	800G-VR8	16	MPO16 APC	30/50m
	800G	100G	802.3df	800G-SR8	16	MPO16 APC	70/100m
	1.6T	100G	Terabit BiDi MSA	1.6T-VR8.2	16	MPO16 APC	30/50m
	1.6T	100G	Terabit BiDi MSA	1.6T-SR8.2	16	MPO16 APC	70/100m
Singlemode	200G	200G	802.3dj	200G-DR1	2	LC	500m
	200G	200G	802.3dj	200G-FR1	2	LC	2km
	400G	200G	802.3dj	400G-DR2	4	2xLC, 2xSN, 2xMDC	500m
	800G	200G	802.3dj	800G-FR4	2	LC	2km
	800G	200G	802.3dj	800G-LR4	2	LC	10km
	800G	200G	802.3dj	800G-DR4	8	MPO8 APC	500m
	800G	100G	802.3dj	800G-DR4-2	8	MPO8 APC	2km
	800G	100G	802.3dj	800G-DR8	16	MPO16, 2xMPO8 APC	500m
	800G	100G	802.3dj	800G-DR8-2	16	MPO16, 2xMPO8 APC	2km
	1.6T	200G	802.3dj	1.6T-DR8	16	MPO16, 2xMPO8 APC	500m
	1.6T	200G	802.3dj	1.6T-DR8-w	16	MPO16, 2xMPO8 APC	2km



Publication dates

- 802.3db – 2022
- Terabit BiDi MSA – 2023
- 802.3df – 2024
- 802.3dj – 2026

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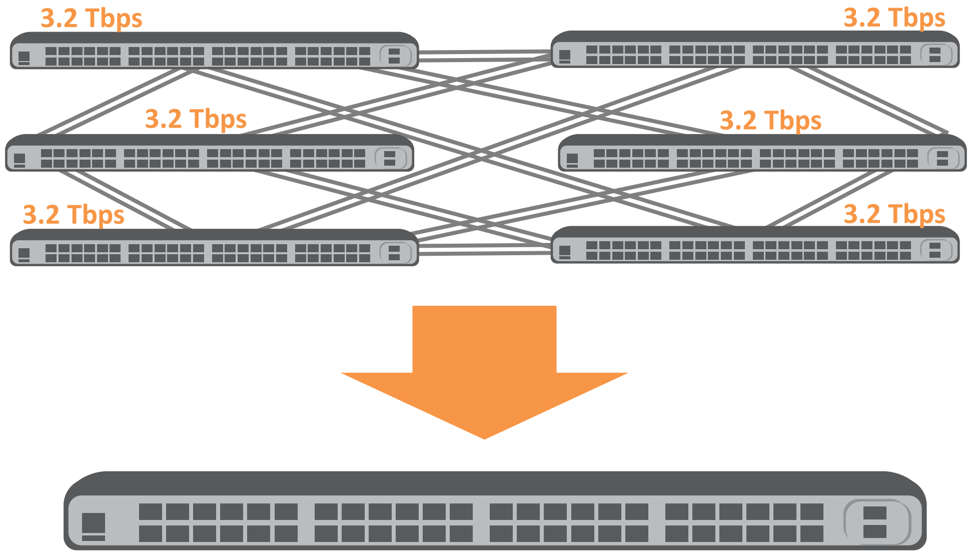
Higher switch capacity: migration from 3.2 to 12.8 Terabytes-per-second



6 x 32 port 100G switches

4x25G lanes

12.8 Tbps

25.6 Tbps

1 x 32 port 400G switch

8x50G lanes

8x100G lanes

More powerful chipsets will power future applications and higher speeds networks, while driving the need for network densification, power savings, and network infrastructure savings.

REDUCTION IN LINKS	• Cooler-running networks • Less switch-to-switch links required
REDUCTION IN POWER	• Power per solution lower • Lower power per Gb of bandwidth
REDUCTION IN COST	• Switch list price saving in excess of $40K • Additional Cable/Fiber savings

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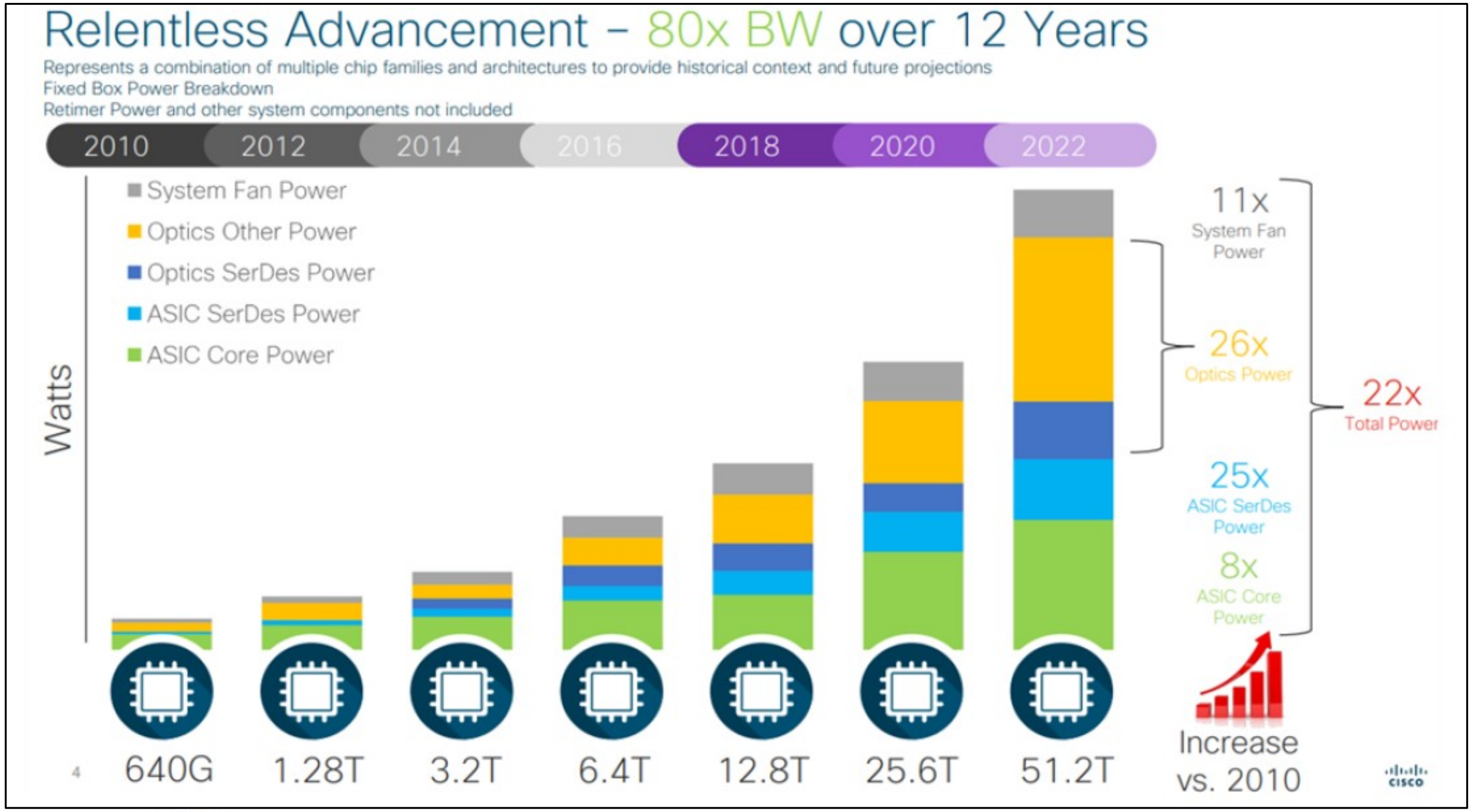
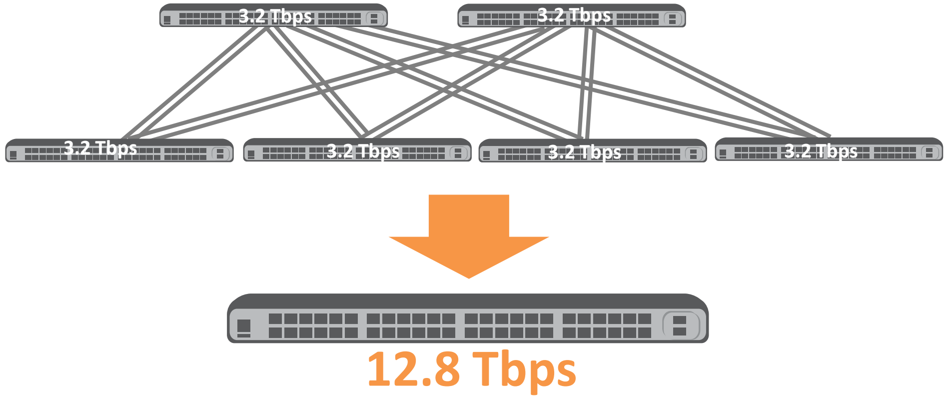
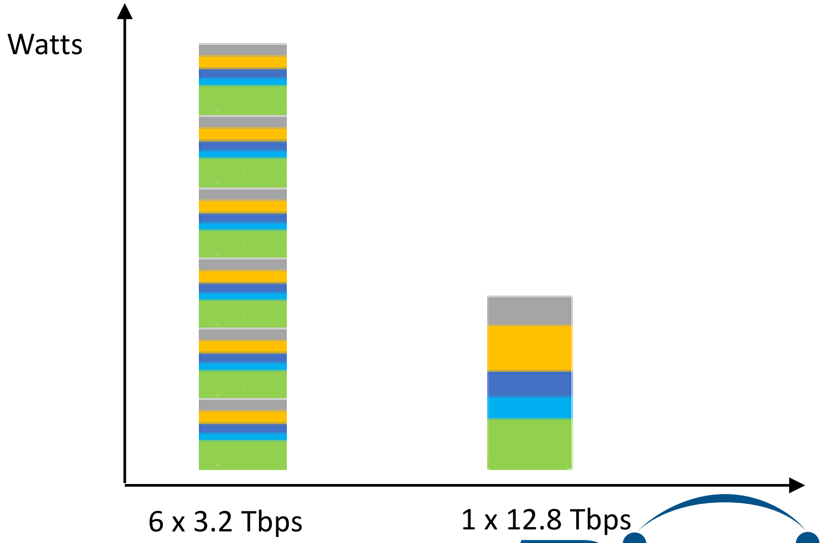
Source: 650 Group (2021)

Power efficiency of high radix switches







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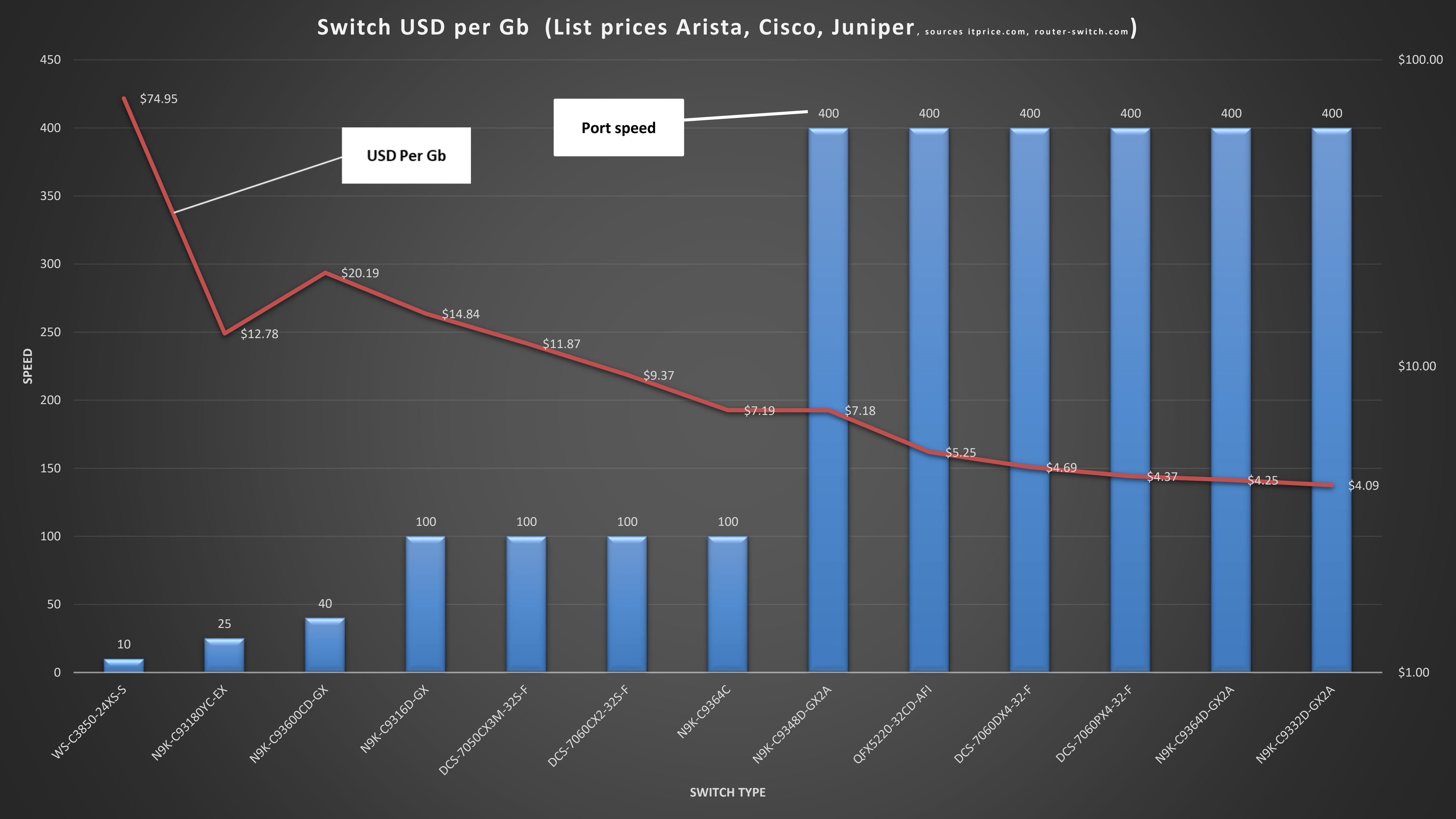
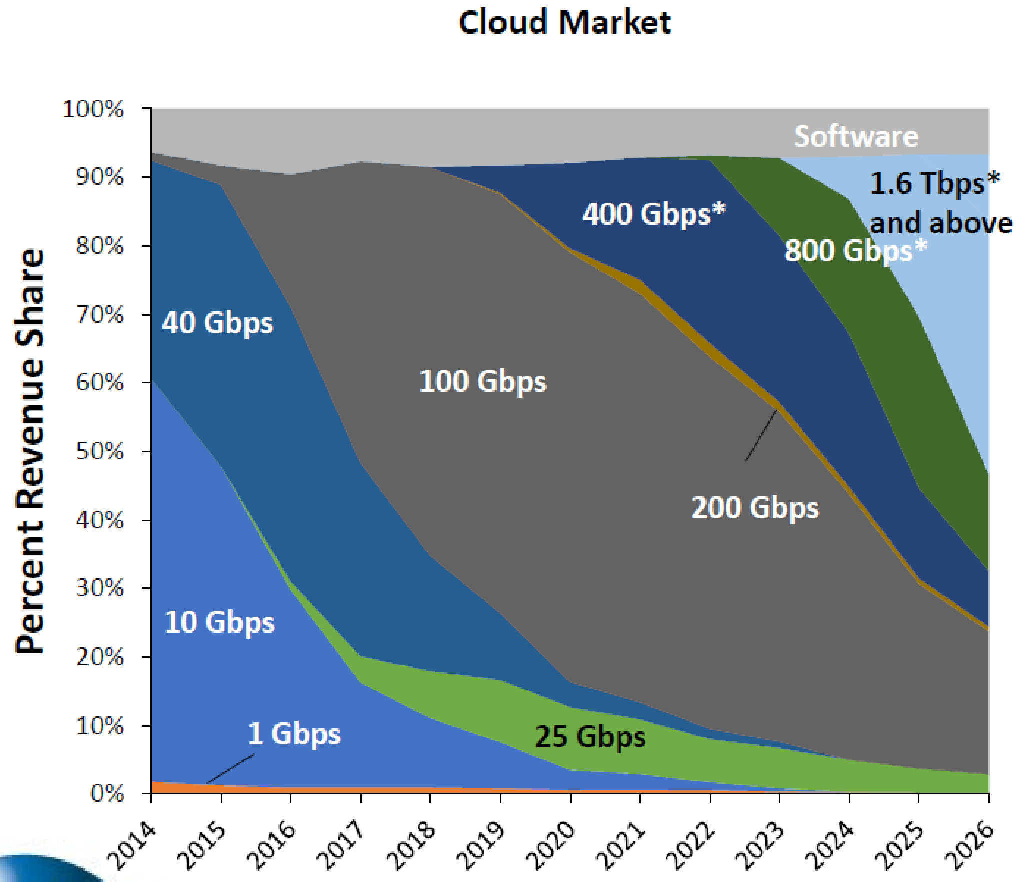
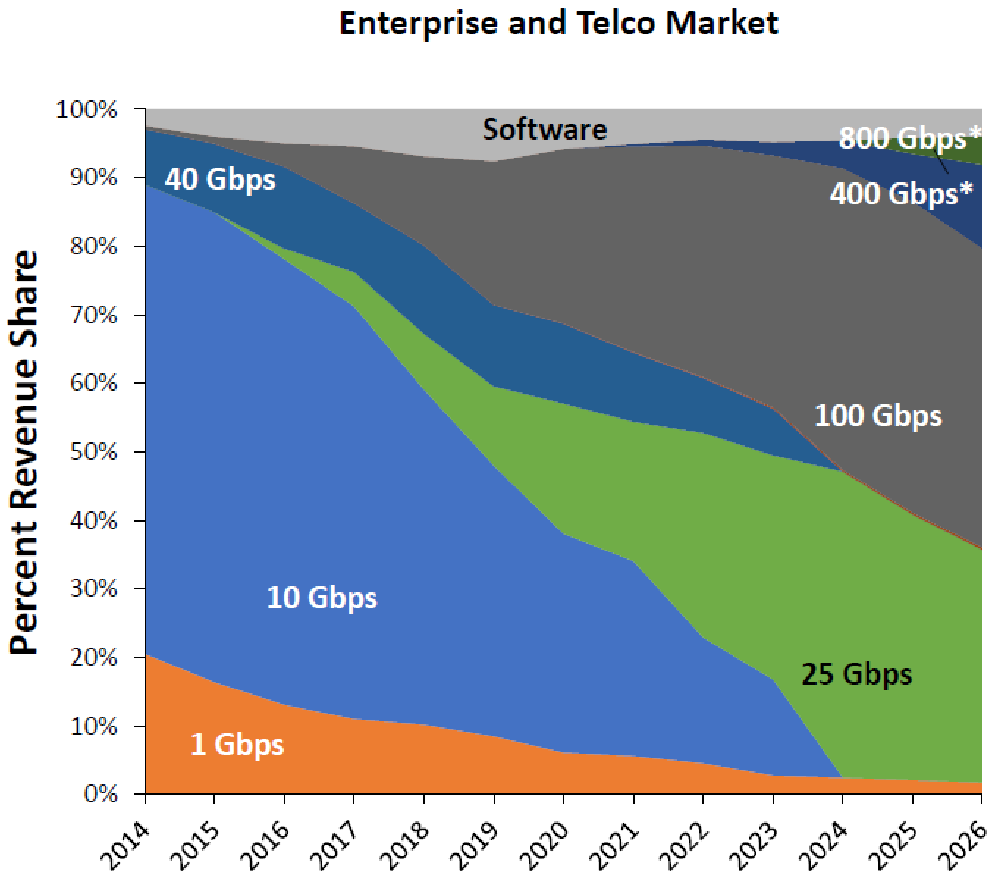

Switch USD per Gb (List prices Arista, Cisco, Juniper, sources itprice.com, router-switch.com)
SPEED
SWITCH TYPE
USD Per Gb
Port speed
450
400
350
300
250
200
150
100
50
0
$100.00
$10.00
$1.00
10
25
40
100
100
100
100
400
400
400
400
400
400
$74.95
$12.78
$20.19
$14.84
$11.87
$9.37
$7.19
$7.18
$5.25
$4.69
$4.37
$4.25
$4.09
WS-C3850-24XS-S
N9K-C93180YC-EX
N9K-C93600CD-GX
N9K-C9316D-GX
DCS-7050CX3M-32S-F
DCS-7060CX2-32S-F
N9K-C9364C
N9K-C9348D-GX2A
QFX5220-32CD-AFI
DCS-7060DX4-32-F
DCS-7060PX4-32-F
N9K-C9364D-GX2A
N9K-C9332D-GX2A

Market research: switch revenue





*25.6 Tbps ASICs are reported under 800 Gbps, 51.2 Tbps ASICs are reported under 1.6 Tbps; optics may lag or be different then front panel port

650 GROUP MARKET INTELLIGENCE RESEARCH

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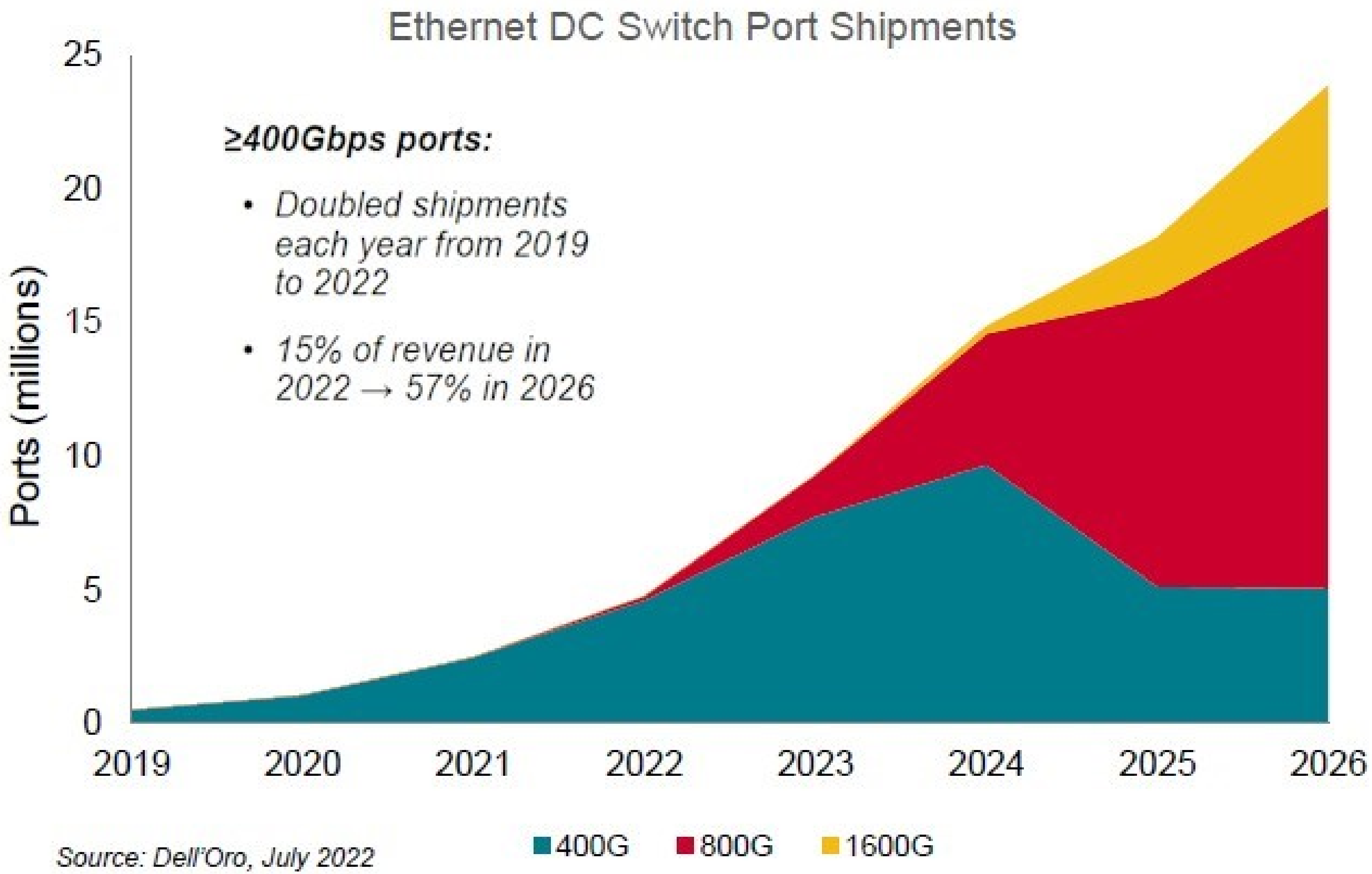
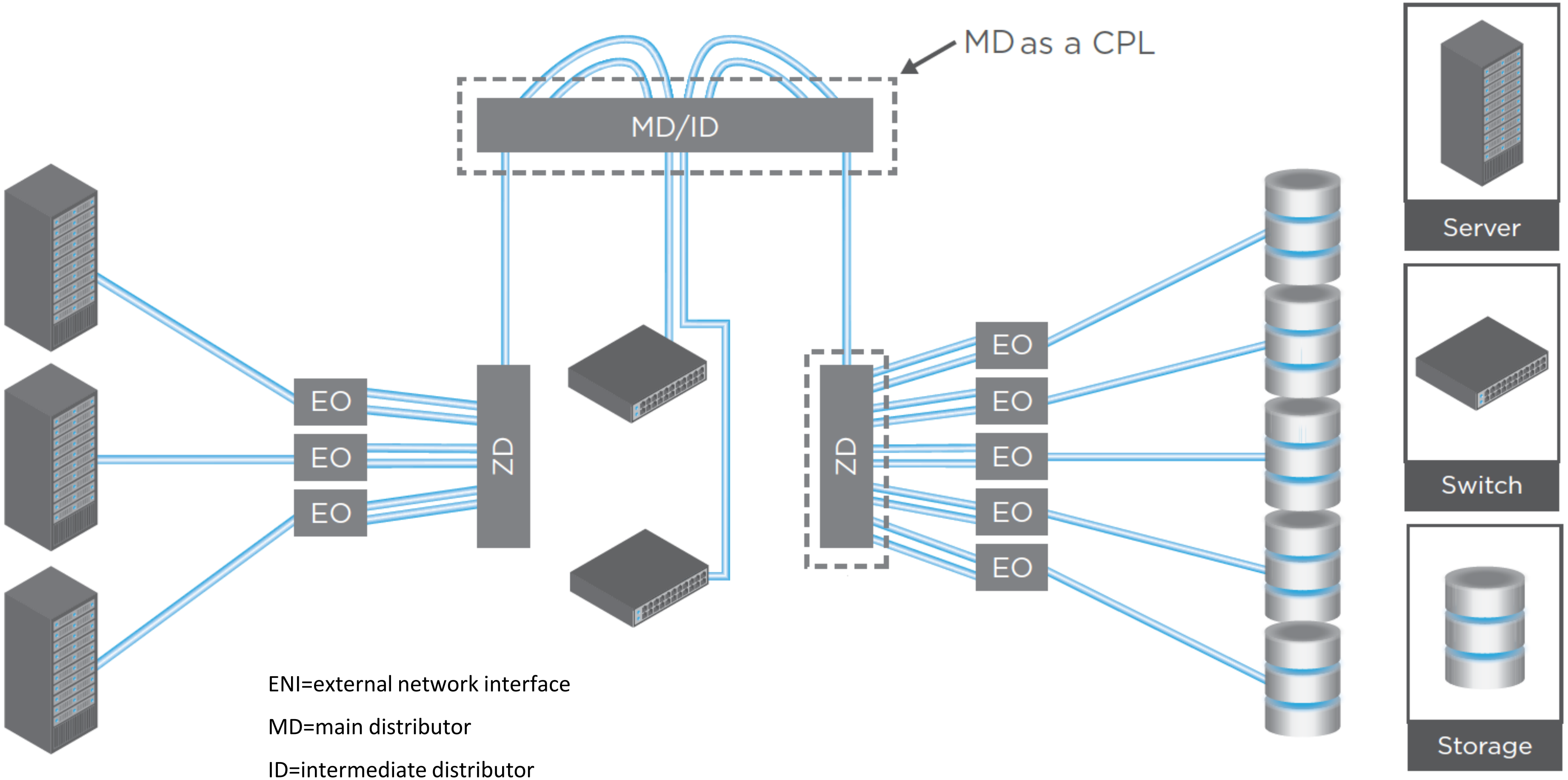
Market research: switch ports by data rate



Source: Dell'Oro, July 2022

EN 50600-2-4 resp. ISO/IEC DTS 22237-5 architecture



ENI=external network interface

MD=main distributor

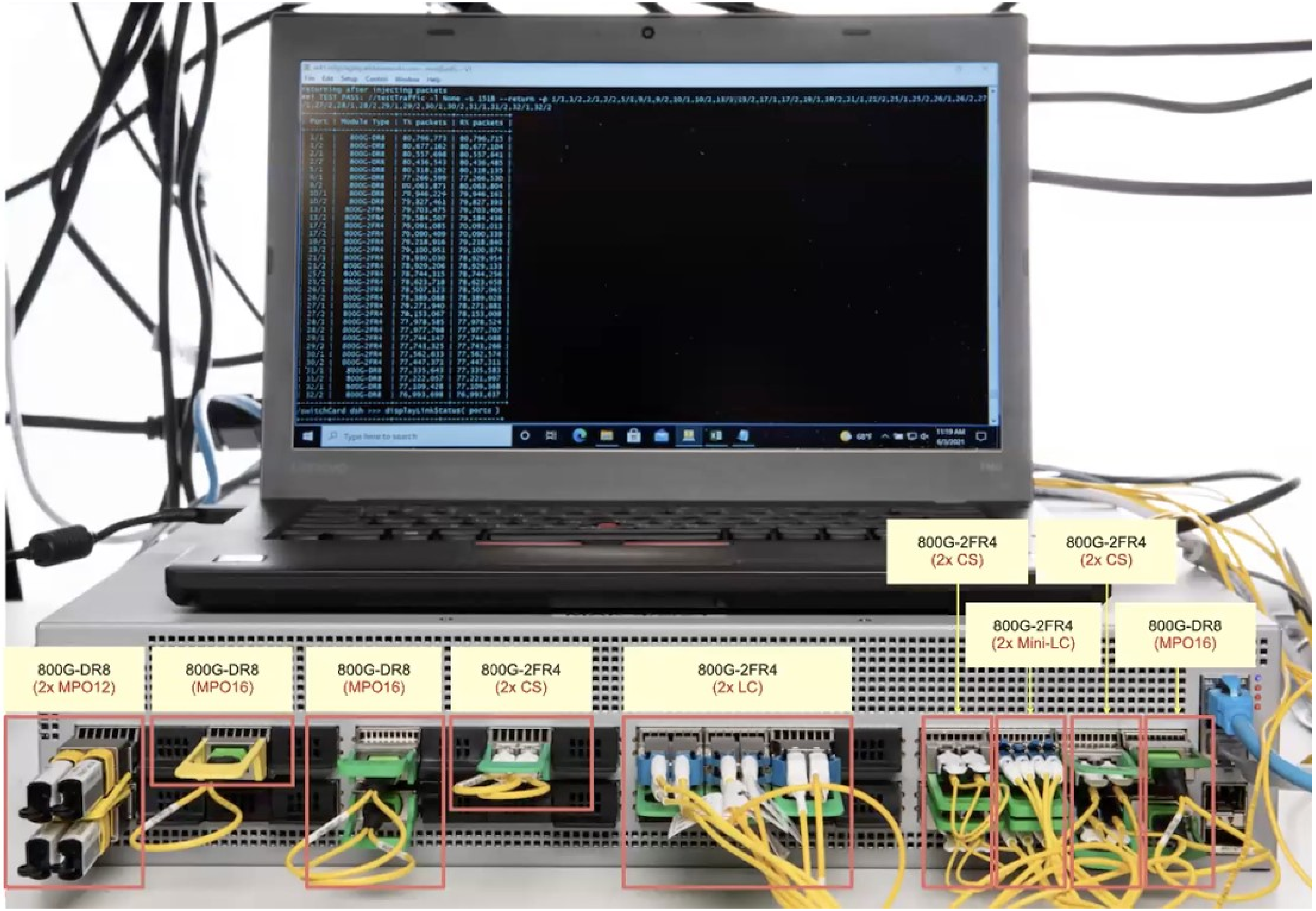
ID=intermediate distributor

ZD=zone distributor

EO=equipment outlet

CPL=central patching location

800G modules in the lab today



intel

eoptolink

INNOLIGHT

Linktel TECHNOLOGIES

AOI APPLIED OPTOELECTRONICS, INC.

SOURCE PHOTONICS

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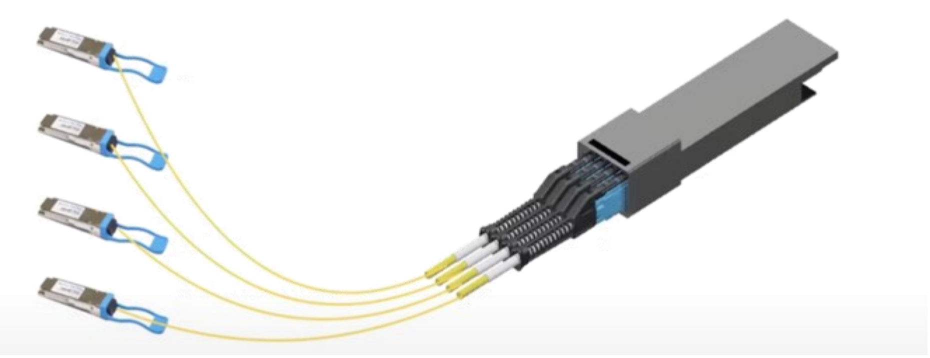
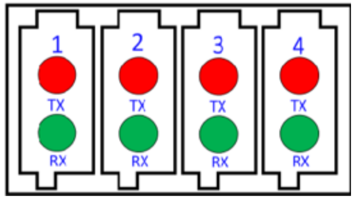
New VSFF connector options

Breakout of 400G 8-lane switch ports to 100GE & 200GE Fabric (inter-switch) links

400G DR4
with 4 duplex 100G-DR fibers



New SN/MDC connector avoids MPO-MTP Splitter cable



Next steps for fiber infrastructure in the DC

Speed applications are increasing

Channel lengths are decreasing

Optical loss budgets are decreasing

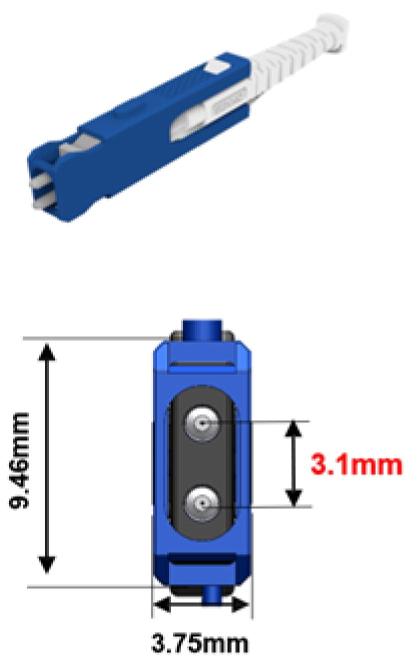
Different options for fiber type and connectivity

Increase infrastructure complexity

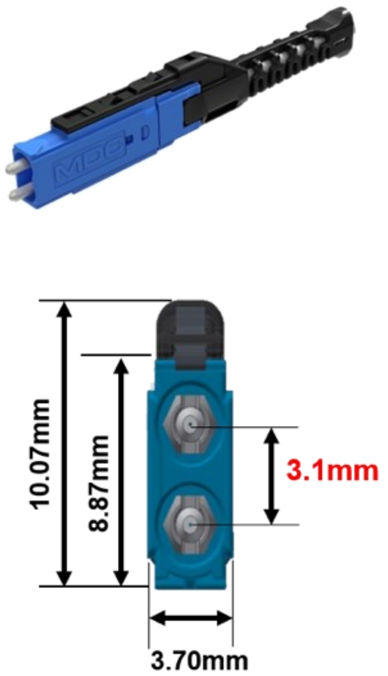
Standards provide limited guidance

Size comparison VSFF connectors vs predecessors

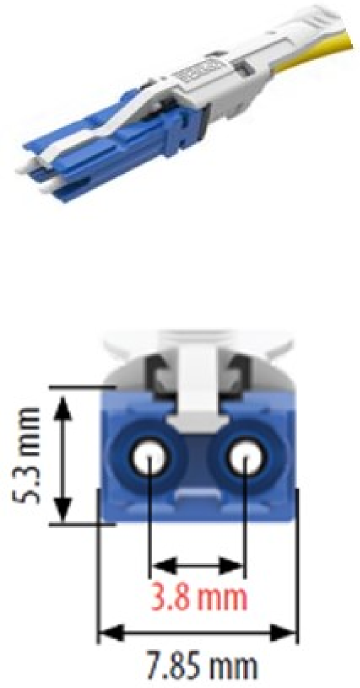
SN®



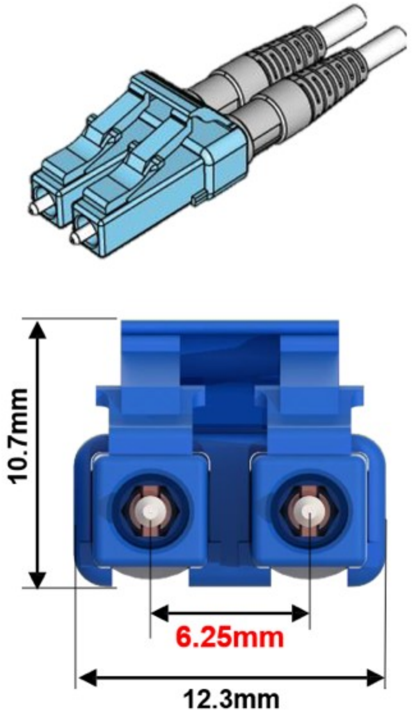
MDC



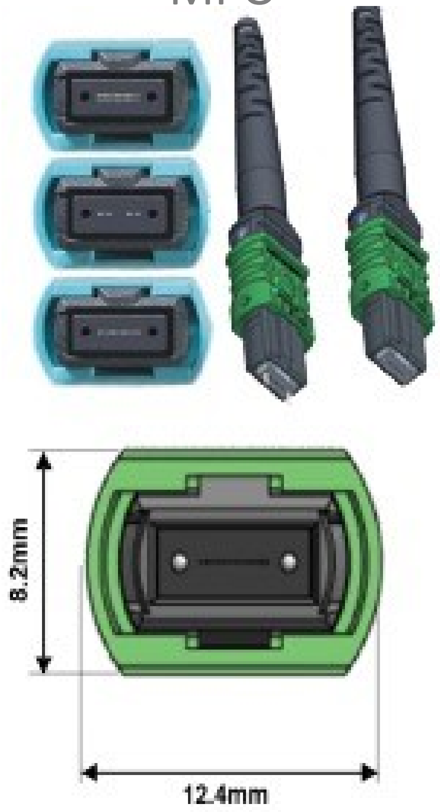
CS



LC Duplex



MPO



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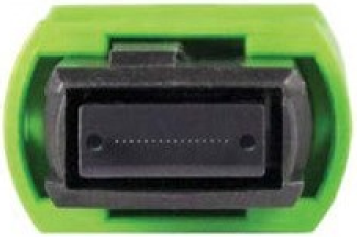
8-FIBER MPO
(MPO-8)

Singlemode APC
Multimode UPC or APC

12-FIBER MPO
(MPO-12)

Singlemode APC
Multimode UPC

16-FIBER MPO
(MPO-16)



Singlemode APC
Multimode APC

24-FIBER MPO
(MPO-24)

Multimode UPC Only

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400G switch to switch connections
400GBASE-SR4.2 link power budget

Parameter	OM3	OM4	OM5	Unit
Effective modal bandwidth at 850 nm[a]	2000	4700	4700	MHz-km
Effective modal bandwidth at 918 nm	1210	1850	2890	MHz-km
Power budget (for max TDECQ)		6.6		dB
Operating distance	70	100	150	m
Channel insertion loss[c]	1.8	1.9	2	dB
Allocation for penalties[d] (for max TDECQ)		4.6		dB
Additional insertion loss allowed	0.2	0.1	0	dB

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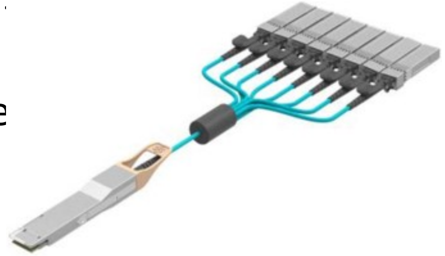
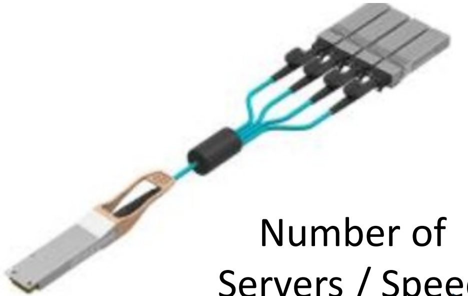
Why not use DACs or AOCs?

Inherent limitations of
Direct Attach Cables and Active Optical Cables

- DACs are bulky
  - Congest pathways
  - Difficult to bend and route compared to fiber
- DACs too short for MoR/EoR switch
  - Reach limited to ToR switch placement
- AOCs require on-site installation
  - Must route transceiver ends thru pathways
  - Longer AOCs hinder deployment speed
- AOCs with breakouts even more difficult
  - Breakout involves routing multiple ends
  - Endpoint location diversity become

AOC/DAC OFC 2019





Number of Servers / Speed

Cable Length ⟷ Breakout Length

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Considerations for selecting optical infrastructure

Appropriate fiber count	Applications, MPO-16
Singlemode vs multimode	Applications, distances
Polarity	Standards, Method B
Transition assemblies	1:1 equipment cord vs array
IL/RL Loss considerations	Minimum guarantee margins
Infrastructure/Network Teams	Align objectives, collaboration

Cabling infrastructure check-list

Cable	• ISP, OSP, I/O, SM, MM, Rollable Ribbon(RR) (16f subunits) • SM, OM5, OM4	
Connectors	• MPO16, 12, 8, 24 & LC Duplex, Mini LC, • + SN, MDC, CS, etc.	
Cable Assemblies	• Trunks, RR Trunks, Equipment & Patch Cords, MPO-MPO, MPO Arrays, Conversion Arrays	

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Panels

- 1U, 2U, & 4U Sliding
- 72 duplex LC/MPO per RU
- 144 SN per RU

Modules

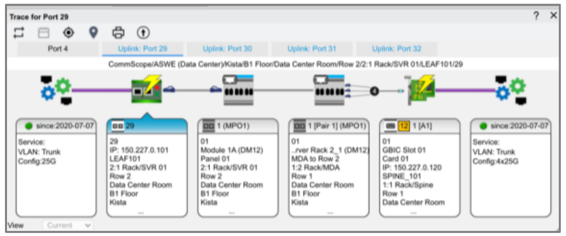
- MM: LC, MPO8/12/16/24
- SM: LC, SN, MPO8/12/16

Adapter Packs

- LC
- SN
- MPO

Traceability

Track optical performance and application support capability



"What did you take away from the meeting?"

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One size does NOT fit all

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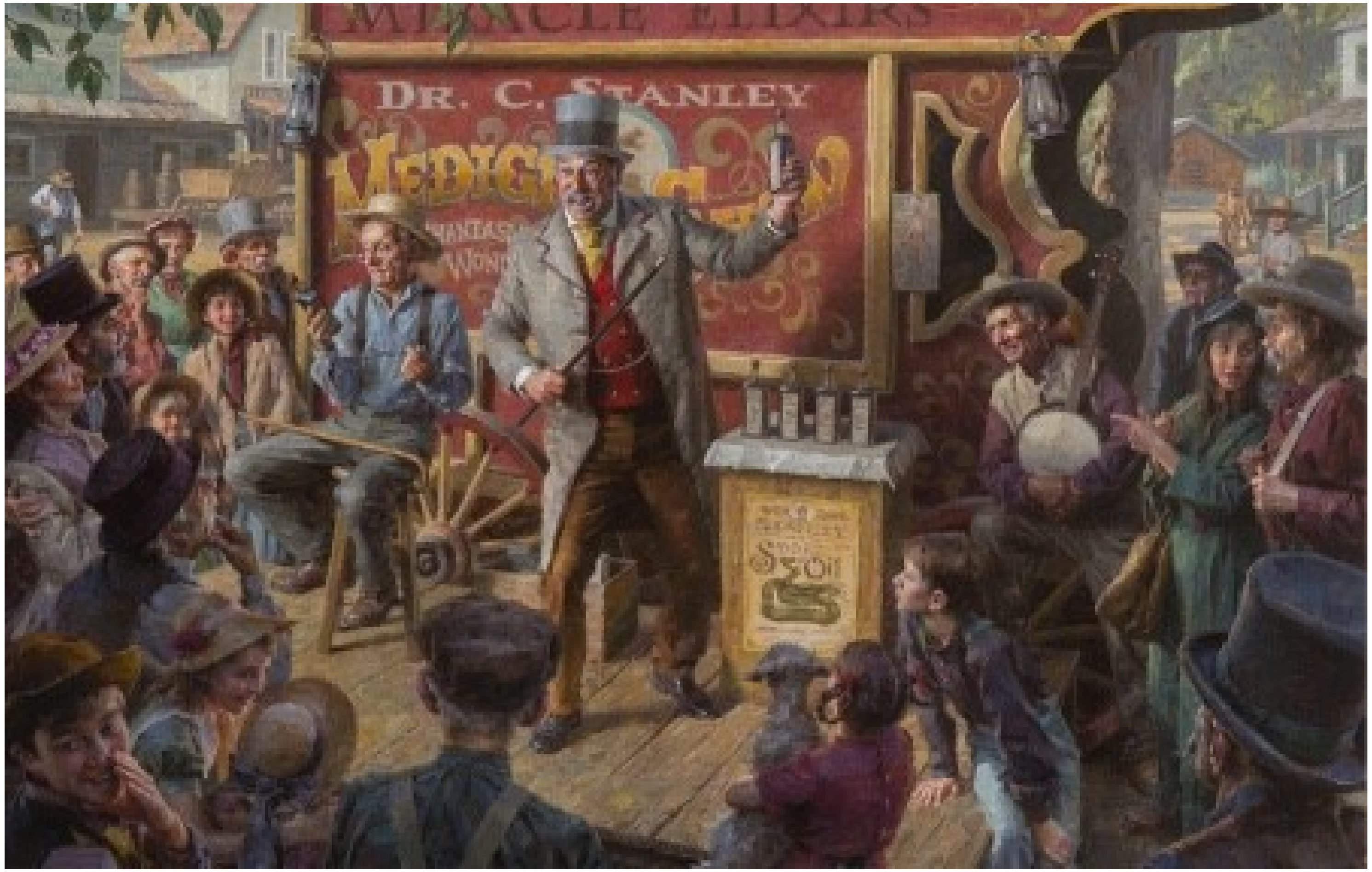
Avoid the charlatans!!!



The good functioning of the network affects on applications and business investments

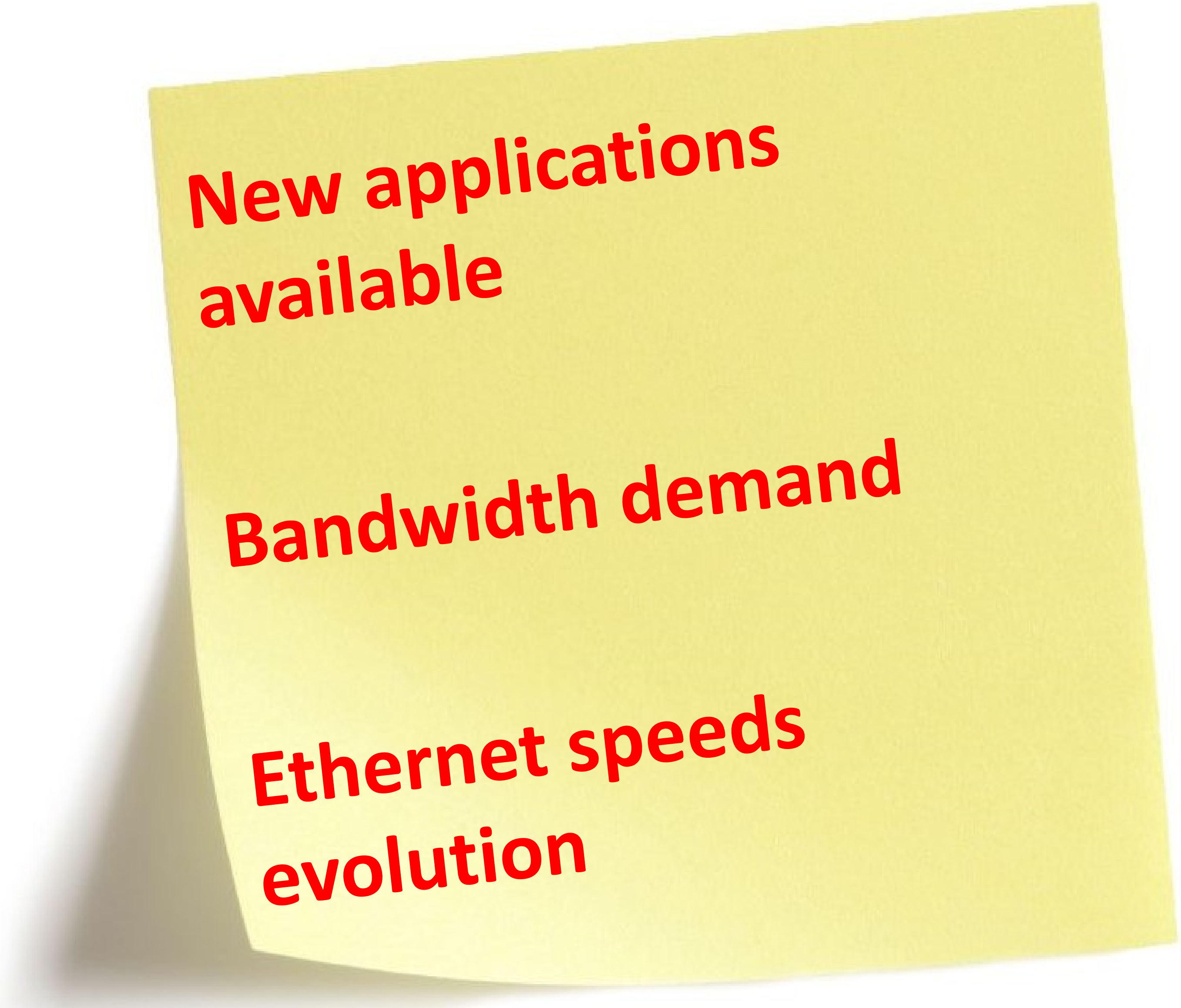

The fiber physical infrastructure is
the foundation of the data center

Major factors driving DC networks evolution

Advancements in electrical and optical network electronics

Next steps for optical fiber infrastructure

Major factors driving DC networks evolution



Advancements in electrical and optical network electronics

Next steps for optical fiber infrastructure

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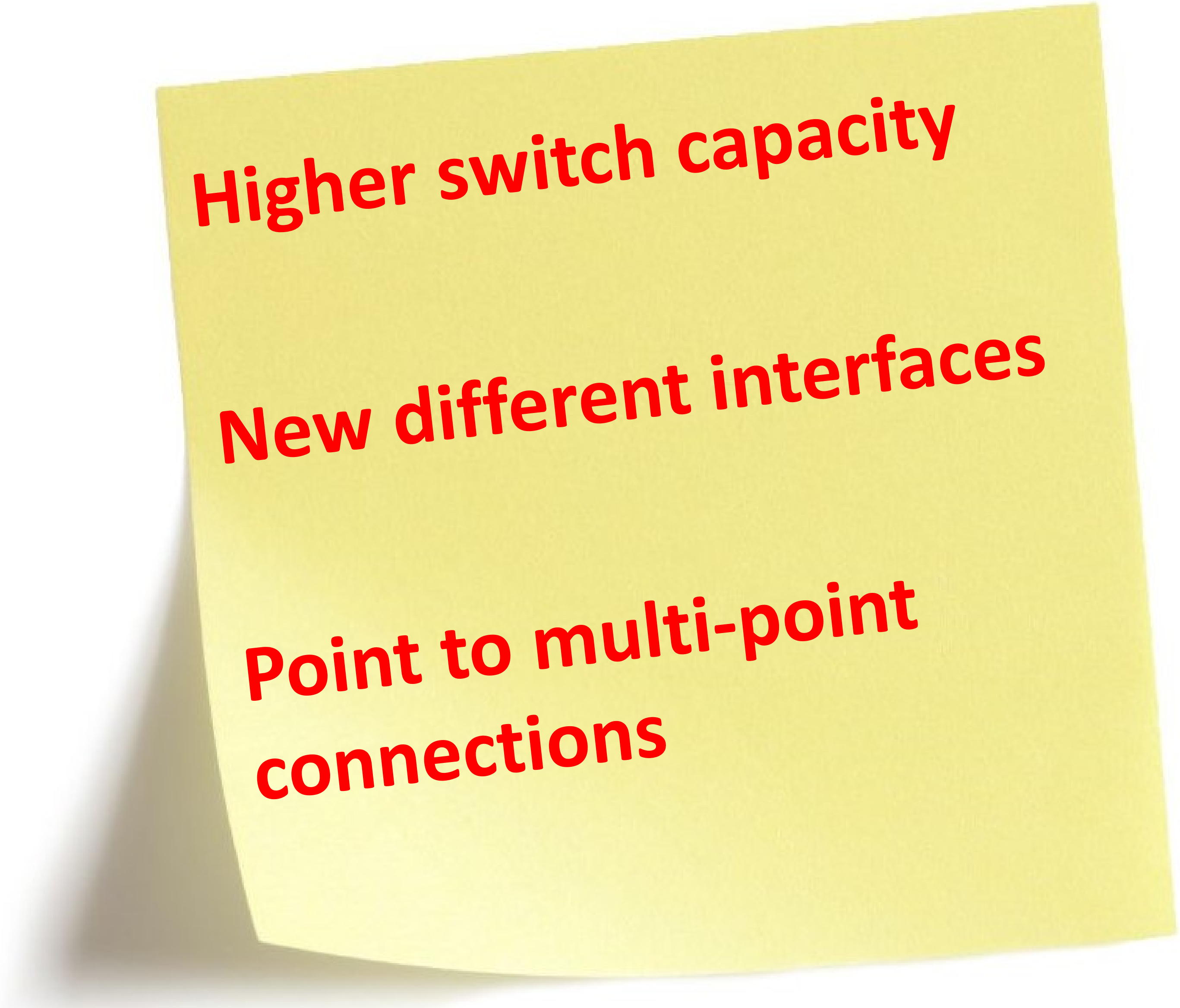

Major factors driving DC networks evolution

Advancements in electrical and optical network electronics

Next steps for optical fiber infrastructure

MPO-16, new kid in town

Flexibility, modularity, management

Performances (ULL) to support new applications

Major factors driving DC networks evolution

Advancements in electrical and optical network electronics

Next steps for optical fiber infrastructure

Thank you!

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